Nutrient and Energy Optimization Study
Harriman Wastewater Treatment Plant
Harriman, Tennessee

June 2021

Tennessee Association of Utility Districts
with funding from the **Tennessee Department of Environmental Conservation**
and support from the **Municipal Technical Advisory Service**,
CleanWaterOps and the **City of Harriman**

Introduction

Tennessee Plant Optimization Program (TN POP) assists water and wastewater utilities in achieving energy efficiency and nutrient optimization through low-and-no-cost measures. TN POP 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 Tennessee Department of Environment and Conservation (TDEC), Division of Water Resources (DWR) with an TDEC/SRF/TAUD contract. Special ***Thank You*** to the Harriman Utility Board (HUB), HUB General Manager Candace Vannasdale, HUB operators Ray Freeman and Donnie Fitzhugh, Grant Weaver of CleanWaterOps, TDEC's Karina Bynum, TDEC's Tim Hill and Brett Ward of UT- Municipal Technical Advisory Service (MTAS). .

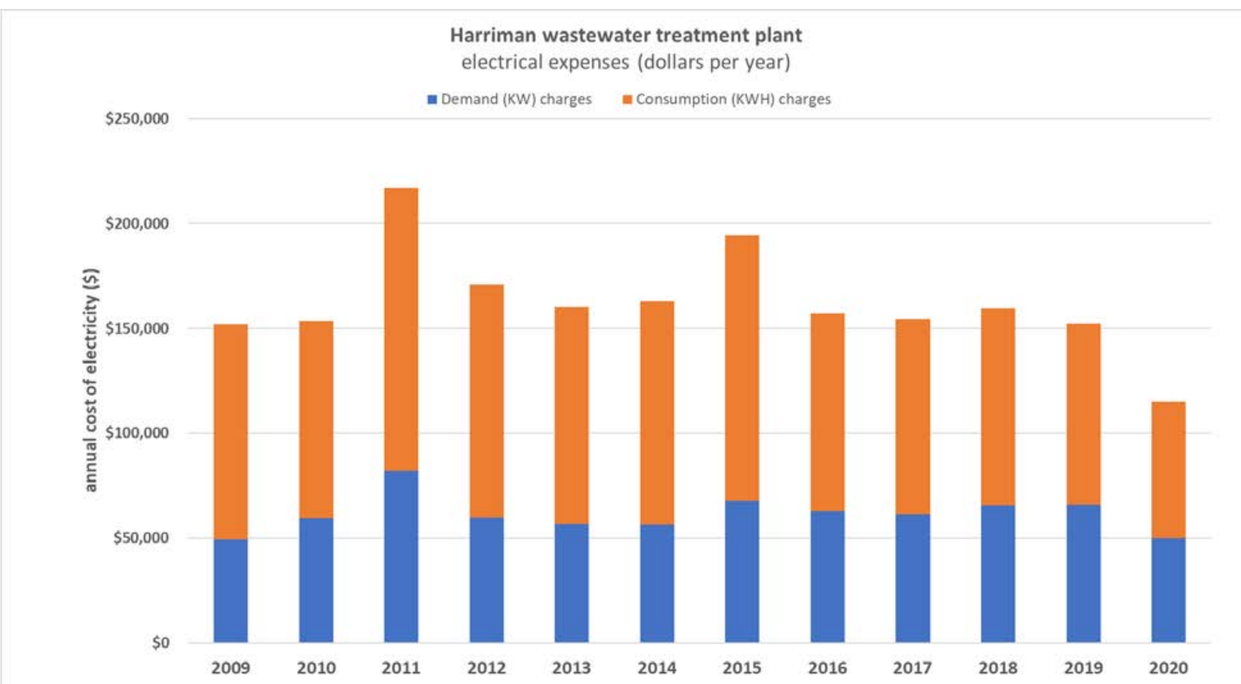
2017-2020 Nutrient and Energy Optimization Study
Harriman, Tennessee
Wastewater Treatment Plant - Permit #TN0025437

Executive Summary

Informed changes to the day-to-day operation of the city's municipal wastewater treatment facilities resulted in electrical savings of $35,000 per year, a 75% reduction in effluent nitrogen, and a 25% decline in the amount of phosphorus discharged from the city's municipal wastewater treatment plant. These improvements were realized by changing day-to-day operations without spending any money on new equipment.

Harriman effluent	Nitrogen		Phosphorus	
	mg/L	lb/day	mg/L	lb/day
Before (2017)	9.2	25.8	1.9	4.5
After (2020)	2.1	6.6	1.4	3.0
Change (mg/L)	7.1	19.2	0.5	1.5
Change (Percent)	77%	74%	25%	33%

Ongoing efforts to optimize phosphorus removal are anticipated to result in lower effluent concentrations in 2021. TDEC's recent approval for a seasonal discharge of treated effluent to the Emory River (250 HP pumps are currently used to pump effluent eleven miles to the Tennessee River) will provide additional electrical savings of $35,000.



Facilities Description

The Harriman wastewater treatment facility (permit number TN0025437) serves 2,400 customers. There are 85 miles of sewer collection lines. The wastewater treatment facility is located at 504 Bullard Ford Road, Harriman, TN 27748 (35.940646°N – 84.535444°W).

The treatment facility's rated design capacity is 1.5 MGD (million gallons per day). During dry summer months, Harriman's wastewater flow averages half the design capacity. During winter months, the wastewater flow increases to the design capacity with daily peaks of 3-4 MGD, double design capacity. Based on 2020 annual average daily flow of 1.10 MGD and 7-day Average Daily Dry Weather Flow of 0.36, the average daily influent I/I flow is 66.9%. This data was generated from the Tennessee Division of Water Resources SRF Infrastructure Scorecard Wastewater I/I assessment tool. The increased flow is the result of the infiltration and inflow (I&I) of non-wastewater into the city's sewer pipes during wet weather and high groundwater conditions.

Notwithstanding flows that frequently exceed design capacity, Harriman's wastewater treatment facility produces a very high-quality effluent as summarized in the table that follows. All figures are annual averages.

Effluent	Flow (MGD)	BOD (mg/L)	TSS (mg/L)	pH (mg/L)	tN (mg/L)	tP (mg/L)
2016	0.58	4	6	6.7	18.6	3.0
2017	0.97	6	5	7.1	9.2	1.9
2018	1.11	6	4	7.0	5.0	0.7
2019	1.09	5	2	6.9	6.8	1.8
2020	1.07	4	2	7.0	2.1	1.4

Utility Information

Harriman Utility Board
General Manager: Candace Vannasdale
P.O. Box 434 (Mailing Address)
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Wastewater Treatment Plant Operator Information

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WWTP Plant Information

Harriman WWTP – Permit #TN0025437
2400 Wastewater Customers.
85 miles of sewer collection lines.

The City of Harriman is authorized to discharge Treated municipal wastewater from Outfall 001 to the Tennessee River at mile 567. Discharge 001 consists of municipal wastewater from a treatment facility with a design capacity of 1.5 MGD. The Permit is attached that shows all permit required parameters, monitoring frequencies, and limits.

Tennessee Water Resources Permit information site:
https://dataviewers.tdec.tn.gov/pls/enf_reports/f?p=9034:34051::::34051:P34051_PERMIT_NUMBER:TN0025437

The WWTP plant's physical address is:
504 Bullard Ford Rd
Harriman, TN 27748
35.940646, -84.535444

Description of the Harriman wastewater treatment facilities

Raw wastewater is pumped across the Emory River to the wastewater treatment plant from the Wood Yard pumping station. Influent passes through an elevated headworks structure consisting of a mechanical step screen and grit removal followed by a Parshall flume influent flow meter. From there, metered wastewater gravity flows to a splitter box. Up to 1700 gallons per minute (GPM) of influent gravity flows to the two parallel oxidation ditches. Flows in excess of the 1700 gallons per minute gravity flow to two repurposed SBR’s used as an Equalization Basin.

Following preliminary treatment in the headworks, wastewater gravity flows from the splitter box into two parallel oxidation ditches. Each of the two oxidation ditches is equipped with two horizontal shaft rotors powered by 50 horsepower (HP) motors. One of two rotors in each ditch is cycled on for a period of (current setting) one hour and cycled off for three hours after which time the other rotor cycles on for one hour; the run times are adjusted from time to time in response to changes in flow and treatment performance. The rotor operations in the two ditches are programmed such that no more than one 50 HP rotor is running at one time. That is, while one rotor is operating in one ditch, none are on in the other ditch. These rotor-on / rotor-off cycles provide optimal habitats for the growth of bacteria that remove conventional pollutants (BOD and TSS). During the rotor-on cycles, ammonia nitrogen is converted to nitrate-nitrogen. During the rotor-off cycles, nitrate-nitrogen is converted to nitrogen gas. Phosphorus, it is theorized, is removed as follows. During the long rotor-off cycles, the oxidation ditch MLSS settles, creating conditions in the bottom of the ditch that are sufficiently anaerobic to energize the phosphorus removing bacteria that exist in the MLSS and during the rotor-on cycles, the ditches become sufficiently aerobic to drive biological phosphorus removal.

Except for waste sludge which is periodically drawn from the bottom of the oxidation ditches, all of the wastewater entering the ditches gravity flows from the ditches into the secondary clarifiers. During normal operations, the flow from one oxidation ditch goes to one clarifier and all of the flow from the other ditch goes to the other clarifier. With the aeration rotors off for extended periods of time, sludge settles in the oxidation ditches to the extent that, more often than not, the water flowing into the clarifiers is already clarified. This fact has allowed Harriman staff to modify return activated sludge (RAS) pumping and now pump the sludge that settles in the secondary clarifiers intermittently, not continuously as is conventionally done for considerable energy savings. Five minutes after one of the aeration rotors turns on, the plant's computerized control system (SCADA or "supervised control and data acquisition") starts the RAS pump in the clarifier receiving flow from that ditch and keeps the pump in operation throughout the rotor-on cycle plus an additional 45-minutes. After which the RAS pump is shut off.

Flow exits the clarifiers by gravity and is dosed with a chlorine bleach solution (12.5% sodium hypochlorite) as it enters the chlorine contact chamber for disinfection. From the chlorine contact chamber, treated wastewater is pumped eleven miles to the Tennessee River. Gravity discharge to Emory River is available but historically not used because of regulatory restrictions. These restrictions have been altered and once the ongoing work to install effluent flow monitoring equipment is completed, the majority of the effluent will gravity flow to the Emory River, providing additional electrical savings projected to equal $35,000 per year.

Equalization basin. The splitter box following the influent flow meter diverts flows in excess of 1700 GPM to the plant's mothballed sequencing batch reactor (SBR) basins for equalization. After flows have subsided to 1.0 MGD (700 GPM), drain lines are opened in the SBR basins and the stored wastewater flows into an onsite pumping station and is pumped into the incoming wastewater flow downstream of the influent flow meter. Equalized flow is typically not mixed nor aerated. However, wastewater stored in the Equalization Basin for an extended period of time is aerated. to avoid unpleasant odors.

Sludge wasting. Pollutants contained in wastewater are converted to bacterial cells. To maintain a proper bacterial population in the oxidation ditches, waste activated sludge (WAS) is removed from the oxidation ditches by the periodic manual opening of oxidation ditch drain lines. Every week or two – depending upon the mixed liquor suspended solids (MLSS) concentration in the oxidation ditches – a drain valve is opened during the rotor-OFF cycle to allow settled MLSS to flow to the WAS pumps and into one of two aerobic digesters.

Grant Weaver of CleanWaterOps and Harriman WWTP Chief Plant Operator Ray Freeman discuss the equipment and RAS and WAS procedures.

Sludge digestion and disposal. Two aerobic digesters, each with a volume of 197,400 gallons are used to stabilize the wasted MLSS to meet the EPA 503 sludge regulations prior to land application. The digesters are aerated and mixed by one of two 50 HP blowers for six hours per day. The blower six-hour run cycle is 12:00 am – 6:00 am to avoid peak demand billing and to allow the sludge to settle so that operators can decant the supernatant during working hours. The supernatant from the digester's gravity flows to the Equalization Basin's onsite pumping station and is pumped into the incoming wastewater flow downstream of the influent flow meter.

Twice yearly sludge from one of two digesters is dewatered using a 1.7-meter belt filter press, augured into a covered sludge holding shed and land applied. A portion of the digested, dewatered sludge is land applied on Harriman Utility District land adjoining the wastewater treatment plant and the remainder is land applied on private land.

Thanks to an optimization effort that precedes this study effort by several years, the Harriman wastewater treatment facility, primarily as a result of the efforts of operator Ray Freeman and his assistant Donnie Fitzhugh, produces a high-quality effluent with an increasingly lower usage of electricity. As shown below, effluent BOD and TSS historically averaged below 5 mg/L (the BOD and TSS permits limits are 30 mg/l monthly average), total-nitrogen historically averaged 5-7 mg/L, under TDEC's 8 mg/L target while total-phosphorus, at 0.7-1.8 mg/L, has approached TDEC's 1.0 mg/L target. During the study, total-nitrogen improved to a very impressive 2020 annual average of 2.1 mg/L!

Harriman Safety Director Jeremy Gibson, Harriman WWTP Operations Specialist Donnie Fitzhugh, Tim Hill (Knoxville TDEC) and Grant Weaver during the initial meeting to come up with a plan for optimization to reduce Total Phosphorus

Needed Infrastructure Repairs

Aging solids handling equipment. Aging sludge handling equipment has been a problem and need of repair. Harriman Utility Board has purchased the parts to repair the 1.7-meter belt filter press from Phoenix Process Equipment. Once all the required parts are on site, the belt filter press will be repaired in-house under the supervision of a Phoenix Process representative. The two 3 HP PDP sludge pumps that pump the digested sludge and the associated piping are being examined to determine if they should be repaired or replaced. Once the update is complete, this should allow for the plant process to be optimized to run at desired MLVSS and resulting in optimization of TP removal with results of <1.0 mg/L consistently.

