CHARLES TOWN UTILITY BOARD
AGENDA

WEDNESDAY, APRIL 7, 2021

Special Meeting | **842 South George Street**
Charles Town, WV 25414
Wastewater Treatment Plant | **4:00 PM**

WORKSHOP:

1. **GWIN DOBSON FOREMAN - RENEWAL AND REPLACEMENT PROJECT REVIEW**
   a. Sludge Handling Options - Site Tour
      2021-03-29 Charles Town WWTP Process Evaluation GDF.pdf
      2021-03-29 Solids Handling Evaluation GDF.pdf

2. **ADJOURNMENT**

INFORMATION ONLY - NEXT MEETING - APRIL 14, 2021 AT 4:00 PM

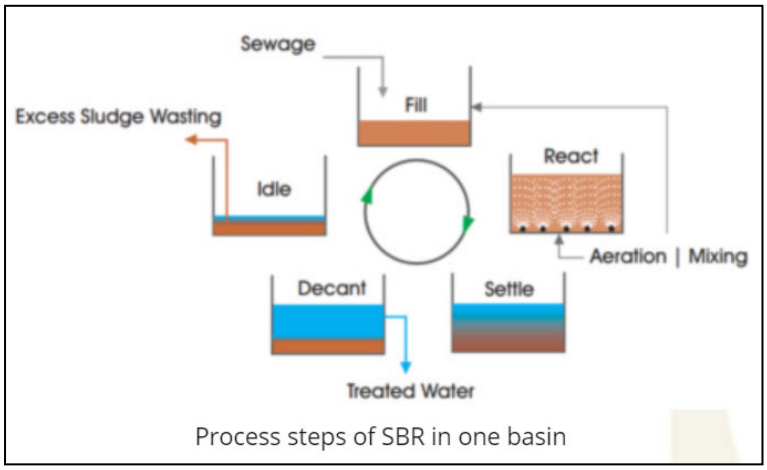
CHARLES TOWN WASTEWATER PLANT - PROCESSS TREATMENT ASSESSMENT

General - The following analysis focuses on the biological treatment process, its current performance and suggested optimization enhancements to extend the service life of the existing facility, enhance process operations, provide additional capacity and improve treatment efficiencies.

These targeted, cost-effective improvements will result in a more robust and reliable process for meeting regulatory standards until such time that a larger and more centralized treatment plant is constructed to meet planning period demands.

Process Description - The Sequencing Batch Reactor (SBR) technology has been in existence for 25 years and is a version of the suspended growth "activated sludge" wastewater treatment process.

The SBR process offers cost savings because of its fill-and-draw configuration. The SBR process treats sewage in "batches" which means all treatment is done in a tank with no flow going in or out until the process is complete and the treated wastewater is discharged. Please refer to the following figure of the SBR process.



Process steps of SBR in one basin

The first operation (Fill Cycle) involves raw sewage entering a tank partially filled with biologically active sludge left over from the last cycle. For nutrient removal, an anoxic fill cycle (no air) is provided prior to reaction/aeration. Next, after a quiescent period, the sewage-sludge mixture is aerated for 2-3 hours (Reaction Cycle). Then the air is turned-off and the wastewater is allowed to settle for several hours (Settling Cycle).

At the end of this cycle, the "clear water" on top is drawn-off (or decanted) for filtering and disinfection (Decant Cycle) and a small fraction of the settled sludge is withdrawn from the tank bottom and pumped to the aerobic sludge digesters (Sludge Wasting Cycle). Waste sludge is digested aerobically.

Historical Plant Influent Flow Data and Loading Review - Charles Town personnel provided Discharge Monitoring Reports from 2016 to 2019. Historic flows were evaluated using a Log Pearson Type III frequency analysis. Plant loadings for the period were also evaluated using a Log Pearson analysis. The proposed plant design flow parameters were determined as follows:

