Figures

ARCADIS

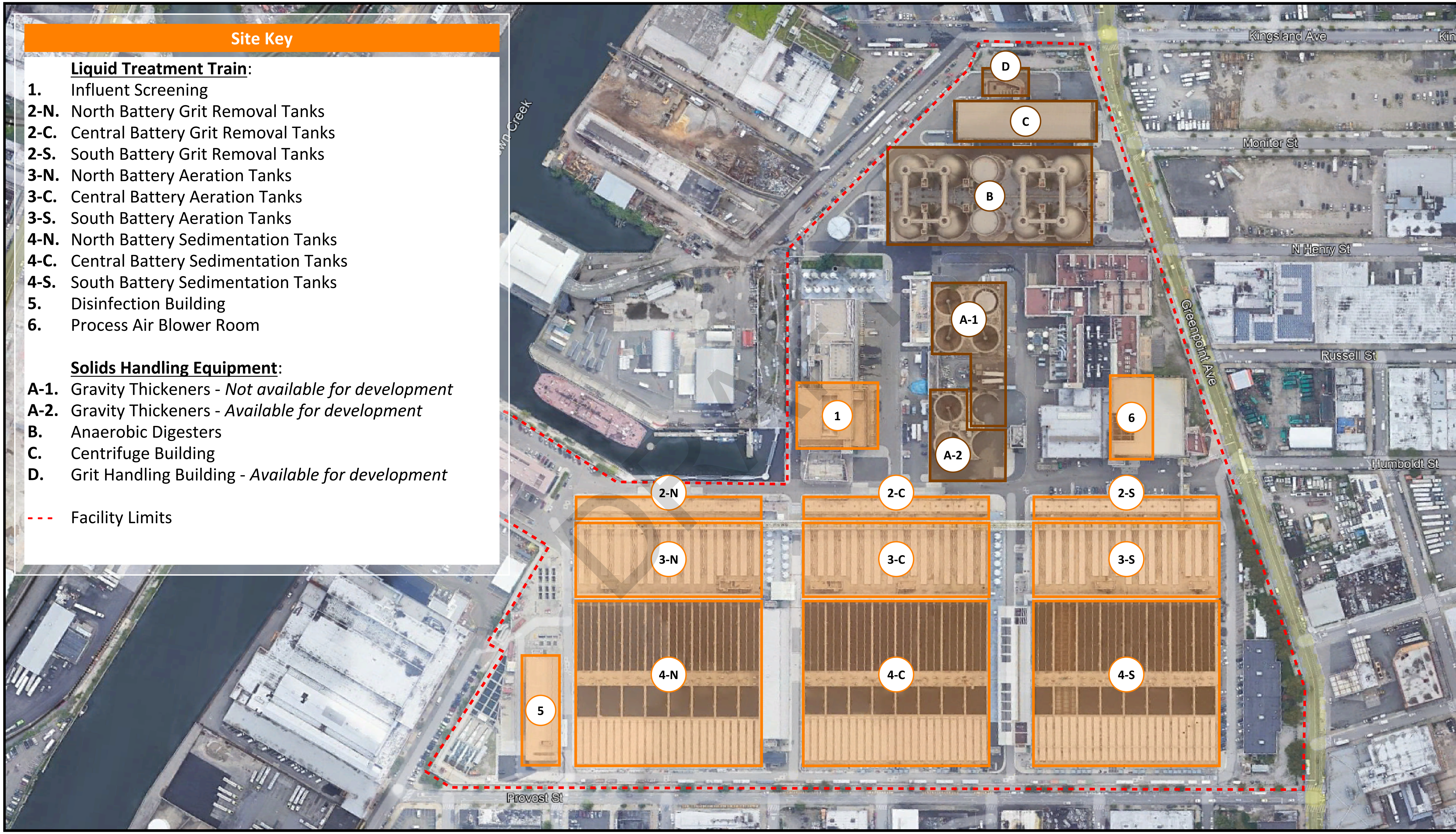

Figure A
Newtown Creek WRRF Site Plan

ARCADIS

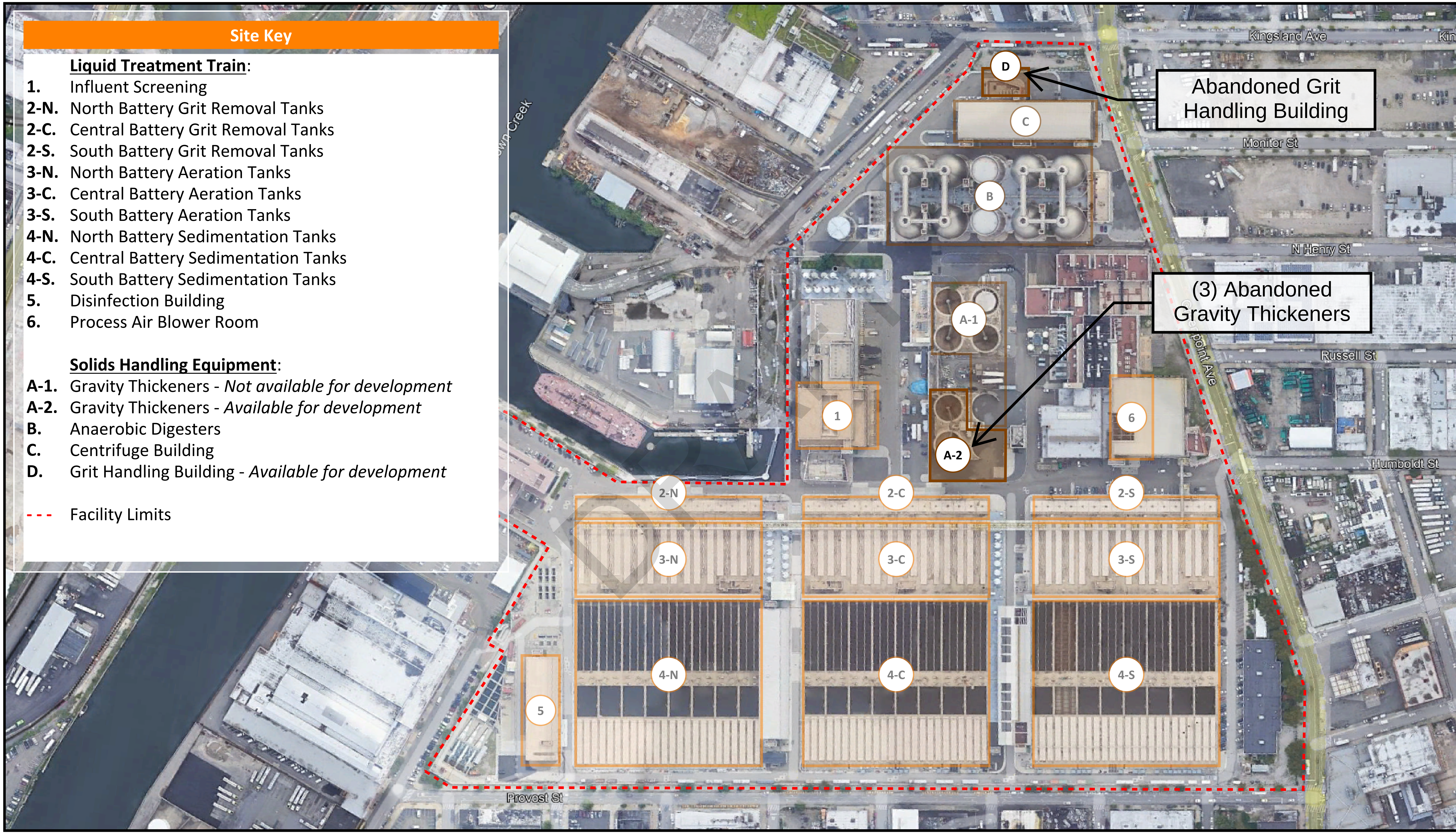