Wastewater Treatment Plant characteristics

Twin Oxidation Ditches each with a total design capacity of 1.9 MGD.
Each Ditch has a volume of 0.95 MG
Each Ditch has two 50 hp rotary aerators and each ditch has one clarifier.
Each Clarifier has a volume of 0.176 MG
Average Year-round Influent flow: 1.0 MGD
WAS 37540 gallons twice / month

Average 2019 -2020 winter wastewater parameters (November – April):

Average Influent Flow: 1.57 MGD ; Max flow: 4.15 MGD
Influent BOD: 83.29 mg/L; Effluent BOD: 4.5 mg/L
Influent TSS : 74.50 mg/L ; Effluent TSS : 2.10 mg/L
Influent pH ; 6.77 s.u.; Effluent pH ; 7.02 s.u.

Average 2019 summer wastewater parameters (May – October):

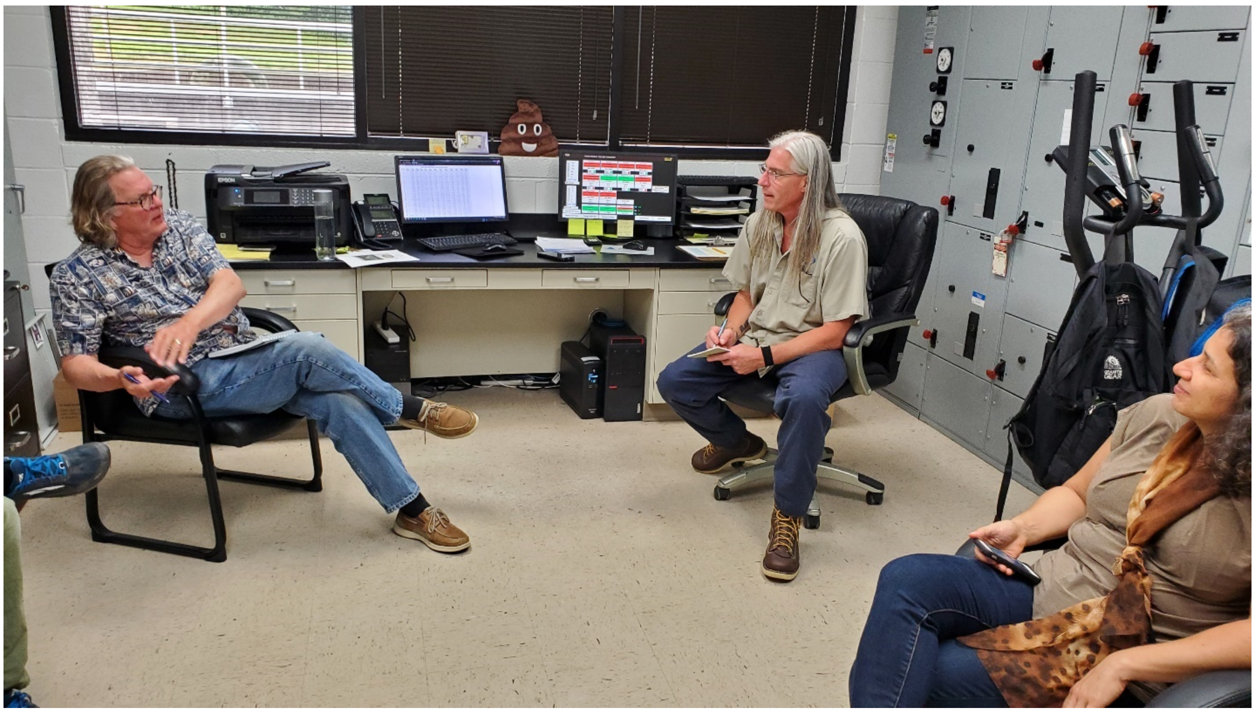
Average Influent flow: 0.74 MGD; Max flow: 3.23 MGD; Min flow: 0.35 MGD
Influent BOD: 153 mg/L; Effluent BOD: 4.64 mg/L
Influent TSS : 149 mg/L ; Effluent TSS : 2.39 mg/L
Influent pH ; 6.78 s.u.; Effluent pH ; 7.17 s.u.

Operating Process Control Parameters:

Average MLSS: 4800
Volatile Solids Content : 65%
Average MLVSS : 3120
Average F/M: 0.03
Average SVI 68.0
MCRT 28 – 30 DAYS
Influent Alkalinity > 150
Effluent Alkalinity >100

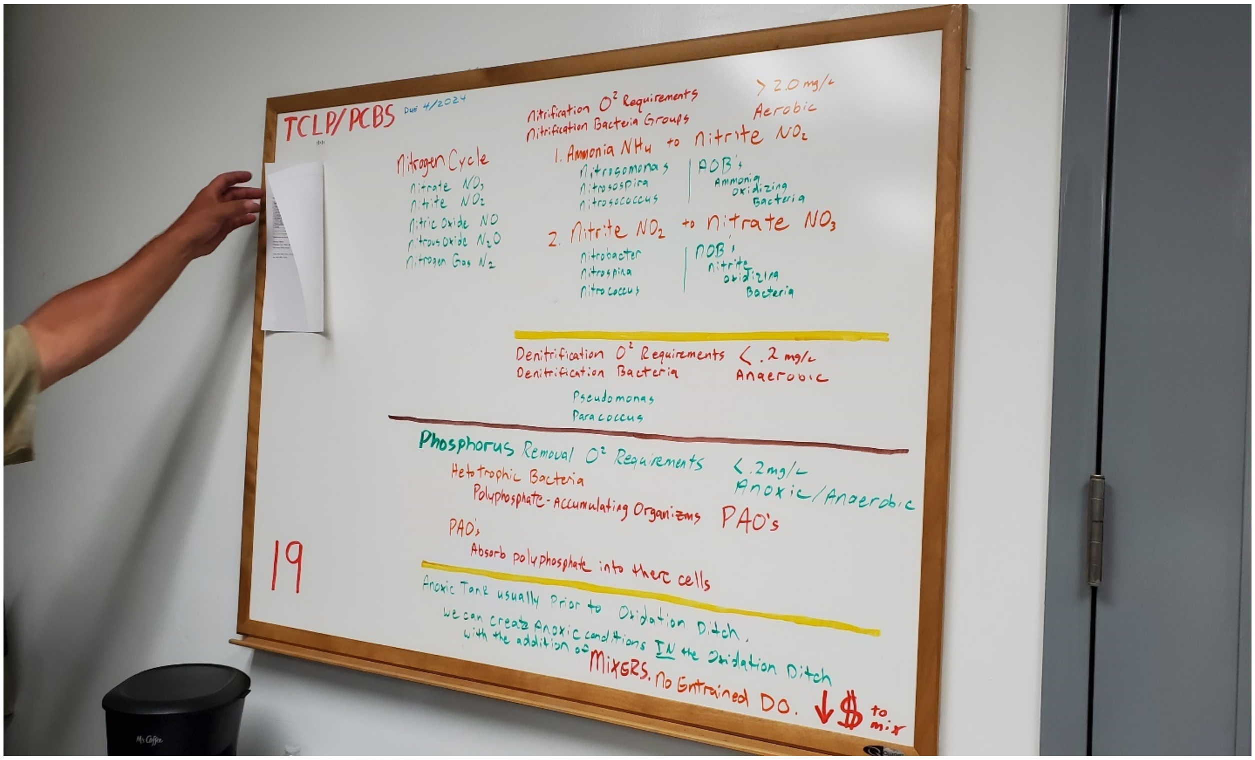
Nutrient Optimization

The Tennessee Association of Utility Districts (TAUD) assembled a team of experts to evaluate Harriman's wastewater treatment plant facilities and recommend changes in day-to-day operations to optimize nitrogen and phosphorus treatment. The team included TAUD's wastewater expert Dewayne Culpepper, TAUD's energy conservation specialist Michael Keeton, and wastewater optimization expert Grant Weaver of CleanWaterOps. The team had the full support of Harriman Utility Board (HUB) General Manager Candace Vannasdale, HUD operators Ray Freeman and Donnie Fitzhugh, and TDEC's Karina Bynum.



Grant Weaver of CleanWaterOps, HUB Ray Freeman and TDEC's Karina Bynum discuss the TNPOP program and the game plan.

In advance of a June 24, 2020, Harriman site visit involving the entire team, TAUD's Dewayne Culpepper visited on May 26, 2020, to gather historical operational data and compile information on Harriman's existing wastewater system. It soon became apparent that Chief Wastewater Operator, Ray Freeman, has effectively applied the knowledge gained from countless hours of studying a spectrum of reference materials to gain his Grade 4 certification. Ray's years of experience in the heavy civil construction industry building water and wastewater plants along with his experience operating numerous types of activated sludge plants and managing biological processes, reviewing the Tennessee Department of Environment and Conservation (TDEC) TNPOP (Tennessee Plant Optimization Program) Professional Training Materials, and consulting with others is apparent. Harriman's Lakeside Twin Oxidation Ditch treatment facility is uniquely operated to the benefit of the ratepayers it serves and the environment in which it exists.



After a delay due to COVID-19 and utilities stipulations, TAUD's first on-site visit was on May 26, 2020, by TAUD'S Dewayne Culpepper Wastewater Trainer to gather operation and system information. Prior to the visit starting April 27, all historical data was transferred and compiled on new State of Tennessee electronic monthly operating report (e-MOR) system, an energy assessment was completed, loaner laboratory analysis equipment and regents were provided, and training completed for analysis on several optimization parameters. This was accomplished with a total of three on-site visits.

On June 24, 2020, the Official TNPOP Harriman optimization initial visit was conducted on-site with Grant Weaver (CleanWaterOps), Karina Bynum (TDEC Cookeville), Tim Hill (Knoxville TDEC), Candace Vannasdale (HUD), Ray Freeman (HUD), Dewayne Culpepper (TAUD), and Michael Keeton (TAUD). During the meeting, all involved evaluated the TNPOP program procedures, goals, and the evaluation of process to develop optimization plan. Since the Harriman Wastewater Treatment plant had already optimized for total-nitrogen removal, it was agreed that the study would focus on total-phosphorus removal and energy optimization.

Throughout the study, constant communication was maintained with all parties involved and four on-site visits to review data, modify implemented monitoring plan and modify process control for total phosphorous optimization strategy with two major outcomes: (1) the total phosphorus was, during the study period, reduced from 2.5 mg/L to 1.3 mg/L and (2) TDEC approval for using the Emory River outfall was obtained. By using this outfall, Harriman will supplement the river with clean water while enjoying potential electrical savings of an additional $35,000 per year.

In summary, the TNPOP optimization program has so far shown successful improvements in constant total-phosphorus nutrient reduction, a years-long decline in electrical use, and potential energy savings promoting a more efficient operating plant and a high-quality, treated effluent to protect public health and for the environment to enjoy.

Emory River outfall. On November 13, 2020, TDEC's Karina Bynum called a virtual meeting with all parties involved on the permit renewal and the Harriman officials were given information on what should be provided in the permit renewal application to proceed on to incorporate the second Emory River outfall use in the new permit. After providing all information including TNPOP data with the permit renewal application and after negotiations, TDEC developed a draft permit for public comment on December 15, 2020.

On January 20, 2021, as a direct result of Harriman's ongoing studies submitted to the State of Tennessee, Harriman's dedicated operations personnel and the TNPOP program efforts, the State of Tennessee NPDES final permit was issued which included the use of two outfalls, Number 1 and Number 2. The number 2 outfall is a gravity flow outfall line and will have potential savings of up to $35,000.00 per year in energy cost resulting from the elimination of pumping treated effluent eight miles to the Tennessee River discharge site outfall number one.

Nitrogen Removal

At 2.1 mg/L (2020 average), Harriman's effluent total-nitrogen concentration is extremely low. So low as to negate the need – or opportunity – for optimization.

Phosphorus Removal

The first step in optimizing phosphorus removal involved the elimination of non-representative samples. Like most treatment facilities, Harriman's sludge handling and disposal practices impact the amount of phosphorus in the wastestream. By digesting/storing sludge for months and dewatering the accumulated sludge over the course of a few days almost certainly results in slugs of phosphorus during periods of dewatering. No attempt to quantify the impact was made however Harriman was advised to not collect phosphorus samples during such events as they are non-representative of Harriman's daily discharge of phosphorus. Ditto for sampling immediately following the decanting of the digesters as the decant is likely to contribute an unusual amount of phosphorus to the wastestream.

Historically, Harriman's effluent phosphorus has been low. At times, well below TDEC's 1.0 mg/L target. This being the case, to dial in phosphorus removal, the team sought (a) to identify why better removal at some times than others and (b) then develop strategies for minimizing the phosphorus spikes and maximizing the periods of low effluent phosphorus. Step 1 being the elimination of non-representative samples. Step 2 being data collection.

It was theorized that biological phosphorus removal was occurring in the oxidation ditches as follows. To "prove" the theory, a sampling regime was developed. The theory being this. During the long rotor-off cycles, a zero-oxygen zone of bacteria rich mixed liquor settle in the ditches. In these septic zones, volatile fatty acids (VFAs), the only food source that will energize phosphorus removal bacteria sufficiently to drive biological phosphorus removal, are formed and consumed by phosphorus removing bacteria. Then, during the rotor-on cycles when the oxygen concentration increases sufficiently, the energized bacteria reproduce and, as they do, pull phosphorus out of solution and concentrate the phosphorus in their cellular bodies.

To test this theory, the following testing protocols were developed.

> Collect samples of mixed liquor leaving the oxidation ditch. Allow the samples to settle and, using the loaner lab equipment, test for orthophosphate (soluble phosphorus). Repeat frequently enough to get an understanding of the impact of the rotors going on and off … and diurnal patterns. That is, see if and when the phosphorus leaving the ditch increases/decreases. And attempt to sleuth out why.
>
> At the same time that the orthophosphate samples are collected, perform a vertical profile of the ORP (oxygen reduction profile) in the ditch including readings at the bottom of the tank, 1-foot from the bottom, and 2-feet from the bottom. Ideally, readings at every foot all the way to the surface … with the understanding that could prove excessive. Not to mention burdensome.
>
> On three separate days, collect orthophosphate profiles as flow passes through the plant: influent, ditch outlet, final effluent, etc.