Flow Type	Influent Flow (MGD)	Remarks
Minimum Hourly Flow*	0.138	Minimum daily flow for the period from January 2016 - December 2019
Monthly Average Flow*	1.50	Monthly average flow for the period from from January 2016 - December 2019
Permitted Plant Capacity*	1.75	WVDEP Permitted Plant Capacity
Permitted Maximum 3 Month Average Flow	1.58	90% of Permitted Plant Capacity
Maximum Monthly Average Flow*	2.22	Maximum monthly average flow occurred in September 2018
Maximum Weekly Flow	1.39	Log Pearson Type III analysis of 50% probability occurrence of all from January 2016 - December 2019 flow events
35% Probability Occurrence, Peak Flow	1.55	Log Pearson Type III analysis of 35% (+/-) probability occurrence of all from January 2016 - December 2019 flow events
20% Probability Occurrence, Peak Flow	1.90	Log Pearson Type III analysis of 20% probability occurrence of all from January 2016 - December 2019 flow events
Maximum 3 Month Running Average	2.00	Log Pearson Type III analysis of 9% probability occurrence of all from January 2016 - December 2019 flow events
Maximum Daily Flow	2.20	Log Pearson Type III analysis of 5% (+/-) probability occurrence of all from January 2016 - December 2019 flow events
Peak Hourly Flow*	2.56	Log Pearson Type III analysis of 2% (+/-) probability occurrence of all from January 2016 - December 2019 flow events
Peak Instantaneous Flow*	4.34	Maximum system flow of 4.339 MGD recorded for from January 2016 - December 2019

Asterisk (*) Denotes Design Flow Parameters

During this same period the Charles Town Utility Board evaluated the plant effluent flows and noted that the maximum 3 month running average reached 1.56 MGD in 2019 and 1.67 MGD in 2018. While 2018 was a year of exceptional rainfall, the 2019 running average approached the permit conditions. This differed from the above values because the WVDEP values were based on effluent flow which has historically been less than the measured influent flow results. Based on the measured influent flow, the plant would have been considered hydraulically overrated.

The existing plant is also designed to meet the NPDES permit limits for BOD5, TSS and ammonia-nitrogen (NH_3), as well as meet annual TMDL limits for Total Nitrogen and Total Phosphorus.

Effluent Characteristics	Monthly Average Loading Rate, lbs./day	Max Daily Loading Rate, lbs./day	Monthly Average Concentration, mg/L	Max Daily Concentration, mg/L
BOD_5	301	601	20.6	41.2
TSS*	438	876	30	60
Ammonia-Nitrogen	60	120	4.1	8.2

The plant currently has the capacity and treatment capabilities to meet the daily limits as well as the annual TMDL limits based on the historical flow analysis without using the denitrifying filters. The plant's current effluent concentrations of total nitrogen and total phosphorus are 6.1 mg/L and 0.49 mg/L respectively. The historic daily average flow results for the annual plant TMDL limits are as follows:

Effluent Characteristics	Charles Town Plant (Outfall 001)
Average Daily Flow, MGD	1.48
Total Nitrogen, mg/L	6.10
Total Nitrogen, lbs./year	27,444
Total Phosphorus, mg/L	0.49
Total Phosphorus, lbs./year	2,216

While the plant meets the average daily flows, based on the historical effluent results, the plant would not meet the TMDL limit for TN at 1.75 MGD (32,495 lbs./year). Residential growth is expected to continue. The residential growth is not expected to impact the overall wastewater influent concentrations, which means the plant should be capable of producing the same effluent concentrations. This shows that as the plant continues to grow over the next 10 years, the average influent rate is expected to approach 1.71 MGD. This will require either upgrades to meet the hydraulic capacity or enhancements and optimization measures outlined herein.

Future Growth and Build-Out - Based on the projected growth EDU's provided by the Charles Town Utility Board, a review of the "Maximum 3 Month Running Average" flow rates was used to determine recommendations on when future expansions should occur and the anticipated future maximum daily flow rates for the Charles Town Plant. Some assumptions were made in reviewing the Charles Town Utility

Board spreadsheet data on planned development activities in the service area. The first being that the Charles Town Wastewater Treatment Plant (CTWWTP) serves roughly 17,500 people which is currently 31% of the population of Jefferson County. For planning purposes, it is assumed that the future population served by the Charles Town wastewater plant would be the same fraction.

Also, the peak flow-to-average daily flow ratio and the "Maximum 3 Month Running Average" flow to Average Daily flow ratios for the last 5 years were used to estimate the ratios for the future growth period. Using these assumptions and estimates, Charles Town would not be considered hydraulically overloaded until the year 2034 when the Maximum 3 Month Running Average flow rates reached 1.59 MGD. Refer to Table 6 below.

Projected Year	**2021**	**2030**	**2034**	**2035**	**2040**
Projected EDUs	66	1,776	2,937	3,212	4,312
Average Daily Flow	1.23	1.31	1.37	1.38	1.43
Maximum 3 Month Running Average	1.43	1.52	1.59	1.60	1.66
Maximum Daily Flow	2.54	2.70	2.82	2.84	2.95

Also, additional review of the historic and projected effluent flows and annual nutrient mass loadings show that they match with the previously reviewed nutrient mass loadings when compared to influent flows (see below). The plant has been meeting the annual nutrient mass loadings mainly by virtue of lower plant flow rates. Issues associated with meeting the effluent nutrient mass loadings will increase as flow increases which will require either the use of the denitrifying filters or optimization upgrades to the SBR process to continue to meet the nutrient mass loadings over the intervening time.