Figure B

Newtown Creek WRRF Site Plan: Available Footprint for New Systems

ARCADIS

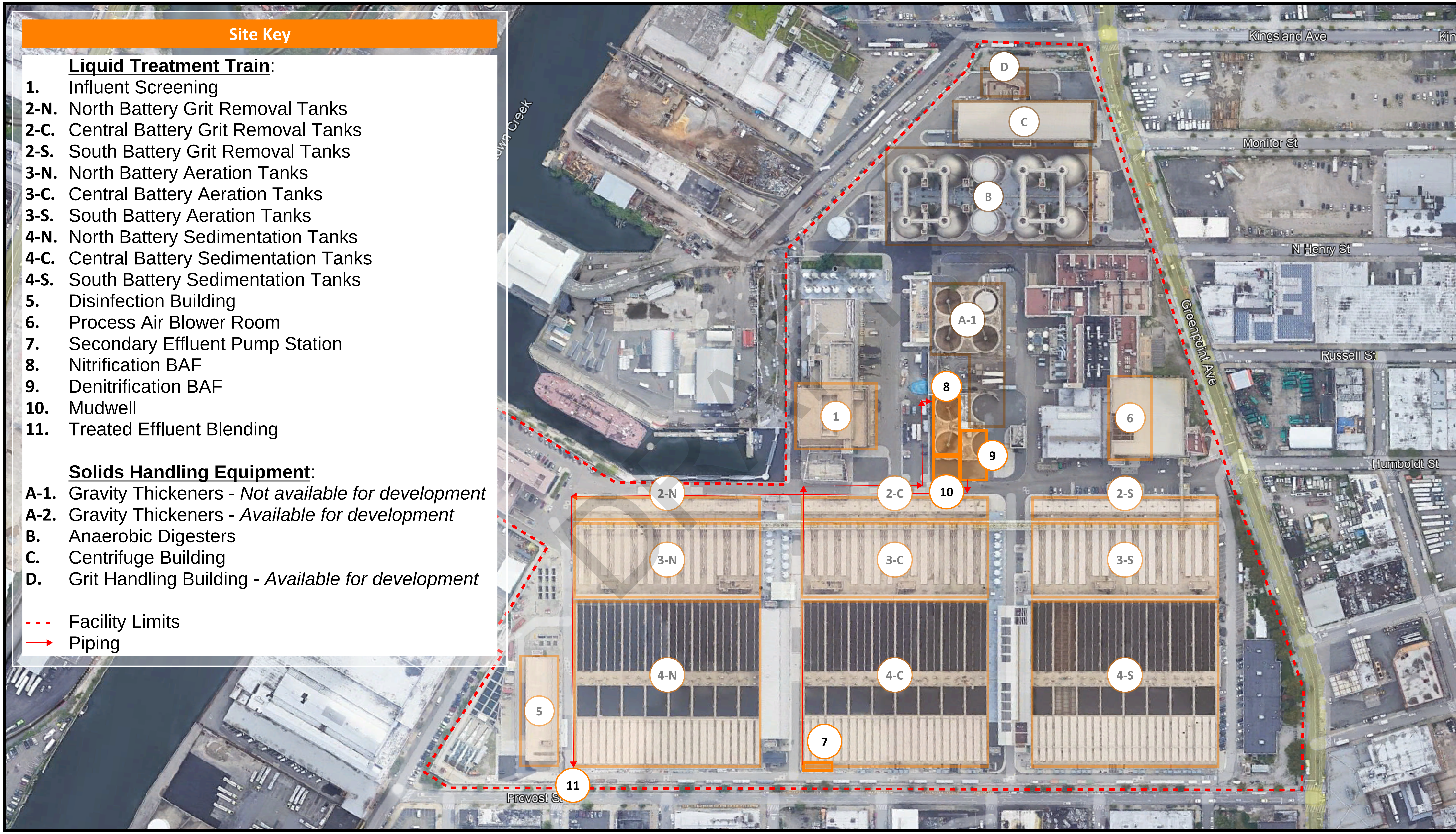