And, finally, confirm that the aeration basin pH always remains at or above 6.8.

Testing was performed in accordance with the protocols. The pH initially was found to be below the critical minimum of 6.8 on several occasions. Because alkalinity testing performed during the profile sampling demonstrated an alkalinity consistently above 100 mg/L through the treatment plant, the pH readings became suspect. HUD purchased a new pH probe. The pH was found to consistently be above 6.8. pH and sufficient to support biological phosphorus removal.

Testing demonstrated that environmental conditions (as measured by ORP) in the oxidation ditch blanket are routinely sufficient to create enough VFAs to energize the bacteria that remove phosphorus. And, given the low to non-existent sludge blankets in the secondary clarifiers, the issue of secondary phosphorus release could all but be eliminated. Meaning, the most likely cause of incomplete biological phosphorus removal is that the rotor-on conditions are somehow insufficient. Either (a) the bacteria aren't getting enough oxygen during the rotor-on cycles to support aerobic bacterial growth and/or (b) there is too little BOD in the ditch during the roto-on cycles to provide the building blocks for aerobic bacterial growth.

Two strategies were tried for increasing the oxygen level during the rotor-on cycles. One, the MLSS concentration, high because of inoperative dewatering equipment (repairs are underway as this report is being written), was reduced from 5000 to 3500 mg/L so that the oxygen demand is reduced and the one hour of rotor-on time will provide a bigger boost to the oxidation ditch dissolved oxygen (DO) concentration. Two, program one daily extended rotor-on cycle of three hours duration.

Harriman staff were asked to monitor conditions to determine how (if at all) the nightly extended aeration cycle affects effluent phosphorus and proceed accordingly. After two weeks of running in the mode no improvement was noted.

In conclusion, the TNPOP optimization program has so far shown successful improvements in constant TP nutrient reduction and potential energy savings promoting a more efficient operating plant and a wonderful, treated effluent to protect public health and for the environment to enjoy. Contract laboratory analysis recently conducted (April 22, 2021) on the effluent showed outstanding results for Total Nitrogen at 1.41 mg/L and Total Phosphorus at 1.01 mg/L Biological Total Phosphorus removal takes time. Once the sludge dewatering equipment updates and repairs are complete, this should allow for the plant process to be optimized to run at desired MLVSS and resulting in optimization of TP removal with results of <1.0 mg/L consistently.

The new NPDES permit will allow Harriman to utilize the number 2 outfall which saves up to $35,000.00 in energy cost. Data supporting Nutrient and Energy Optimization has been documented for this final report.

Energy Optimization

Twelve years of monthly utility billings are provided in the table that follows. It documents a remarkable decline in kilowatt-hours (KWH). Prior to 2017, Harriman's annual electrical usage averaged over 1,600,000 KWH/year. For the period 2018-2020, electrical usage declined by 28% to less than 1,200,000 KWH/yr with the 2020 usage totaling 845,000 KWH, approximately one-half the pre-2017 average. A marked drop in electrical demand also occurred in 2020. Prior to 2020, the KW demand averaged 371. In 2020 it was 20% less, 295 KW.

Annual billing totals		Consumption		Demand	
		$/year	KWH/year	$/year	avg KW
2009	$151,929	$102,726	1,586,575	$49,203	303
2010	$153,621	$93,970	1,605,280	$59,650	348
2011	$216,864	$134,674	1,882,140	$82,190	454
2012	$170,783	$110,992	1,620,520	$59,791	379
2013	$160,100	$103,448	1,511,300	$56,651	358
2014	$162,939	$106,670	1,503,680	$56,269	349
2015	$194,391	$126,680	1,859,280	$67,711	405
2016	$156,922	$94,247	1,360,170	$62,675	373
2017	$154,370	$93,026	1,311,910	$61,344	362
2018	$159,617	$94,141	1,322,070	$65,476	377
2019	$152,214	$86,411	1,182,370	$65,803	373
2020	$115,139	$65,260	845,820	$49,880	295

The largest electrical consuming devices at the Harriman wastewater treatment plant are:

Effluent Pumps – 3 @ 250 HP each
Aeration Rotors – 4 @ 50 HP each
Digester / Equalization Basin Blowers – 2 @ 50 HP each
Return Activated Sludge (RAS) Pumps – 4 @ 15 HP each
Waste Activated Sludge (WAS) Pumps – 2 @ 10 HP each
Sludge Pumps – 2 @ 3 HP each

An explanation of how the electrical savings were realized and opportunities for additional savings follow.

Harriman staff embraced a series of operational changes recommended by University of Tennessee's (Municipal Technical Advisory Service, MTAS) Brett Ward and University of Memphis' Larry Moore in 2016, supported by TDEC's John West in 2017, and the TAUD team in 2020. And went beyond the advisors' recommendations to create environmental habitats that provide improved biological treatment and substantial energy savings.

A discussion of year-to-year changes in the largest energy consuming pumps, motors, and blowers follows. 2021 and 2022 projections are included in the descriptions that follow.

Effluent pumps
(3 @ 250 HP each; fixed speed with soft-start, no VFD)

2015: 1 pump operates 10-11 hr per day 365 days per year
2016: 1 pump operates 10-11 hr per day 365 days per year
2017: 1 pump operates 10-11 hr per day 365 days per year
2018: 1 pump operates 10-11 hr per day 365 days per year
2019: 1 pump operates 10-11 hr per day 365 days per year
2020: 1 pump operates 10-11 hr per day 365 days per year
2021: 1 pump operates 10-11 hr per day 275 days per year
2022: 1 pump operates 10-11 hr per day 182.5 days per year

Note: In no small part due to the TAUD optimization study, TDEC has authorized Harriman to seasonally discharge treated wastewater to the Emory River that flows by the plant instead of pumping eleven miles to the Tennessee River. The gravity discharge to the Emory River discharge will become operational by the end of 2021.

Aeration rotors
(4 @ 50 HP each; fixed speed, no VFD, no soft-start)

2015: 4 aeration rotors 24/7
2016: 0.5 yr, 2 rotors on 1 hr, off 4 hr … 0.5 yr, 2 rotors on 1 hr, off 3 hr (1976 hr/yr per ditch)
2017: 0.5 yr, 2 rotors on 1 hr, off 4 hr … 0.5 yr, 2 rotors on 1 hr, off 3 hr
2018: 0.5 yr, 2 rotors on 1 hr, off 4 hr … 0.5 yr, 2 rotors on 1 hr, off 3 hr
2019: 0.5 yr, 2 rotors on 1 hr, off 4 hr … 0.5 yr, 2 rotors on 1 hr, off 3 hr
2020: 0.5 yr, 2 rotors on 1 hr, off 4 hr … 0.5 yr, 2 rotors on 1 hr, off 3 hr
2021: 0.5 yr, 2 rotors on 1 hr, off 4 hr … 0.5 yr, 2 rotors on 1 hr, off 3 hr
2022: 0.5 yr, 2 rotors on 1 hr, off 4 hr … 0.5 yr, 2 rotors on 1 hr, off 3 hr

Note: Prior to 2016, all four aeration rotors operated 24/7. Beginning 2016 after aeration rotors were cycled on and off … all four aeration rotors were turned on for a period of 4-5 hours weekly to resuspend settled materials in the oxidation ditch while sludge was wasted. Beginning 2020, this practice was only used occasionally as sludge was now being wasted through the drain lines in the oxidation ditches.

Aeration rotors (4 @ 50 HP each; fixed speed, no VFD, no soft-start)

Digester / Equalization basin blowers
(2 @ 50 HP each, no VFD, no soft-start)

2015: 1 blower operates 15.5 hr/day, 5 days per week and 24 hr/day 2 days per week
2016: 1 blower operates 15.5 hr/day, 5 days per week and 24 hr/day 2 days per week
2017: 1 blower operates 15.5 hr/day, 5 days per week and 24 hr/day 2 days per week
2018: 1 blower operates 6 hr/day, 7 days per week
2019: 1 blower operates 6 hr/day, 7 days per week
2020: 1 blower operates 6 hr/day, 7 days per week
2021: 1 blower operates 6 hr/day, 7 days per week
2022: 1 blower operates 6 hr/day, 7 days per week

Return Activated Sludge (RAS) pumps
(4 @ 15 HP each with VFDs)

2015: 2 pumps operate at 85% 24/7, 365 days per year
2016: 2 pumps operate at 85% 24/7, 365 days per year
2017: 2 pumps operate at 85% 24/7, 365 days per year
2018: 2 pumps operate at 85% 24/7, 365 days per year
2019: 2 pumps operate at 85% 24/7, 365 days per year
2020: 0.5 yr, 2 pumps operate at 85% 1.75 hrs on and 3.25 hrs off … 0.5 yr, 2 pumps operate at 85% 1.75 hrs on and 2.25 hrs off
2021: 0.5 yr, 2 pumps operate at 85% 1.75 hrs on and 3.25 hrs off … 0.5 yr, 2 pumps operate at 85% 1.75 hrs on and 2.25 hrs off
2022: 0.5 yr, 2 pumps operate at 85% 1.75 hrs on and 3.25 hrs off … 0.5 yr, 2 pumps operate at 85% 1.75 hrs on and 2.25 hrs off

Note: As discussed elsewhere in this report, Harriman operates the RAS pumps intermittently instead of continuously as is the industry practice. The current method of RAS pumping was initiated in 2020.

Waste Activated Sludge pumps
(2 @ 10 HP each, no VFD, no soft-start)

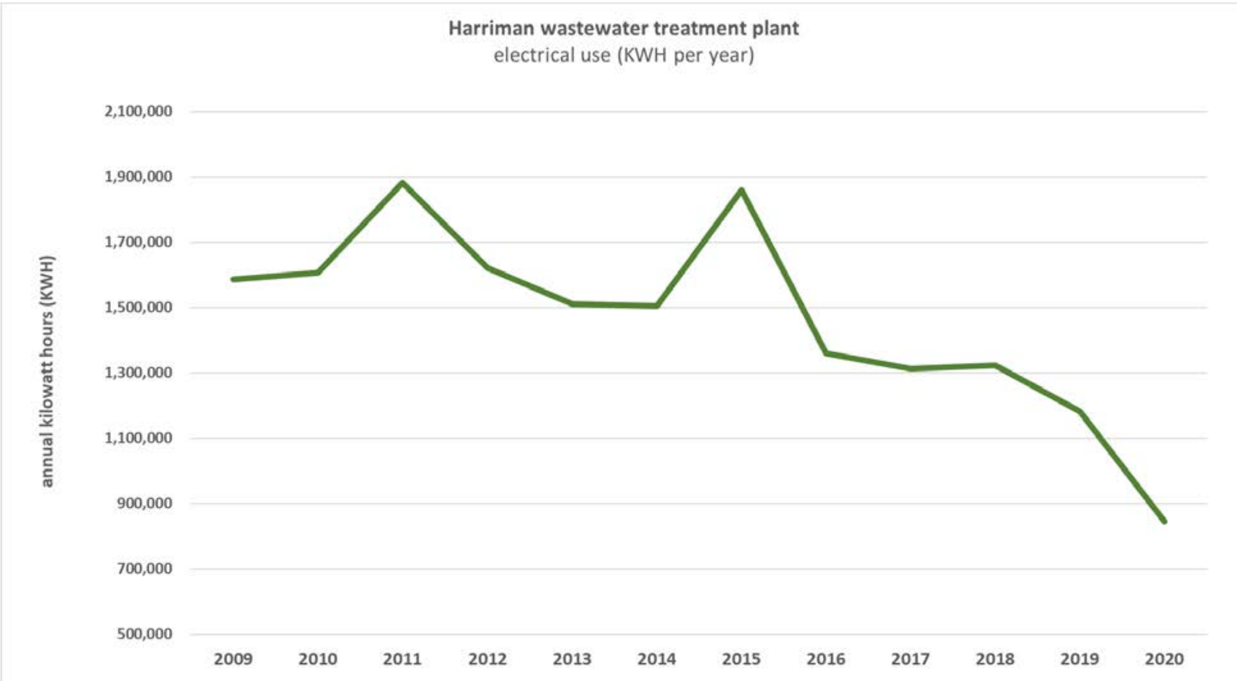
2015: 1 pump operates 4 hrs/wk
2016: 1 pump operates 4 hrs/wk
2017: 1 pump operates 4 hrs/wk
2018: 1 pump operates 4 hrs/wk
2019: 1 pump operates 4 hrs/wk
2020: 1 pump operates 4 hrs/wk
2021: 1 pump operates 4 hrs/wk
2022: 1 pump operates 4 hrs/wk

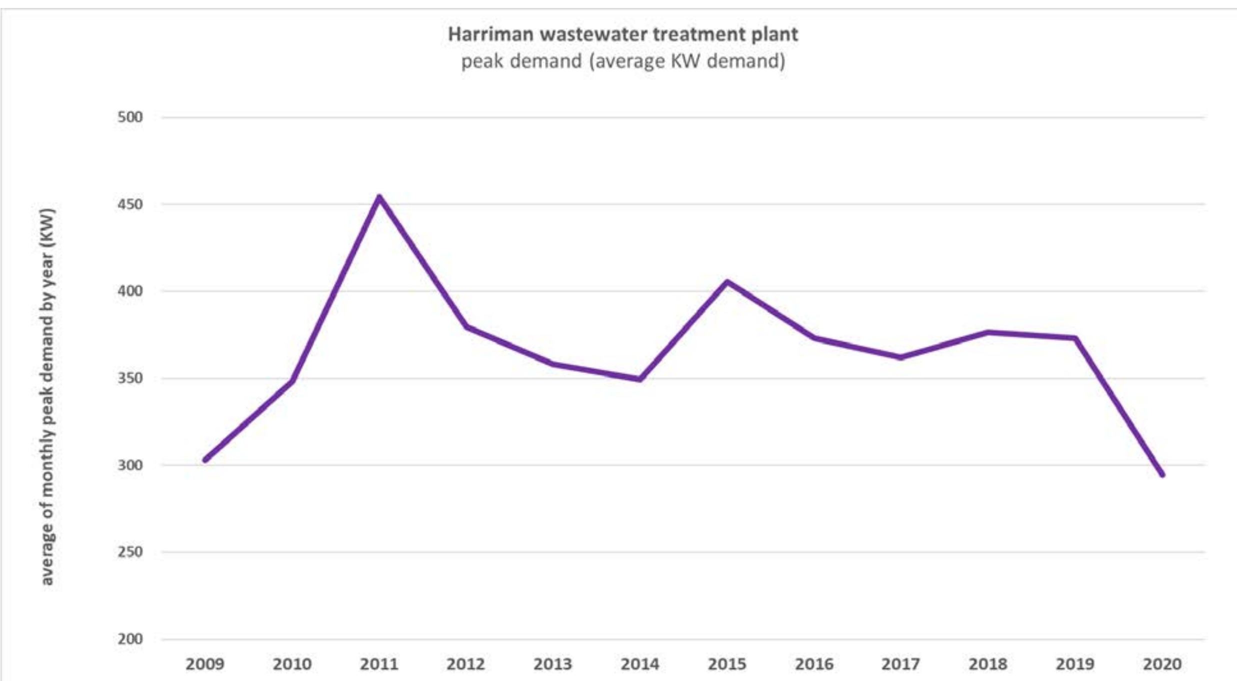
Note: Instead of wasting sludge from the clarifier as is traditionally done at wastewater treatment plants, sludge is instead wasted by opening drain lines in the oxidation ditches. This practice was initiated in 2020.