Projected Year	**2021**	**2030**	**2034**	**2035**	**2040**
TN (lbs/yr)	24,060	25,612	26,665	26,915	27,913
TP (lbs/yr)	1,864	1,984	2,065	2,085	2,162

Another item that should be taken into consideration with future growth and build-out is the biological loading on the plant and associated equipment. The plant currently sees an average influent BOD concentration of 344 mg/L which is significantly higher than average strength wastewater.

It should be noted that due in part to the higher strength influent, it may be possible to provide upgrades to the biological treatment process that could potentially prolong the life of the existing plant, reduce operating costs and provide better biological treatment. This, in turn, would insure more reliable effluent quality and improve and enhance the sludge digestion, dewatering and disposal processes. The optimization upgrades have the potential to provide additional treatment capacity and possible hydraulic rerating of the plant by WVDEP.

The following sections will discuss the existing process treatment and proposed optimization enhancements.

Typical SBR Process Considerations Performance – Because of the unique fill-and-draw nature of the SBR process, the following factors should be considered in SBR design and operation. Many of the items listed are deficiencies currently existing at the Charles Town wastewater treatment plant.

- SBR's are vulnerable to high strength waste loads and wet-weather flows that can dilute or washout process biomass during storm events.

- Based on a nationwide survey, the majority of SBR systems are used in smaller applications where wastewater flows are more contained and not subject to high peaking factors. In general, there are more than 1,000 SBR-type facilities operating in the United States. About 70% of these plants are less than 0.5 MGD capacity and 80% are less than 1 MGD. Comparatively few plants are greater than 10 MGD capacity.

- Several publications and texts provide cautionary factors when considering SRB systems. (Reference: WEF MOP #8/ASCE MEP #76, Metcalf & Eddy, Wastewater Engineer; USEPA Wastewater Technology Fact Sheet - SBR's). Many of these observations have been noted as impacting the performance of the existing Charles Town treatment plant.

    a. A higher level of operational sophistication is required (compared to conventional systems), especially for larger systems, of timing units and controls.

    b. Higher level of maintenance (compared to conventional systems) associated with more sophisticated instrumentation and controls, automated switches and automatic valves.

    c. Potential of discharging floating or settled sludge during the draw or decant phase with some SBR configurations.

    d. Because substrate concentration changes with time, the substrate utilization and oxygen demand rates change, progressing from high to low levels. The aeration system should be designed to reflect changing requirements in oxygen demand. Wet-weather systems are vulnerable to these changing substrate conditions as the influent becomes more diluted.

    e. Process control is more complicated due to the number and timing of the various cycles.

    f. Potential for sludge bulking at low food-to-microorganisms ratio.

    g. Inability to chlorinate return activated sludge for filamentous bacteria control.

    h. For biological nutrient removal, reaction rates will be depressed if the reactor is not thoroughly mixed, therefore, mechanical mixing is warranted.

i. Some SBR systems use less efficient aeration devices and are prone to plugging during selected operating cycles. For optimum nutrient removal, fine bubble diffused air, via membrane diffusers mounted in tank bottoms, should be considered at Charles Town.

Existing Process Operational and Performance Limitations - Based on discussions with plant operators and observations of the existing process, the following operational limitations and performance problems have been noted at the Charles Town SBR process:

- The Charles Town SBR's have coarse bubble diffusers which are more energy intensive and less efficient in terms of oxygen transfer than fine bubble diffusers. Fine bubble diffused aeration systems are a feature of SBR design when nutrient removal is required. Also, coarse bubble diffusers can result in non-filamentous foam production (due to higher shearing action) when influent contains high concentrations of surface acting agents (i.e., surfactants in detergents and cleaning products) generated in institutional and industrial discharges.

- The plant does not have aeration blowers controlled by key process parameters such as dissolved oxygen (DO) and oxygen reduction potential (ORP). Over-aeration can break biomass floc particles apart, causing pin floc or small, dispersed floc that does not settle well. Anoxic zones (settling phase) used for denitrification can also turn partially aerobic, or oxic, due to high DO thus resulting in lower nitrogen removal.