Sludge Pumps (to Gravity Belt Thickener)
(2 @ 3 HP each)

2015: 1 pump operates 40 hr/wk for 4 weeks twice per year
2016: 1 pump operates 40 hr/wk for 4 weeks twice per year
2017: 1 pump operates 40 hr/wk for 4 weeks twice per year
2018: 1 pump operates 40 hr/wk for 4 weeks twice per year
2019: 1 pump operates 40 hr/wk for 4 weeks twice per year
2020: 1 pump operates 40 hr/wk for 4 weeks twice per year
2021: 1 pump operates 40 hr/wk for 4 weeks twice per year
2022: 1 pump operates 40 hr/wk for 4 weeks twice per year

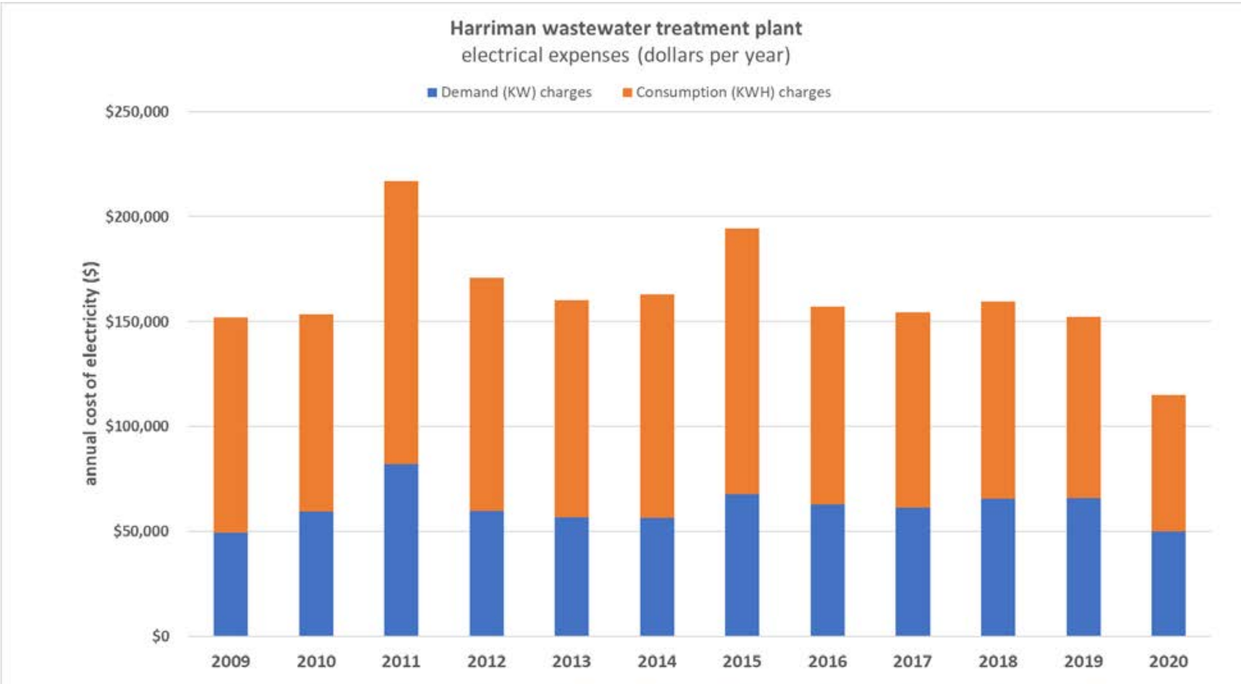
Graphs illustrating historical electrical use at the Harriman wastewater treatment plant follow. With an average daily flow of 1.07 MGD and an electrical usage of 845,820 KWH, the 2020 electrical use was 2166 KWH per million gallons of wastewater treated, a 41% improvement over 2017 (3705 KWH/MG; 1.311.910 KWH, 0.97 MGD).



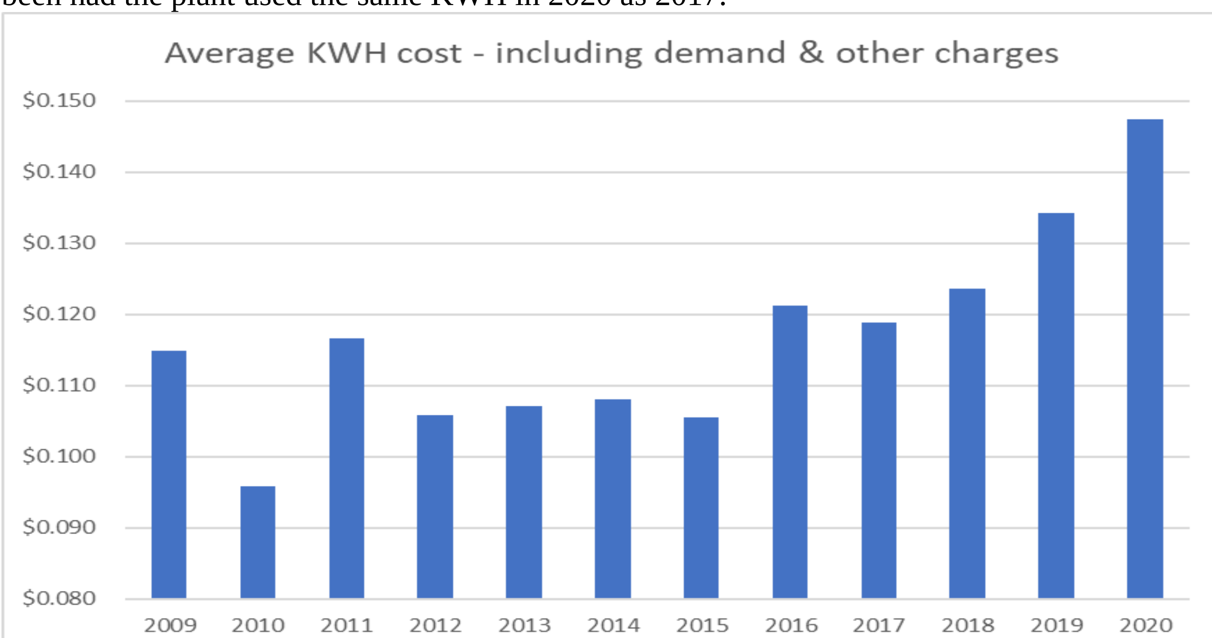


As shown below, Harriman's wastewater treatment plant's electric bill has been reduced by one-third (Graph 1: 2020 vs. 2017), an annual savings of $30,000 (2020 vs. 2015).

Graph 1: Annual cost of electricity



This reduction in electrical expenses was realized notwithstanding a twenty-five percent increase in electric rates (Graph 2: 2020 vs. 2017), *Graph 2: Average cost per KWH (including demand and other charges)*. Harriman's 2020 electrical expenses were $75,000 less than they would have been had the plant used the same KWH in 2020 as 2017.



Opportunities for additional electrical savings

By utilizing the gravity discharge to the Emory River for half the year, Harriman's electrical use is projected to decline by an additional 350,000 KWH per year, a 40% reduction in KWH from 2020 for anticipated additional annual savings of $35,000. Further reduction in power consumption could be realized with the addition of variable frequency drives (VFDs) on the rotor motors. Dissolved oxygen (DO) probes placed in the oxidation ditches and run through the plants SCADA (SCADA could use an update too) would automate the rotor on/off run times based on aerobic/anaerobic conditions desired.

Appendices

The following information is provided as Appendices to this report: nutrient data, discharge permit, electrical data, and progress reports.

Appendix 1: Water Quality Data

The following Data was compiled from Harriman's 2016 -2020 Monthly Operation Reports. All information from the Harriman's MOR's was transferred to Tennessee Water Resources Bulk EMOR system to generate the reports for this report.

Harriman, Tennessee

Influent	Flow (MGD)	BOD (mg/L)	TSS (mg/L)
2016	0.58	244	185
2017	0.97	191	133
2018	1.11	133	116
2019	1.09	118	117
2020	1.07	153	172

Effluent	Flow (MGD)	BOD (mg/L)	TSS (mg/L)	pH (su)	tN (mg/L)	tP (mg/L)
2016	0.58	4	6	6.7	18.6	3.0
2017	0.97	6	5	7.1	9.2	1.9
2018	1.11	6	4	7.0	5.0	0.7
2019	1.09	5	2	6.9	6.8	1.8
2020	1.07	4	2	7.0	2.1	1.4

Effluent		BOD (lb/d)	TSS (lb/d)		tN (lb/d)	tP (lb/d)
2016		19	27		89	14
2017		48	37		74	15
2018		53	40		46	7
2019		42	22		62	16
2020		40	19		19	13

Removal	BOD		TSS	
	(mg/L)	(percent)	(mg/L)	(percent)
2016	240	98%	179	97%
2017	185	97%	128	97%
2018	127	96%	112	96%
2019	114	96%	115	98%
2020	148	97%	170	99%

Appendix 2: Discharge Permit

Tennessee Water Resources Permit information site:

https://dataviewers.tdec.tn.gov/pls/enf_reports/f?p=9034:34051::::34051:P34051_PERMIT_NUMBER:TN0025437

Appendix 3: Electrical Use Data

Billing Info							
Billing Period		Pres Rdg Dt	Days Use	Reporting Revenue	% TOTAL $ for Usage	% TOTAL $ for Demand	$/day
2008-2021		Average		$13,512	62.1%	37.9%	$445.55
		Median		$13,417	61.9%	38.1%	$450.66
		Maximum		$32,834	100.0%	63.2%	$1,172.63
		Minimum		$5,748	36.8%	0.0%	$190.98
2009		Average		$12,661	66.5%	33.5%	$416.70
		Median		$11,632	63.6%	36.4%	$387.75
		Maximum		$18,492	100.0%	45.7%	$596.51
		Minimum		$9,462	54.3%	0.0%	$305.22
			2009 total:	$151,929	total bill		
2010		Average		$12,802	61.8%	38.2%	$411.12
		Median		$11,301	60.9%	39.1%	$365.80
		Maximum		$19,237	71.6%	47.1%	$641.22
		Minimum		$9,682	52.9%	28.4%	$302.55
			2010 total:	$153,621	total bill		
2011		Average		$18,072	62.6%	37.4%	$608.92
		Median		$17,262	62.7%	37.3%	$566.51
		Maximum		$32,834	72.3%	48.5%	$1,172.63
		Minimum		$9,807	51.5%	27.7%	$445.77
			2011 total:	$216,864	total bill		
2012		Average		$14,232	65.1%	34.9%	$468.59
		Median		$14,397	64.9%	35.1%	$472.06
		Maximum		$16,749	69.2%	38.7%	$545.61
		Minimum		$12,285	61.3%	30.8%	$399.16
			2012 total:	$170,783	total bill		

Billing Info							
Billing Period		Pres Rdg Dt	Days Use	Reporting Revenue	% TOTAL $ for Usage	% TOTAL $ for Demand	$/day
2013			Average	$13,342	64.7%	35.3%	$440.72
			Median	$13,986	65.6%	34.4%	$472.16
			Maximum	$21,081	71.7%	45.4%	$638.81
			Minimum	$8,242	54.6%	28.3%	$257.56
			2013 total:	$160,100	total bill		
2014			Average	$13,578	66.0%	34.0%	$448.82
			Median	$14,187	64.7%	35.3%	$489.10
			Maximum	$16,425	72.3%	39.2%	$566.37
			Minimum	$10,097	60.8%	27.7%	$318.85
			2014 total:	$162,939	total bill		
2015			Average	$16,199	64.9%	35.1%	$532.78
			Median	$15,926	64.3%	35.7%	$524.83
			Maximum	$19,680	70.8%	39.0%	$641.38
			Minimum	$13,925	61.0%	29.2%	$464.17
			2015 total:	$194,391	total bill		
2016			Average	$13,077	59.2%	40.8%	$431.46
			Median	$12,418	59.0%	41.0%	$402.33
			Maximum	$18,268	68.3%	50.0%	$571.28
			Minimum	$10,130	50.0%	31.7%	$337.67
			2016 total:	$156,922	total bill		

Billing Info							
Billing Period		Pres Rdg Dt	Days Use	Reporting Revenue	% TOTAL $ for Usage	% TOTAL $ for Demand	$/day
2017		Average		$12,864	60.1%	39.9%	$424.40
		Median		$12,577	60.4%	39.6%	$426.51
		Maximum		$16,056	64.3%	46.6%	$510.94
		Minimum		$10,320	53.4%	35.7%	$344.01
			2017 total:	$154,370	total bill		
2018		Average		$13,301	58.6%	41.4%	$439.82
		Median		$13,496	59.5%	40.5%	$443.99
		Maximum		$16,150	66.3%	52.3%	$533.10
		Minimum		$10,361	47.7%	33.7%	$318.55
			2018 total:	$159,617	total bill		
2019		Average		$12,684	55.8%	44.2%	$416.14
		Median		$11,687	56.2%	43.8%	$379.45
		Maximum		$17,762	64.5%	53.8%	$634.37
		Minimum		$9,076	46.2%	35.5%	$302.54
			2019 total:	$152,214	total bill		
2020		Average		$9,595	56.2%	43.8%	$315.52
		Median		$9,758	58.9%	41.1%	$326.20
		Maximum		$14,595	62.2%	63.2%	$456.10
		Minimum		$5,748	36.8%	37.8%	$190.98
			2020 total:	$115,139	total bill		

Consumption			
Usage	Reading Usage	Use Revenue	$/KWH
122,147	122,147	$8,463	$0.070
121,920	121,920	$8,254	$0.070
215,900	215,900	$19,271	$0.116
35,560	35,560	$3,228	$0.047
132,215	132,215	$8,560	$0.063
124,460	124,460	$7,943	$0.061
179,000	179,000	$17,359	$0.097
96,520	96,520	$5,553	$0.051
$102,726	consumption (KWH)		
133,773	133,773	$7,831	$0.059
122,555	122,555	$7,300	$0.060
196,850	196,850	$11,813	$0.070
104,140	104,140	$6,115	$0.047
$93,970	consumption (KWH)		
156,845	156,845	$11,223	$0.072
156,210	156,210	$11,302	$0.069
215,900	215,900	$19,271	$0.116
80,010	80,010	$5,657	$0.061
$134,674	consumption (KWH)		
135,043	135,043	$9,249	$0.069
132,080	132,080	$9,383	$0.069
161,290	161,290	$11,165	$0.073
110,490	110,490	$7,994	$0.063
$110,992	consumption (KWH)		

Consumption			
Usage	Reading Usage	Use Revenue	$/KWH
125,942	125,942	$8,621	$0.069
120,650	120,650	$8,377	$0.069
196,850	196,850	$13,443	$0.073
78,740	78,740	$5,407	$0.065
$103,448	consumption (KWH)		
125,307	125,307	$8,889	$0.071
130,175	130,175	$8,890	$0.071
156,210	156,210	$10,469	$0.076
91,440	91,440	$6,984	$0.065
$106,670	consumption (KWH)		
154,940	154,940	$10,557	$0.068
145,415	145,415	$10,021	$0.068
203,200	203,200	$13,364	$0.072
120,650	120,650	$8,488	$0.065
$126,680	consumption (KWH)		
113,348	113,348	$7,854	$0.071
104,140	104,140	$7,522	$0.072
190,500	190,500	$12,429	$0.080
67,310	67,310	$5,270	$0.063
$94,247	consumption (KWH)		

Consumption			
Usage	Reading Usage	Use Revenue	$/KWH
109,326	109,326	$7,752	$0.071
107,950	107,950	$7,584	$0.070
147,320	147,320	$10,328	$0.077
78,740	78,740	$5,529	$0.067
$93,026	consumption (KWH)		
110,173	110,173	$7,845	$0.072
118,745	118,745	$8,198	$0.072
146,050	146,050	$9,919	$0.078
72,390	72,390	$5,626	$0.068
$94,141	consumption (KWH)		
98,531	98,531	$7,201	$0.074
88,900	88,900	$6,572	$0.076
160,020	160,020	$11,202	$0.079
53,340	53,340	$4,190	$0.069
$86,411	consumption (KWH)		
70,485	70,485	$5,438	$0.080
56,515	56,515	$4,609	$0.082
125,730	125,730	$9,074	$0.091
35,560	35,560	$3,228	$0.070
$65,260	consumption (KWH)		

Demand							
Demand Rdg	Reading KW	$/KW read	Billing Dmd	Billed KW	Billed minus	Demand Revenue	$/KW billed
0.29	359.6	$13.84	1254	360.6	1.00	$5,049	$13.79
0.29	368.3	$13.94	1270	368.3	0	$5,176	$13.93
0.54	685.8	$31.41	1270	685.8	20.96	$13,563	$31.41
0	0	$0.00	0	0	0	$0	$0.00
0.25	303.1	$12.41	1131	303.1	0.00	$4,100	$12.41
0.24	304.8	$13.15	1270	304.8	0	$4,008	$13.15
0.48	480	$14.15	1270	480	0.00	$6,764	$14.15
0.00	0	$0.00	0	0	0	$0	$0.00
$49,203	demand (KW)						
0.27	348.2	$14.07	1270	348.2	0.00	$4,971	$14.07
0.27	336.55	$14.19	1270	336.55	0	$4,777	$14.19
0.39	495.3	$14.99	1270	495.3	0.00	$7,423	$14.99
0.17	215.9	$12.81	1270	215.9	0	$2,766	$12.81
$59,650	demand (KW)						
0.36	454.0	$15.01	1270	454.0	0.00	$6,849	$15.01
0.35	438.15	$13.42	1270	438.15	0	$6,080	$13.42
0.54	685.8	$31.41	1270	685.8	0.00	$13,563	$31.41
0.25	317.5	$12.24	1270	317.5	0	$3,887	$12.24
$82,190	demand (KW)						
0.30	378.9	$13.14	1270	379.4	0.53	$4,983	$13.12
0.29	368.3	$13.09	1270	368.3	0	$4,845	$13.09
0.35	444.5	$13.74	1270	444.5	6.35	$5,921	$13.74
0.24	304.8	$12.55	1270	304.8	0	$3,825	$12.55
$59,791	demand (KW)						

Demand							
Demand Rdg	Reading KW	$/KW read	Billing Dmd	Billed KW	Billed minus	Demand Revenue	$/KW billed
0.28	357.7	$13.04	1270	358.2	0.48	$4,721	$13.03
0.31	387.35	$13.07	1270	387.35	0	$5,064	$13.07
0.44	558.8	$14.08	1270	558.8	5.72	$7,637	$14.03
0.18	228.6	$11.92	1270	228.6	0	$2,725	$11.92
$56,651	demand (KW)						
0.28	349.3	$13.27	1270	349.3	0.00	$4,689	$13.27
0.30	374.65	$13.65	1270	374.65	0	$5,234	$13.65
0.35	444.5	$14.15	1270	444.5	0.00	$6,119	$14.15
0.19	241.3	$12.10	1270	241.3	0	$2,919	$12.10
$56,269	demand (KW)						
0.32	405.3	$13.92	1270	405.3	0.00	$5,643	$13.92
0.31	393.7	$13.81	1270	393.7	0	$5,483	$13.81
0.36	457.2	$14.46	1270	457.2	0.00	$6,316	$14.46
0.29	368.3	$13.40	1270	368.3	0	$4,937	$13.40
$67,711	demand (KW)						
0.29	370.4	$14.11	1270	372.9	2.49	$5,223	$14.01
0.30	374.65	$13.95	1270	379.413	1.5875	$5,252	$13.94
0.33	419.1	$14.87	1270	419.1	9.52	$5,853	$14.65
0.26	330.2	$13.62	1270	334.645	0	$4,574	$13.60
$62,675	demand (KW)						

Demand							
Demand Rdg	Reading KW	$/KW read	Billing Dmd	Billed KW	Billed minus	Demand Revenue	$/KW billed
0.28	355.6	$14.41	1270	361.8	6.24	$5,112	$14.13
0.28	355.6	$14.23	1270	361.633	3.4925	$5,097	$14.13
0.33	419.1	$15.33	1270	421.005	20.96	$5,962	$14.48
0.21	266.7	$13.94	1270	269.875	0	$3,742	$13.87
$61,344	demand (KW)						
0.30	375.7	$14.52	1270	376.6	0.90	$5,456	$14.48
0.30	374.65	$14.57	1270	374.65	0	$5,298	$14.54
0.34	431.8	$15.02	1270	431.8	6.35	$6,368	$15.02
0.24	304.8	$14.03	1270	304.8	0	$4,405	$14.03
$65,476	demand (KW)						
0.29	372.5	$14.72	1270	373.0	0.42	$5,484	$14.70
0.27	342.9	$14.72	1270	344.17	0	$5,176	$14.72
0.36	457.2	$15.09	1270	457.2	2.54	$6,792	$15.09
0.27	342.9	$14.25	1270	342.9	0	$4,886	$14.25
$65,803	demand (KW)						
0.23	293.2	$13.93	1270	294.5	1.38	$4,157	$13.88
0.26	323.85	$14.16	1270	325.12	0	$4,589	$14.10
0.30	381	$15.35	1270	381	11.43	$5,849	$15.35
0.15	190.5	$12.30	1270	190.5	0	$2,344	$12.30
$49,880	demand (KW)						

Appendix 4: TAUD Progress Reports

The following information is a day-to-day activity report to document progress of the TNPOP program efforts.

Harriman Utility Board TNPOP Project Progress Report Summary

The Harriman Utility Board General Manager, Candace Vannasdale, Board and Wastewater Treatment Plant Chief Operator, Ray Freeman, and Donnie Fitzhugh are fully engaged in optimizing the Harriman Utility Board's Wastewater Treatment Plant for both, nutrient, and energy optimization. The Chief Wastewater Operator, Mr. Freeman, is applying the knowledge gained from countless hours of studying a spectrum of reference materials to gain his Grade 4 certification, experience of operating and managing biological processes, reviewing the TNPOP Professional Training Materials, and consulting with Grant Weaver with CleanWaterOps and Tennessee of Association of Utility Districts (TAUD) staff to operate the Lakeside Twin Oxidation Ditch for optimization of nutrient removal and energy savings .

After a delayed due to COVID-19 and utilities stipulations, TAUD's first on-site visit was on May 26th, 2020, by TAUD'S Dewayne Culpepper Wastewater Trainer to gather operation and system information. Prior to the visit starting April 27, all historical data was transferred and compiled on new State of Tennessee electronic e-MOR, Energy assessment was completed, laboratory analysis equipment and regents were provided, and training completed for analysis on several optimization parameters. This was accomplished with a total of 3 on-site visits.

On June 24th, the Official TNPOP Harriman optimization initial visit was conducted on-site with Grant Weaver, Karina Bynum, Tim Hill (Knoxville TDEC), Candace Vannasdale, Ray Freeman, Dewayne Culpepper, and Michael Keeton. During the meeting, all involved evaluated the TNPOP program procedures, goals, and the evaluation of process to develop optimization plan. Since the Harriman Wastewater Treatment plant had already optimized for Total Nitrogen removal, the emphasis would be on Total Phosphorous and Energy optimization.

Since July 7th, there has been constant communication with all parties involved and 4 on site visits to review data, modify implemented monitoring plan and modify process control for total phosphorous optimization strategy. The total phosphorus has been reduced from 2.5 mg/L to 1.30. Also, contacted Karina regarding using the Emory River out fall. Using this outfall will have up to $35,000 in potential energy savings.

November 13th, Karina called a virtual meeting with all parties involved on the permit renewal and the Harriman officials was given information on what should be provided in the permit renewal application to proceed on to incorporate the 2nd outfall use in the new permit. After providing all information including TNPOP data with the permit renewal application and after negotiations, the State of Tennessee developed a draft permit for public comment on December 15th, 2020.

On January 20, 2021, as a direct result of Harriman's ongoing studies submitted to the state of Tennessee, Harriman's dedicated operations personnel and the TNPOP program efforts, The State of Tennessee NPDES final permit was issued which included the use of two out falls, Number I and Number 2. The number 2 outfall is a gravity flow out fall line and will have potential savings of up to $35,000.00 per year in energy cost resulting from the elimination of pumping treated effluent 10 miles to the Tennessee River discharge site outfall number one.

In conclusion, the TNPOP optimization program has so far shown successful improvements in constant TP nutrient reduction and potential energy savings promoting a more efficient operating plant and a wonderful, treated effluent to protect public health and for the environment to enjoy. Contract laboratory analysis recently conducted (April 22, 2021) on the effluent showed outstanding results for Total Nitrogen at 1.41 mg/L and Total Phosphorus at 1.01 mg/L. The new NPDES permit will allow Harriman to utilize the number 2 outfall which saves up to $35,000.00 in energy cost. Data supporting Nutrient and Energy Optimization has been documented for final reports.

TNPOP Program Progress Report -Harriman Utility Board

Utility Information

Harriman Utility Board
General Manager: Candace Vannasdale
P.O. Box 434 (Mailing Address)
300 N. Roane Street (Main Office)
101 Margrave (Shipping Address)
Harriman TN 37748
(865) 882-3242
cvannasdale@hub-tn.com
www.hub-tn.com

WWTP Operator Information:

Ray Freeman
Chief Plant Operator
Grade IV Certification
Harriman Utility Board
rfreeman@hub-tn.com
865-321-3557 cell
865-882-3242 x 263 office

Donnie Fitzhugh
Operations Specialist
Grade III Certification
865-389-4537
dfitzhugh@hub-tn.com

WWTP Plant Information

Harriman WWTP – Permit #TN0025437
2400 Wastewater Customers.
85 miles of sewer collection lines.

The City of Harriman is authorized to discharge Treated municipal wastewater from Outfall 001 to the Tennessee River at mile 567. Discharge 001 consists of municipal wastewater from a treatment facility with a design capacity of 1.5 MGD. The Permit is attached that shows all permit required parameters, monitoring frequencies, and limits.