- New aeration blowers with variable frequency drives (VFD's) controlled by DO and ORP meters will better control the aeration cycle and result in less DO carryover to the anoxic nitrogen removal phase. Along with these benefits, better blower control will be less wasteful and more energy efficient.

- New high efficiency turbo blowers for the existing digester tank are being recommended as the existing 250 HP blowers are not energy efficient. These blowers must also feature backup power when relying on true sludge digestion, thus a new generator should be considered.

- Excess sludge wasted (or removed) from the biological process at a high rate. This results in thinner waste sludge in terms of solids content with a lower volatile solids fraction. This is opposed to sludge that is allowed to accumulate and compact resulting in a thicker sludge blanket with a higher volatile fraction. The best means to remove sludge from the process is via pumping which is more easily controlled that the current method of a piped gravity discharge.

- The excess and high rate wasting of sludge has a "domino effect" in the sludge handling system since the aerobic digesters are less efficient in stabilizing sludge (less volatile solids removal). The continuous wasting of sludge from the digesters to the dewatering system results in excessive use of the plant belt filter press. Finally, since the plant volatile solids reduction does not meet the pathogen reduction criteria for Class "B" biosolids, Charles Town must continuously add lime to

stabilize plant bio-solids. These problems are costly in terms of material costs and energy inefficiencies (digester blower and sludge operations).

- Aggravating the sludge digestion process is that the existing digesters do not have adequate decant mechanisms (i.e., adjustable, automatic decant valve) which could provide a denser and higher solids product for dewatering than the solids "carryover" that currently occurs in the thinner sludge that is processed by the belt filter press. A thinner sludge requires more polymer addition for conditioning purposes which is a wasteful and costly chemical addition.

- The anoxic phase of the SBR process is the principal means of nitrogen removal where nitrogen gas is released. The objective of mixing in anoxic and anaerobic zones is to maintain optimum conditions for nutrient removal. Maintaining anoxic/anaerobic zones requires mixing of the basin contents while avoiding the introduction of free oxygen. Submersible or propeller mixers are commonly use to achieve these purposes.

Recommended Optimization Enhancements and Costs – The following recommended optimization enhancements have the ability to extend the service life of the existing facility, enhance process operations, provide additional capacity, improve treatment efficiencies and provide a more robust and reliable treatment process.

1. **Fine Bubble Diffused Air System** – Install membrane fine bubble diffusers in the SBR tank bottoms involving an aeration grid, connecting piping and air supply. Estimated Cost - $250,000.

2. **New High Efficiency Digester Blowers** – Install two (2) new 200 HP high efficiency digester turbo blowers to serve the existing large digester tank. Estimated Cost - $225,000.

3. **New Emergency Generator to Run New Digester Blowers** – Install new diesel generator with associated wire and gear to place new Digester Blowers on backup power. Estimated Cost - $200,000.

4. **New Aeration Blowers** – Provision for new aeration blowers properly sized for process conditions and equipped with variable frequency drives to better control air supply to the SBR process reactors resulting in less DO carryover and more energy efficiency. Piping and valve modifications are also necessary. Work includes blower control system integrated with the plant SCADA system. Estimated Cost - $300,000.

5. **Process Instrumentation** – Installation of DO and ORP instrumentation probes to better measure biological activity in the SBR's with output to the aeration blowers to control air volume to the react (aeration) process. Estimated cost - $50,000.

6. **Anoxic Zone Mixing System** – Furnish submersible mixers in the anoxic zone to ensure optimum mixing conditions during the denitrification phase of the SRB process including electrical work. Estimated Cost - $150,000.

7. **Aerobic Digester Decant Mechanism** – Provision for adjustable decant mechanism to improve removal of supernatant from the aerobic digesters and provide for better digested sludge with a higher solids content prior to the sludge dewatering system. Estimated Cost - $100,000.

8. **SBR Control System Modifications** – Provide for integration of the above blower and mixer controls and plant instrumentation system (DO, ORP meters) with the plant SCADA system along with new SBR cycle times and control intervals. Estimated cost - $50,000.

9. **Waste Activated Sludge (WAS) System Improvements** – The need to better control waste activated sludge (WAS) removal from the SBR process would involve new WAS pumps including pump controls and piping. Estimated cost - $175,000.

The estimated construction cost of the recommended optimization enhancements is $1,500,000. Along with associated engineering and administrative costs of $200,000, the total estimated project cost is $1,700,000.