Tennessee Water Resources Permit information site:

https://dataviewers.tdec.tn.gov/pls/enf_reports/f?p=9034:34051::::34051:P34051_PERMIT_NUMBER:TN0025437

The WWTP plant's physical address is:

504 Bullard Ford Rd
Harriman, TN 27748
35.940646, -84.535444

Wastewater Treatment Plant characteristics
Twin Oxidation Ditches with a total design capacity of 1.5 MGD.
Each Ditch has a volume of 0.6 MG
Each Ditch has two 50 hp rotary aerators and each ditch has one clarifier.
Each Clarifier has a volume of 0.185 MG
Average Year-round Influent flow: 1.0 MGD
WAS 37540 gallons twice / month
Based on 2020 annual average daily flow of 1.10 MGD and 7-day Average Daily Dry Weather Flow of 0.36, the average daily influent percent I/I flow is 66.9%.
Average 2019 -2020 winter wastewater parameters (November – April):
Average Influent Flow: 1.57 MGD ; Max flow: 4.15 MGD
Influent BOD: 83.29 mg/L; Effluent BOD: 4.5 mg/L
Influent TSS : 74.50 mg/L ; Effluent TSS : 2.10 mg/L
Influent pH ; 6.77 s.u.; Effluent pH ; 7.02 s.u.
Average 2019 summer wastewater parameters (May – October):
Average Influent flow: 0.74 MGD; Max flow: 3.23 MGD; Min flow: 0.35 MGD
Influent BOD: 153 mg/L; Effluent BOD: 4.64 mg/L
Influent TSS : 149 mg/L ; Effluent TSS : 2.39 mg/L
Influent pH ; 6.78 s.u.; Effluent pH ; 7.17 s.u.
Operating Process Control Parameters:
Average MLSS: 4800
Volatile Solids Content : 65%
Average MLVSS : 3120
Average F/M: 0.03
Average SVI 68.0
MCRT 28 – 30 DAYS
Influent Alkalinity > 150 & Effluent Alkalinity >100

Harriman TNPOP/TAUD Summary Report of Activities to Date
(Detailed Observations, Recommendations and Comments Follows this report)

April 27 – TNPOP - Home Office- State contract TPOP Harriman, transferring historical data (2018 - 2020) to bulk eMOR.

April 28 - TNPOP - Home Office- State contract TPOP Harriman, transferring historical data (2018 - 2020) to bulk e MOR.

April 29 - State optimization contract TNPOP - Harriman data entry to Bulk EMOR System

May 18 - Researching and gathering reagents, laboratory supplies and analytical test strips for TNPOP Wastewater analysis

May 19 - Working with TNPOP eMOR info for Harriman, Building TNPOP Lab Reagent list with Grant Weaver for USA Blue Book order.

May 20 - Modified TNPOP REAGENT Order List. Sent to Brent. Reviewed method procedures for each reagent

May 22 - State Score Card Review, State Contract Meeting, Review of State lab equipment and reagent order to conduct testing. Reviewed testing methods.

May 26 - Travel to Harriman. On- site visit - State optimization contract TNPOP - Harriman, TNPOP review with Harriman Staff and Management

May 27 - Coordinating with TDEC on lab equipment pick up and working with Ariel on Harriman Emor

May 29 - TNPOP - Coordinating agendas with Grant Weaver, Harriman, Cowan and Karina Bynum - TDEC for the month of June on- site visits

June 1 - TNPOP EQUIPMENT EVALUATION, CALIBRATION. REVIEWING TNPOP TRAINING MODULES

June 3 - Travel to Knoxville TDEC office, picked up TNPOP Equipment at Knoxville TDEC Office for Harriman, Travel to Harriman for On-site visit for TNPOP LAB EQUIPMENT and Chemistries delivery, set up and training. Provided EMOR Training

June 4 - Home Office - reviewing TNPOP Program, contract and Grant Weaver past TNPOP reports. Emailed Grant, Harriman and Cowan agendas for June on-site meetings. Booked Rooms

June 8 - State Optimization Contract - TNPOP update report sent to Karina and prep for TNPOP Visits to Cowan and Harriman

June 9 - Travel to Harriman WWTP, On-site Lab training and SRF WEBX meeting. Energy Audit performed

June 22 - State Contract- TNPOP, Training Received from Training Modules, Emailed All TNPOP participants on upcoming on-site visits

June 24 - State Contract - TNPOP - State contract TPOP Harriman, On-site Initial Visit with Grant Weaver, Karina, TDEC, Harriman Management for evaluation of process and to develop optimization plan

June 29 – Received Grant Weaver's email concerning Initial on-site report of observations and initial recommendations for developing the process sampling and monitoring plan and nutrient optimization strategy.

July 1 – Conducted conference call with Grant Weaver, Michael Keeton and Dewayne Culpepper reviewing Grant Weavers initial on-site report.

July 7 – On-site visit to review and implement monitoring plan and nutrient optimization strategy. Conference call with Grant on results from initial monitoring plan and Grant revised a new monitoring plan and nutrient optimization strategy. Also, contacted Karina regarding using the Emory river out fall. Permit writer wanted river monitoring performed every 2 hours. USGS station only give a 24-hour flow report.

July 14 - Karina consulted with TDEC permit writer and negotiate some resolve. Contacted Ray and reviewed plant data and discussed the information from Karina concerning the progress on Emory river out fall.

July 17 - Ray emailed Grant with process data results from the 07/07/2020 recommended adjustments (See attached reports TNPOP 7/13, TNPOP 7/14 and TNPOP 7/15). Grant followed up with comments and recommendations. Ray also informed Grant that we are experiencing extremely low flows (.34mgd - .36mgd). We are growing algae in the clarifiers (apparent in the TSS) and water fleas are proliferating. Clarifier temps are 24.5.

July 28 – On-site Visit to deliver HACH TNT Phosphorus reagents, ORP storage solution and to review process control data. Performed Total alkalinity test and Ph on influent and effluent. Influent alkalinity was >150 and effluent was > 100. Ordered new Ph probe. We had a conference call with Grant Discussing options concerning the low ph of the MLSS in the ditches. See statements in detailed observations section.

August 10 – After using new probe, Ray sent the following information out by email.

Good morning gentlemen,

Happy to report that we are consistently in the 7.3 – 7.4 range for PH. Can't say for sure whether the change is from an increase in flow (which has cleared up our algae issues too), the reduction in MLSS (in the low 4000's now), or the replacement of our PH probe to the HACH Mr. Culpepper recommended. I'm betting the probe is about 99.99% though. I'm hoping to have my MLSS down to 3500 by the end of this week. So…

Let's get this show on the road. Grant, how would you like me to proceed?

Ray Freeman

August 11 – Conference call between Ray, Grant and Dewayne. Developed new plan for bio-P plan of action. See details in detailed observations section.

August 31 – Called Grant and Ray discussing data and process changes.

September 10 – On site visit reviewing process and lab results. Total Nitrogen = 1.2, (Total, Nitrites = <.1 Nitrates = <1.0 used test strips) Phosphorous= 2.5, Effluent Total ALK = >150. Plant process is maturing since last process update with rotor timers on 09/02/2020

September 25 – Called Ray and discussed plant process and laboratory analysis. TP and TN was affected by heavy dewatering of digested sludge and belt pressing of biosolids. Also set up date to visit on-site on October 1st .

September 26- Called Grant to let him know the status of the plant operations and TP and TN. Grant agreed that the dewatering of sludge had an impact TN and TP removal rates and to keep the plant running as planned to see if the TP and TN removal improves.

October 1 – On site visit, Reviewing TP data and plant process.

October 14 – Correspondence with emails with Grant, Ray concerning TP data and process.

October 19 – On site visit - Reviewing TP data and plant process.

November 5 – After test results from third party were received, the results were 3 times lower than the in-house TP results for October. We looked at the DR 2800 and the TP results were in the wrong form. The DR2800 went into default mode after a power loss in late September. The reporting TP form should be corrected from PO3/4 to PO3/4-P. After correction, the average TP is 1.23 - 1.36! We are going in the right direction! Emailed Karina the good news.

November 6 – Submitted a progress report and summary report to Brent and Karina.

November 10 – TDEC SRF State Contract Virtual Meeting – Score card and TNPOP reports

November 10 – Called Karina concerning Harriman's TP analysis and during the call the subject of use of the 2nd outfall came up for energy optimization. I Told Karina that Harriman was in process of the renewal of the NPDES permit and would like to get direction on how to include it with the application. Karina said she would contact the permit writers and see what needs to me done.

November 13 – Karina called a virtual meeting with all parties involved on the permit renewal and the Harriman officials was given information on what should be provided in the permit renewal application to proceed on to incorporate the 2nd outfall use in the new permit. The following was the results of the meeting:

Harriman needs apply to revoke and re-issue their permit. They need to send this request with their application to Jim McAdoo and copy Wade Murphy. The application needs to include Outfall 002. For flow monitoring of the River, Harriman needs to propose a draft standard operating procedure how will they assure that the plant does not discharge to Outfall 002 when the River flow is below 200 cfs. The procedure will be finalized after a year of operation. Also, Harriman needs to include River gage record each month with their eMOR when they start using Outfall 002. Application is due by the end of November. All were in agreement and Thankful!

November 13 - Ray Freeman sent out the TP results for the week of 11/09/2020 as follows:
9th - 1.03 mg/l, 10th - 1.12 mg/l, 11th - 1.18 mg/l, 12th - 1.16 mg/l, 13th - 0.98 mg/l. Great Job!

December 2 – On site visit. Reviewed TP data and Process control. Also discussed new NPDES permit renewal negotiations, including utilizing Out Fall 002.

December 7 – Ray Freeman sent out the TP results for the week of 11/30/2020 as follows:
11-30 1.03
12-1 1.11
12-2 1.15
12-3 1.28
12-4 1.21

December 11 – Wade Murphy sent Draft NPDES Permit to be reviewed before sending to public comment.

December 14 - Ray Freeman sent out the TP results for the week of 12/07/2020 as follows:
Phosphorus for week of 12-7 thru 12-11.
12-7 1.36
12-8 1.33
12-9 1.47
12-10 1.42
12-11 1.41

December 15 – The Draft NPDES Permit with outfall # included goes out to public comment.

December 16 – Reviewed proposed Harriman draft NPDES permit and submitted commits to Wade **Murphy**.

December 16 through 17 – updating Harriman bulk eMOR with new data for final reports, updating TNPOP progress reports.

December 29 – TP results:
Here are some numbers for you for 12-14 thru 12-18 2020.
12-14 1.37
12-15 1.42
12-16 1.46
12-17 1.42
12-18 1.45
Have a great new year…Ray.

January 8, 2021 – Virtual meeting with Karina, Grant Weaver and Dewayne Culpepper to discuss TNPOP Program final reports and recommendations.

January 11, 2021 – Updating bulk EMOR data to prepare submit to Grant Weaver for TNPOP final report. Updated progress reports.

January 20, 2021 – As a Direct result of the TNPOP program efforts, The State of Tennessee NPDES final permit was issued which included the use of two out falls, Number I and Number 2. The number 2 outfall is a gravity flow out fall line and will have potential savings of up to $35,000.00 per year in energy cost resulting from the elimination of pumping treated effluent 10 miles to the Tennessee River discharge site.

January 22, 2021 – Virtual meeting with Karina, Grant Weaver, Micheal Keeton and Dewayne Culpepper to discuss TNPOP Program final reports for energy optimization.

February 26, 2021 - Virtual meeting with Karina, Grant Weaver, Micheal Keeton and Dewayne Culpepper to discuss TNPOP Program final reports for energy optimization.

March 12, 2021 - Virtual meeting with Karina, Grant Weaver, Micheal Keeton and Dewayne Culpepper to discuss TNPOP Program final reports for energy optimization.

March 26, 2021 - Virtual meeting with Karina, Grant Weaver, Micheal Keeton and Dewayne Culpepper to discuss TNPOP Program final reports for energy optimization.

April 23, 2021 - Virtual meeting with Karina, Grant Weaver, Micheal Keeton, Brent Ogles and Dewayne Culpepper to discuss TNPOP Program final reports for energy optimization.

May 26, 2021 – Grant Weaver emailed out Harriman's Draft electrical savings report for display and comments. Brett and Ray commented.

June 4, 2021 - Grant Weaver emailed out Harriman's Draft Final Report for comments.

June 7 – June 9, 2021 – Comments on Grants Final report were submitted from Ray, Karina, Brett, and myself for several days.

June 9, 2021 – Contacted Ray Freeman and he updated me on effluent TN and TP quarterly results.
Harriman's contract lab results for the 1st quarter of 2021 are as follows:
Total Nitrogen 1.38 mg/L
Total Phosphorus 1.41 mg/L
The test were analyzed in early January 2021.

Harriman's contract lab results for the 2nd quarter of 2021 are as follows:
Total Nitrogen 1.41 mg/L
Total Phosphorus 1.01 mg/L
The test were analyzed April 22, 2021.

Detailed Observations, Recommendations and Comments

Report of the Harriman's Initial Visit on 06/24/2020 with Grant Weavers Observations and Initial Recommendations

With an effluent total-N concentration of 2 mg/L, Harriman is doing an awesome job removing nitrogen! No way can we improve on that!

Phosphorus removal is good to excellent.
But inconsistent.
We should be able to figure why it is sometimes better than other times.
And give Ray Freeman the tools he needs to make phosphorus removal consistently excellent.

When at the plant last week, Dewayne, you found that the mixed liquor settles sufficiently during the air-off cycling of the rotors to create one or more anaerobic zones in the bottom of the ditches.
Presumably, VFAs are formed and consumed by PAOs in the settled sludge.
And, during aeration, enough of the PAOs are resuspended to biologically remove phosphorus.