Charles Town WWTP Solids Handling Evaluation

March 2021

Option	1A New Belt Filter Press & Lime Equipment	1B New Belt Filter Press w/ Digestion Upgrades	2 Centrifuge w/ Digestion Upgrades	3 Rotary Press w/ Digestion Upgrades
Capital Improvements				
Purchase Cost	$277,000	$277,000	$456,900	$415,000
Lime Feed	$200,000	-	-	-
Digestion Upgrades	-	$1,500,000	$1,500,000	$1,500,000
Building Costs	$250,000	$250,000	$250,000	$250,000
Total Capital Cost	$727,000	$2,027,000	$2,206,900	$2,165,000
Annual Operations and Maintenance Costs[1]				
Daily Operating Time	8 hours	6 hours	6 hours	10 hours
Electricity[2]	$2,480	$44,600	$51,080	$44,520
Water	$44,928	$35,942	$2,051	$2,486
Lime	$13,000	-	-	-
Polymer	$49,608	$49,608	$49,608	$49,608
Sludge Disposal Costs[3]	$123,000 (18% solids)	$107,000 (18% solids/no lime)	$77,000 (25% solids)	$96,000 (20% solids)
Sludge DT/WT/#Loads	746/4,146/691	649/3,606/601	648/2,592/432	647/3,234/539
Labor ($30/hr)	$62,400 (8 hrs)	$46,800 (6 hrs)	$31,200 (4 hrs)	$46,800 (6 hrs)
Annual O&M Cost	$295,416	$283,950	$210,939	$239,414
PW of 10 Years O&M[4]	$2,716,172	$2,610,750	$1,939,457	$2,201,268
PW of 20 Years O&M[4]	$5,043,506	$4,847,752	$3,601,268	$4,087,409
Present Worth				
Capital & 10 Years O&M	$3,443,172	$4,637,750	$4,146,357	$4,366,268
Capital & 20 Years O&M	$5,770,506	$6,874,752	$5,808,168	$6,252,409

[1] All annual costs are based on operating 5 days per week. Annualized maintenance/replacement costs are similar enough between each option that they are assumed not to have an effect on the final comparison cost.

[2] The electricity cost is significantly less expensive for option 1A because this alternative does not include the additional operating costs of equipment added to upgrade the digestion process (SBR Mixers, additional WAS pump, digester blowers).

[3] Assumes 6 wet tons per load and $178 per load.

[4] All present worth calculations assumed an interest rate of 1.557%.

Each option listed above has benefits and disadvantages. The Belt Filter Press (BFP) has the lowest capital cost and is the easiest to perform maintenance on. However, the BFP requires the largest amount of space and drainage area because of the spray bars that clean the press and generates the lowest percent solids sludge. The BFP, while being the easiest to perform maintenance on, also requires the most overall maintenance and requires constant supervision while operating. The BFP also has the greatest annual operating costs requiring the most water and second highest energy usage. The BFP will also create the lowest percent solids prior to lime addition.

A Centrifuge while having the largest capital cost have the same sludge flow rates as the BFP and will have a lower annual operating cost. The Centrifuge, while not requiring much continuous maintenance, should be inspected by a manufacturer's representative annually and typically requires complete scroll replacement every 10 years. The scroll replacement must be done by a manufacturer certified installer and is costly. This makes the maintenance on centrifuges costly once every 10 years, but costs are comparable to the BFP for the same time period. The main advantages to the Centrifuge are: they require less building space, require little to no supervision while operating, and create the driest sludge.

The Rotary Press has the second highest capital cost and the lowest sludge flow rate, but generates the second driest sludge. Similar to a centrifuge, the rotary press requires little to no supervision while in operation. The rotary press has the least amount of maintenance due to having the slowest moving parts with the least number of moving parts. The only major disadvantage to the rotary press is that a single unit is likely not capable of meeting the current sludge flow demands of the system. A summary of the pros/cons to each system is summarized below.

Equipment	***Benefits***	***Disadvantages***
Belt Filter Press	• Low capital cost • Easy maintenance	• Large footprint and concrete curbing • Constant supervision • High annual operation costs • Low percent solids • Continuous maintenance • High water usage and return flow • Safety concerns associated with moving parts and mist during operation
Centrifuge	• Highest percent solids • Lower annual operation costs • Little supervision • Typically, only annual maintenance • Small footprint • Self-contained	• 10-year maintenance costs • Maintenance repairs require manufacturer reps • High capital cost • High electrical costs associated with drying
Rotary Press	• Medium footprint • Little supervision • High percent solids • Low maintenance • Self-contained	• Medium footprint • High capital cost • May not be able to meet current sludge flow rate demand with a single 8 channel unit