We didn't discuss this while at the plant, but I believe that we should attempt to quantify the phosphorus inputs.
My thinking being … it should be possible to operate the facility to produce a low effluent phosphorus during routine operations but may not be possible to do so when "shock loads" are added.
Further … if digester supernate is a significant source of phosphorus, one solution may be to supernate more routinely so that the daily input is consistent.
And, to build up the PAO population to accommodate the additional load.
(The PAOs don't respond to sudden spikes of phosphorus but they can often be "trained" to deal with a higher than otherwise normal load, if that makes sense.)

To understand the inputs, I'd like to quantify how many pounds of phosphorus are contained in each of the following:
a. influent
b. digester supernate
c. belt filter pressate

To understand the phosphorus release and phosphorus uptake that is now occurring with the one of two rotors cycling on for one hour and off for two hours followed by the other rotor cycling on for one hour and off for two hours …
I'd like to get hourly orthophosphate testing done on the supernate from mixed liquor samples collected at the railing before the effluent box.
And, have the testing repeated such that it done on three separate days.

At the same time that the ortho-P samples are collected, I'd like to have a vertical profile of the ORP in the ditch.
Including readings at the bottom of the tank, 1-foot from the bottom, and 2-feet from the bottom.
Ideally, readings at every foot all the way to the surface … but, I realize, that is asking a lot.

pH may be an issue as PAOs quit removing phosphorus (per my experience) at 6.8.
Something we need to keep in mind.

Later, I'd like to have some ortho-P profiles performed through the plant.
That is, influent, ditch outlet, final effluent.
There may be some release of ortho-P in the clarifiers … but, given Ray's practice of near zero blankets, there shouldn't be … nonetheless, something to check.

… … … … … …

Here's what I suspect we'll find.
Decanting supernate from the top of the digester will need to be done more routinely; perhaps daily.
And, if so, we'll want to work with Ray on ideas on how to automate or simplify the task.
And, as long as pH isn't an issue, we'll be able to make effluent total-phosphorus less than 1.0 mg/L.

Harriman Visit 07/07/2020 – Grant Weaver's Process Control Adjustments Report

***Grant was given an update on the initial visit process sampling plan 06/24/2020 and the following information was determined from the results of several parameter data points.

Ray & Dewayne,

Impressive work, team!

Sadly, pH appears to be a major issue; very possible pH is too low to support biological phosphorus removal.
But, before giving up, the plan we discussed today follows.
Please, please, correct any mistakes … make additions … make deletions … etc.

First, to summarize the good work already done.
The vertical profiles done by Ray and staff document that sufficiently anaerobic conditions exist at the bottom of the ditch to support VFA production and uptake by PAOs.
The ORP values on the bottom two feet of the ditch are routinely -200 mV with little change regardless of rotor ON or OFF.
No real change through the day in oxidation ditch orthophosphate.
On the two sample days it held pretty constant at 4ish mg/L regardless of the air-ON / air-OFF status.

The bad news.
At 6.5-7.0, pH is an issue.
In my experience biological phosphorus removal (uptake) ceases at a pH of 6.8 or less.
Eight of the 12 oxidation ditch pH samples had a pH of 6.8 or less … all six tests on 6/29 were 6.7.

Before we give up …
Let's see how high the ORP gets in the top layer of the ditch.
For the rest of the week, collect a few ORP readings at the near surface of the ditches.

We know it goes low enough for VFA production and uptake by PAOs, let's see if it goes high enough to support phosphorus uptake by the PAOs.
And, beginning Monday, July 13, double the air-ON time by changing the rotor operations from 1 hour ON and 2 hours OFF to 2 hours ON and 2 hours OFF.
After making the change, collect data on three different days …
Once near the end of the rotor ON time
Once near the end of the rotor OFF time
And, a third sample at a convenient time
Test the ORP in three locations
One foot below the water surface
One foot above the bottom of the tank
Midway
Test pH
Test orthophosphate
And, this can be done the following week, test orthophosphate at the following locations on three different days …
Influent
RAS
Clarifier inlet
WAS decant
Effluent
Daily, test pH in each oxidation ditch.
Daily, collect the following effluent data …
Ammonia
Nitrite
Nitrate
Orthophosphate

What did I miss?
What did I get wrong?
What needs clarification?

Grant

Harriman Update 07/17/2020 – Grant Weaver's Process Control Adjustments Report (See attached data for supporting documents)

Not what we are hoping for.
But if .. IF … the beneficial upward bump in pH is in any way a result of the extra aeration … this could be good news.

Ray, do you mind running for another week with the 2 hr ON / 2 hr OFF cycle and collecting daily (or even a few times a day) mixed liquor pH samples?
If we see a pH that no longer drops below 6.8 we should be able to get better biological phosphorus removal.

Meanwhile …
Take a break from ORP readings.
And, phosphorus testing.

Thanks!

Grant

Harriman Visit 07/28/2020 – On-site report, Ray Freemans & Grant Weaver's Process Control Adjustments Report

***Grant was given an update on the current process sampling plan from 07/17/2020 and the following information was determined from the results of several parameter data points.

Hi Grant,
As we had discussed Tuesday 7-28-2020 while Mr. Culpepper was at the plant, this is what I propose I try to effect positive change in PH.
I would like to start slowly dropping my MLSS from 5000mg/l down to 3300 mg/l over the next couple of weeks. From mid-August I will hold
MLSS at the 3300 mg/l through mid-October. October the water temperature will start dropping so I will let the MLSS start to climb to around
4000mg/l and hold that for the duration of the year as long as I am not experiencing any negative results.
I honestly don't know what this will do to PH if anything at all. But what it will do is let me purge some of the very old sludge and replace it with
a younger sludge prior to the winter months. Hopefully I can increase my % volitiles too.
When my MLSS is down to 3300mg/l I will resume ORP, DO, PH, Alkalinity and Nitrate testing and sampling. Kinda restart a baseline and see
what we can do with it. In the meantime, I would request returning my air on/off back to 1hr on 2hr off.
I'm open to any suggestions from you (or anyone).

Thanks

Ray Freeman
Chief Plant Operator

Grants Response
Ray,
Good plan!
You bet; return to your mode of aeration.
And, please …
Once the new pH probe arrives, gather some data on aeration tank pH.

Thanks!!!
Grant

Harriman – Grant Emailed 08/10/2020 – Ray Freemans & Grant Weaver and Dewayne over Ph findings.

First, indeed, great news!
The "high" effluent alkalinity had Dewayne suspecting as much.
Nicely sleuthed out, superbly resolved.
Well done!

Second, some theory.
Biological phosphorus removal (bio-P) proceeds as follows …
1. VFA (volatile fatty acid) formation in septic conditions.
2. VFAs are "eaten" by bio-P bugs (PAOs) in septic conditions.
PAOs use the VFAs as an energy source but don't grow.
As they take in VFAs, orthophosphate (ortho-P) is released into solution, causing the soluble phosphorus concentration to be three times that of the influent.
3. Under aeration (pH of 7.0 or higher and goodly DO/ORP), the energized PAOs reproduce.
As the PAOs grow, they bioaccumulate phosphorus, leaving very little ortho-P in solution.
4. Under the wrong conditions (for example, warm water and thick blankets in clarifiers), some of the phosphorus can get released back into solution.

More theory.
I may be the only guy in the country with the following theory.
Given there are a lot of people smarter than me who are experts, I'm probably wrong.
But, guys, I'm not wrong.
I believe that … if there isn't enough soluble BOD in the wastewater as it is aerated, then there is too little PAO growth to support the phosphorus uptake described in step 3 above.
Resulting in high effluent total-P.

Which brings us to Ray's "what now?"

The answer is consistent phosphorus removal.
To do this, Harriman's plant needs to effectively complete steps 1 and 2, and 3, and not step 4.

A. So far, we've determined that the conditions are right for steps 1 and 2.
That is, that the bottom of the ditch is sufficiently anaerobic to support VFA production and uptake by the PAOs.
I'm comfortable assuming that this part of bio-P is working, and consistently doing so.

B. With no blanket in the clarifier, it is unlikely that step 4 is much of a problem.
So, that isn't the issue.

C. Meaning, the issue is likely with step 3.
During summer months I suspect that almost all of the BOD is consumed during the air-OFF cycles and the only thing occurring during the air-ON cycles is ammonia conversion to nitrate, something that does not require BOD.
Something that, in fact, requires little BOD present for it to occur.
Meaning, to get good bio-P we need to figure out a way to make the air-ON cycle work for us.

We need enough BOD to support cellular growth when the VFA-energized PAOs get into solution.

My suggestion: next time Dewayne is at the plant, we get on the phone together and brainstorm.
And/or, if I need to come down, I will.
But let's have a conference call to discuss first.
Does that sound like a plan?
Does everything above make sense / are you in agreement?

Grant

Harriman Conference call 08/11/2020 – Ray Freemans & Grant Weaver and Dewayne over Ph findings and new Process Control Adjustments Report.

Ray, Dewayne & Karina,

During today's conference call we discussed the following – Karina, credit goes to Ray for the good thinking on this.
Over the course of the next week or two …
Using a portable DO meter, Ray is going to see how long it takes the DO halfway down the ditch from where the influent enters to rise to 1.5 / 2.0 after the rotors have been off.

(Ray, we didn't discuss, but might you see what happens to the ORP near surface too?
I'd like to see it climb to +100 or higher.)

With this information, Ray will talk to the City's SCADA programmer.
As-is, rotors can be turned off in one-hour increments.
We suspect he'll need 10-minute increments, one-minute increments being ideal.

After SCADA is programmed, Ray will cycle the influent-end-of-the-ditch-rotor to come on most frequently when the influent flow is the highest and less frequently at night when flows are low.

We're hoping that the DO bursts will stimulate PAO growth sufficiently to biologically remove phosphorus.

Potential downsides.
Decline in total-nitrogen removal … effluent is now 2-3 mg/L total-N.
Rise in effluent ammonia … is now typically non-detect.
Greater energy use.

What did I miss? Grant

Harriman – 08/14/2020 – Ray Freemans & Grant Weavers Email conservation on SCADA controlled rotors vs influent pump station run times.

Mark Eddings has changed the programming in SCADA for me. It is now possible to run the rotors (aerators) in any order for any time interval between 1 second and 5.5 hrs.

This will now give me the ability to reduce the run time and save $ in reduced power consumption. Previously I could only run the rotors in 1 hour increment's.

Next thing I would like to experiment with is (this is totally theoretical) getting a signal from the woodyard pump station (either level or motor start) and have the

Rotors start when the plant is being fed. This will mix the incoming charge with fresh O2 allowing the PAO's (phosphate accumulating organisms) to multiply. This could

Also save $ by not running the rotors when they are not needed (enough DO for BOD removal).

Ray Freeman

Ray,
Good news.
And.
I very much like your "theoretical" plan.
Might it be possible to do this?

Grant

Harriman – 08/24/2020 – Ray Freemans & Grant Weavers Email conservation on process control.

Gentlemen,

This is some of the averages I collected last week on the 1st week of altering the rotor cycles. All of these tests were only running 1 rotor in each ditch (the one at influent). All samples were taken at midpoint of the ditch.

The P/H avg was 7.3. The avg temp was 24.1.

I feel like my DO is too low for all of these (best being 8.19.20).

Is there a schedule that you would like me to try?

Ray Freeman

Chief Plant Operator

Ray with copy to Dewayne,

Agree.

DO and ORP are too low for phosphorus "uptake."

I wonder.

Maybe one or two extended operations of the rotor that aerates the flow as it enters the ditch during peak flows … that is, keep the rotor on long enough to raise the DO / ORP into target areas (DO of 1.5 and ORP of +150) … will get bio-P going.

What do you think?

Want to try it?

Grant

Harriman – 09/01/2020 – Ray Freemans & Grant Weavers Email conservation on process control and NEW recommendations.

<u>Rays Email:</u>

Gentlemen,

These are the average for ORP and DO I have gathered for this aeration cycle
Rotors 1 and 4 (at influent) run for 40 mins then off for 80 mins.
At the end of the 80 mins -
Rotors 2 and 3 (at return) run for 40 mins then off for 80 mins.
The cycle repeats 24 hr.

Each of the 4 rotor's are running 4 hours per day. 2 rotors puts 8 hours of total run time for mixing/O2 per ditch/day.

Just before rotors 1 and 4 start

	ORP	DO
Top	-138	.28
Bottom	-181	.16

Just after rotors 1 and 4 stop (40 min run time)

	ORP	DO
Top	-61	1.57
Bottom	-143	.41

The DO/ORP are better, but I am starting/stopping the rotors more frequently increasing cost.

I suspect the nitrogen will increase also.

Ray Freeman

Chief Plant Operator

Harriman Utility Board

865-882-3242 x 263   Office

865-321-3557 Cell

<u>Grants Response to Ray:</u>

Ray,

As you and I discussed by phone just now …

To get phosphorus removal, we're going to need a positive ORP, much more DO.

What you're doing isn't doing it.

And, as you mention … lots of starts and stops … and, lots of electrical use.

Beginning tomorrow …

Work on creating a once per day high-DO / high-ORP at the influent at a time of day when a goodly amount of influent arrives.

The plan being …

From 9 AM to 11 AM daily, run all four rotors and monitor DO and ORP at the inlet.

(Take advantage of your new programming to stagger the starts to keep the power factor charge to a minimum.)

For the rest of the day, return to your normal mode of operation: cycling one rotor at a time ON for 1 hour with both OFF for 3 hours.

Grant

<u>Dewayne's follow up:</u>

Sounds like a game plan and I plan to be in Cowan next Wednesday 09/09/2020 and Harriman next Thursday 9/10/2020 that morning to catch up with Ray and Donnie. Thanks for the information Grant and Ray!

Good Day!

Dewayne T. Culpepper

Harriman – 09/08/2020 – Ray Freemans & Grant Weavers Email conservation on process control and lab results.

From: rfreeman@hub-tn.com <rfreeman@hub-tn.com>
Sent: Tuesday, September 8, 2020 12:01 PM
To: Grant Weaver <g.weaver@cleanwaterops.com>
Subject: Harriman WWTP results

Gentlemen,

As per our discussion and changing rotor times these are my averages for the week of 8-31-2020

1 rotor on 1hr off 3hr each ditch at 2am - 6am - 2pm - 6pm – 10pm.
Results did not change much from before

Before rotor on

	ORP	DO
Top	-141	.25
Bottom	-192	.13

After rotors stop

	ORP	DO
Top	-53	1.44
Bottom	-138	.45

2 rotors on 2hr each ditch (all 4 running) on at 9am – off at 11am

Before rotors on (8:55am)

	ORP	DO
Top	-48	.56
Bottom	-169	.14

After rotors stop (11:05am)

	ORP	DO
Top	131.9	2.26
Bottom	66.3	2.07

Ray Freeman
Chief Plant Operator

Harriman Utility Board
865-882-3242 x 263   Office
865-321-3557   Cell

<u>Grant Weavers Response:</u>

Ray,

Am very happy with these results!
Keep this setting.

And, as we discussed on the phone, begin collecting final effluent grab samples and testing for orthophosphate.
Within a week or two, the concentration should drop below 1.0 mg/L.
Possibly below 0.5 mg/L.

If so, celebrate, we got it!
If not, we talk.

Grant

Harriman – 10/14 – 11/06 : Ray Freemans, Karina Bynum, Dewayne Culpepper & Grant Weavers Email conservation on TP lab results.

Karina,
We found out that these TP results were in the form of data as PO3/4 and not PO3/4-P. After dividing each result by 3.06 for results from 10/19 – 10/23, we are doing great on TP with an average of 1.37 when corrected! When you look at the results from 9/30 to 10/14 and correct those, the average for TP is 1.46! So we are gaining on the removal after lowering the MLVSS and current process control optimization plan. The corrected form P03/4 – P (TP) is in red. The following is the email string.

From: Ray Freeman <rfreeman@hub-tn.com>
Sent: Monday, October 26, 2020 8:26 AM
To: Grant Weaver <g.weaver@cleanwaterops.com>
Cc: Dewayne Culpepper <dewayneculpepper@taud.org>
Subject: RE: any updates?

Good morning Grant.

Phosphorus levels for last week.
10.19.20   4.13 mg/L PO3/4 / 1.34 mg/L PO3/4-P (TP)
10.20.20   4.07 mg/L PO3/4 / 1.32 mg/L PO3/4-P (TP)
10.21.20   4.27 mg/L PO3/4 / 1.39 mg/L PO3/4-P (TP)
10.22.20   4.34 mg/L PO3/4 / 1.41 mg/L PO3/4-P (TP)
10.23.20   4.22 mg/L PO3/4 / 1.37 mg/L PO3/4-P (TP)
We did no digester decanting and no pressing of sludge so this is just normal plant operations.

Plant conditions did not vary much from the previous email.
Nitrogen averages 2.3 mg/l
Effluent temp has dropped from 21.5 to 20.4
Effluent PH fluctuates between 7.44 - 7.61
Inf BOD5 averages around 200 mg/l
Effluent BOD5 averages around 5 mg/l
MLSS 3800 mg/l
Attached are the current rotor settings.

Have a great day

Ray

From: Grant Weaver <g.weaver@cleanwaterops.com>
Sent: Wednesday, October 14, 2020 10:34 AM
To: rfreeman@hub-tn.com
Cc: Dewayne Culpepper <dewayneculpepper@taud.org>
Subject: RE: any updates?

Ray,

Thank you!
If no change after a couple weeks of stable operations, we should talk.

Grant

CLEAN WATER OPS.COM™

Grant Weaver
C: 860.777.5256
O: 617.505.5095

From: rfreeman@hub-tn.com <rfreeman@hub-tn.com>
Sent: Wednesday, October 14, 2020 9:26 AM
To: Grant Weaver <g.weaver@cleanwaterops.com>
Subject: RE: any updates?

Howdy Grant.

Sorry for the lack of info for the last 3-4 weeks. I have been trying to reduce my MLSS with inadequate tools to do so. (Broken belt press. Broken WAS pump. Broken RAS pumps).
I have finally got my MLSS down to 3750 mg/l on Oct 12th.

Series of events. I pressed out digester #1 12 hrs. a day from Sept 4th through Sept 22nd. Sept 23rd, I started an extremely aggressive wasting trend (MLSS was over 7000mg/l).
Sept 30th, I resumed sampling. Here is some data.

Phosphorus
9.30.2020 4.42 mg/l PO3/4 / 1.44 mg/L PO3/4-P (TP) - The night before I decanted digester.
10.2.2020 4.39 mg/l PO3/4 / 1.42 mg/L PO3/4-P (TP) - The night before I decanted digester.
10.5.2020 4.73 mg/l PO3/4 / 1.55 mg/L PO3/4-P (TP) -
10.7.2020 4.55 mg/l PO3/4 / 1.49 mg/L PO3/4-P (TP) - The night before I decanted digester.
10.9.2020 4.41 mg/l PO3/4 / 1.44 mg/L PO3/4-P (TP) - The night before I decanted digester.
10.12.2020 4.48 mg/l PO3/4 / 1.44 mg/L PO3/4-P (TP) -
10.14 2020 4.42 mg/l PO3/4 / 1.34 mg/L PO3/4-P (TP) - The night before I decanted digester.
Nitrogen averages 2.3 mg/l
Effluent temp has dropped from 21.5 to 20.4
Effluent PH fluctuates between 7.39 - 7.48
Inf BOD5 averages around 200 mg/l
Effluent BOD5 averages around 5 mg/l

I believe the constant pressing, wasting and decanting has rendered these results unreliable, but at least my plant is safe for a while. I will continue testing.

Ray

From: Grant Weaver <g.weaver@cleanwaterops.com>
Sent: Tuesday, October 13, 2020 10:47 AM
To: rfreeman@hub-tn.com
Cc: Dewayne Culpepper <dewayneculpepper@taud.org>
Subject: any updates?

Ray,

Are you seeing any improvements in effluent phosphorus?

Grant

Grant Weaver, PE & Wastewater Operator
President

The Water Planet Company DBA CleanWaterOps
www.cleanwaterops.com
132A Cross Road
Waterford, CT 06385-1241
OFFICE: 617.505.5095

From: Grant Weaver <g.weaver@cleanwaterops.com>
Sent: Thursday, November 5, 2020 12:51 PM
To: Ray Freeman <rfreeman@hub-tn.com>; Dewayne Culpepper <dewayneculpepper@taud.org>
Cc: Karina Bynum <karina.bynum@tn.gov>
Subject: RE: phosphorus

Ray,

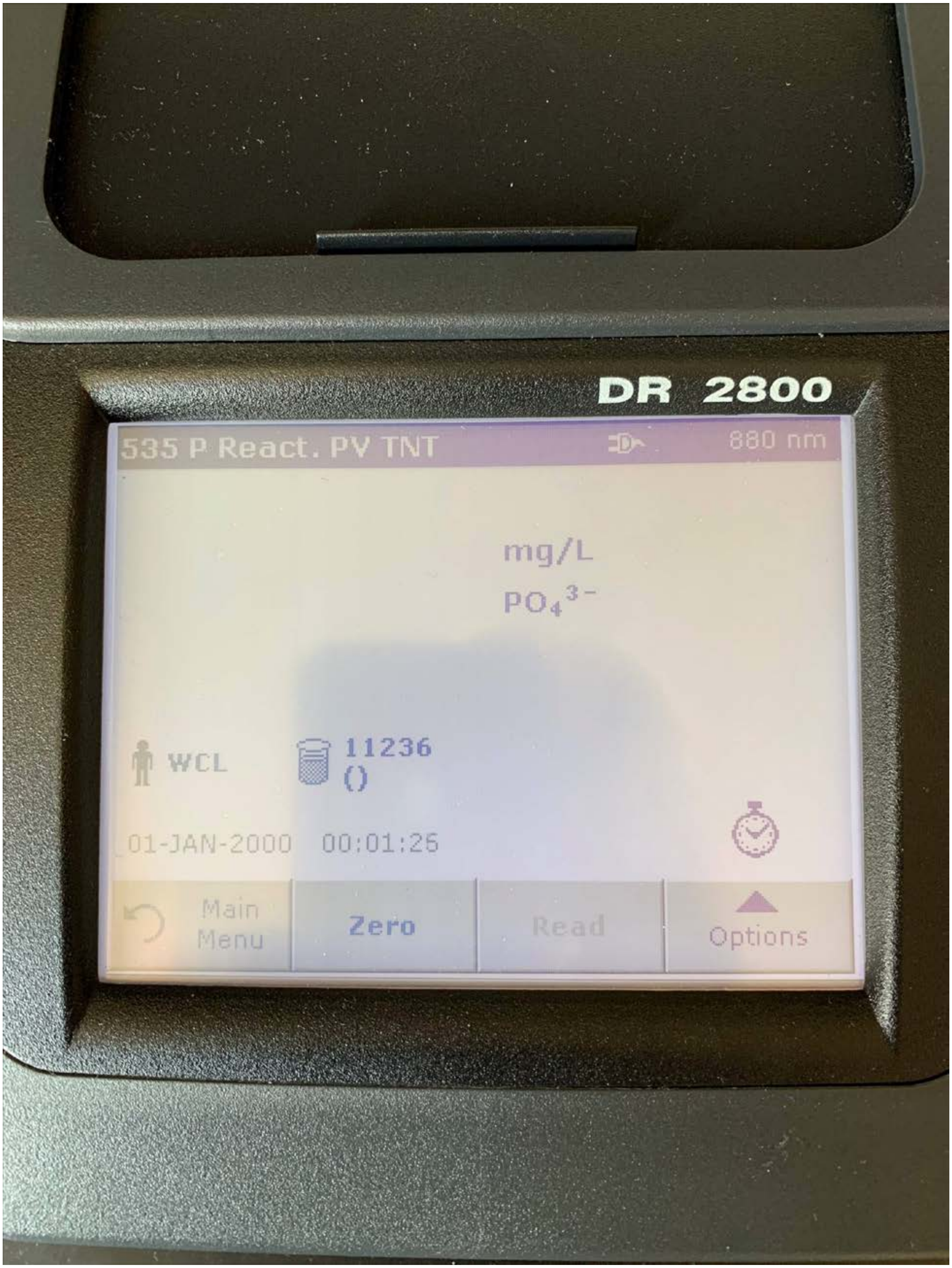
Sometimes, this is one of those times, it's good to make a goof.
All of your in-house phosphorus readings should be divided by three as your meter is reporting the data as PO_4 vs PO_4-P.
While the lab reports phosphorus as PO_4-P.

Grant

Grant Weaver
C: 860.777.5256
O: 617.505.5095

From: Ray Freeman <rfreeman@hub-tn.com>
Sent: Thursday, November 5, 2020 11:52 AM
To: Grant Weaver <g.weaver@cleanwaterops.com>; Dewayne Culpepper <dewayneculpepper@taud.org>
Subject: FW: phosphorus

From: tacobella517@gmail.com <tacobella517@gmail.com>
Sent: Thursday, November 5, 2020 11:50 AM
To: Ray Freeman <rfreeman@hub-tn.com>
Subject:


DR 2800
535 P React. PV TNT
880 nm
mg/L
PO4 3-
WCL
11236
()
01-JAN-2000 00:01:25
Main Menu
Zero
Read
Options

Harriman – 11/10 : Karina Bynum, Ray Freemans, Dewayne Culpepper Email conservation on Renewal of NPDES permit to include outfall 002.

Hello Dewayne,

Harriman needs apply to revoke and re-issue their permit . They need to send this request with their application to Jim McAdoo and copy Wade Murphy. The application needs to include Outfall 002. For flow monitoring of the River, Harriman needs to propose a draft standard operating procedure how will they assure that the plant does not discharge to Outfall 002 when the River flow is below 200 cfs. The procedure will be finalized after a year of operation. Also, Harriman needs to include River gage record each month with their eMOR when they start using Outfall 002. Application is due by the end of November. If you think a group call would be helpful, I am happy to set one up, just send me couple of dates and times that would work for you all.

Karina

Karina Bynum, Ph.D., P. E. |Integrated Water Resources Engineer
Division of Water Resources
1221 South Willow Avenue, Cookeville, TN 38506
p. 931 - 520 - 6688
karina.bynum@tn.gov
tn.gov/environment

Harriman – 11/13 : Karina Bynum conducted a virtual meeting concerning the Renewal of NPDES permit to include outfall 002.

November 13 – Karina called a virtual meeting with all parties involved on the permit renewal and the Harriman officials was given information on what should be provided in the permit renewal application to proceed on to incorporate the 2nd outfall use in the new permit. The following was the results of the meeting:

Harriman needs apply to revoke and re-issue their permit. They need to send this request with their application to Jim McAdoo and copy Wade Murphy. The application needs to include Outfall 002. For flow monitoring of the River, Harriman needs to propose a draft standard operating procedure how will they assure that the plant does not discharge to Outfall 002 when the River flow is below 200 cfs. The procedure will be finalized after a year of operation. Also, Harriman needs to include River gage record each month with their eMOR when they start using Outfall 002. Application is due by the end of November.

All were in agreement and Thankful!

Harriman – 12/16: Reviewed proposed Harriman draft NPDES permit and submitted commits to Wade Murphy.

Good Evening Wade,
Speaking for TAUD's perspective, I reviewed the permit and it looked well written and fair to all involved in this effort. The only thing that I picked up on was on page 2, (located below the line - code 81011 TSS, % removal) there was no Influent heading that indicates Influent parameters. Other than that, the monitoring and reporting is clearly defined and up to date with the TDEC electronic reporting platforms. I really like the format of this permit compared to previous formats. I want to Thank all that was involved with this effort, Harriman Utility Board Officials, Tennessee Water Resource Officials and the EPA, as the negotiations were very constructive and productive.