Figure C

Newtown Creek WRRF Conceptual Layout: Installation of Tertiary BAF Units

ARCADIS

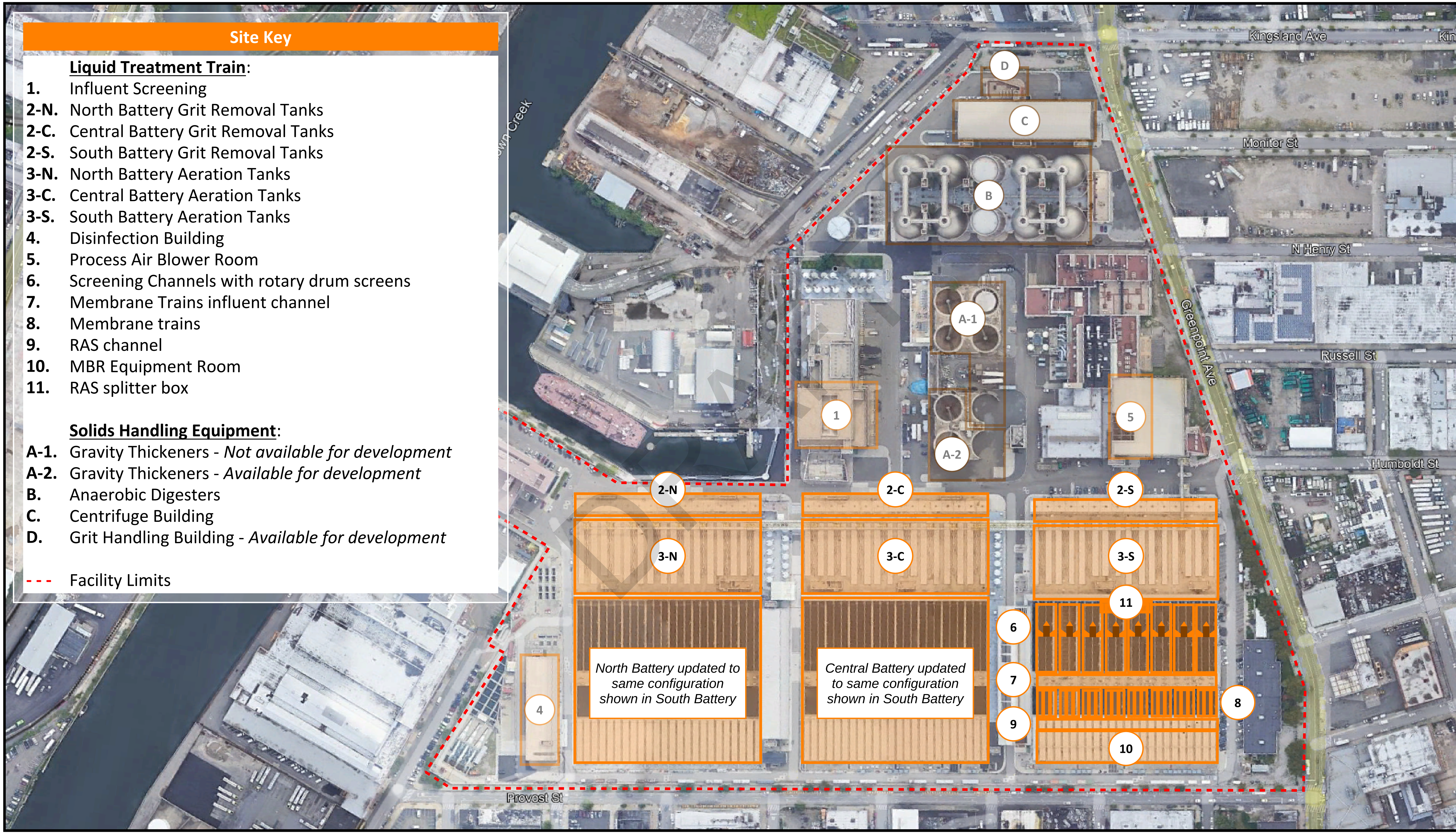

Figure D

Newtown Creek WRRF Conceptual Layout: Implementation of MBR

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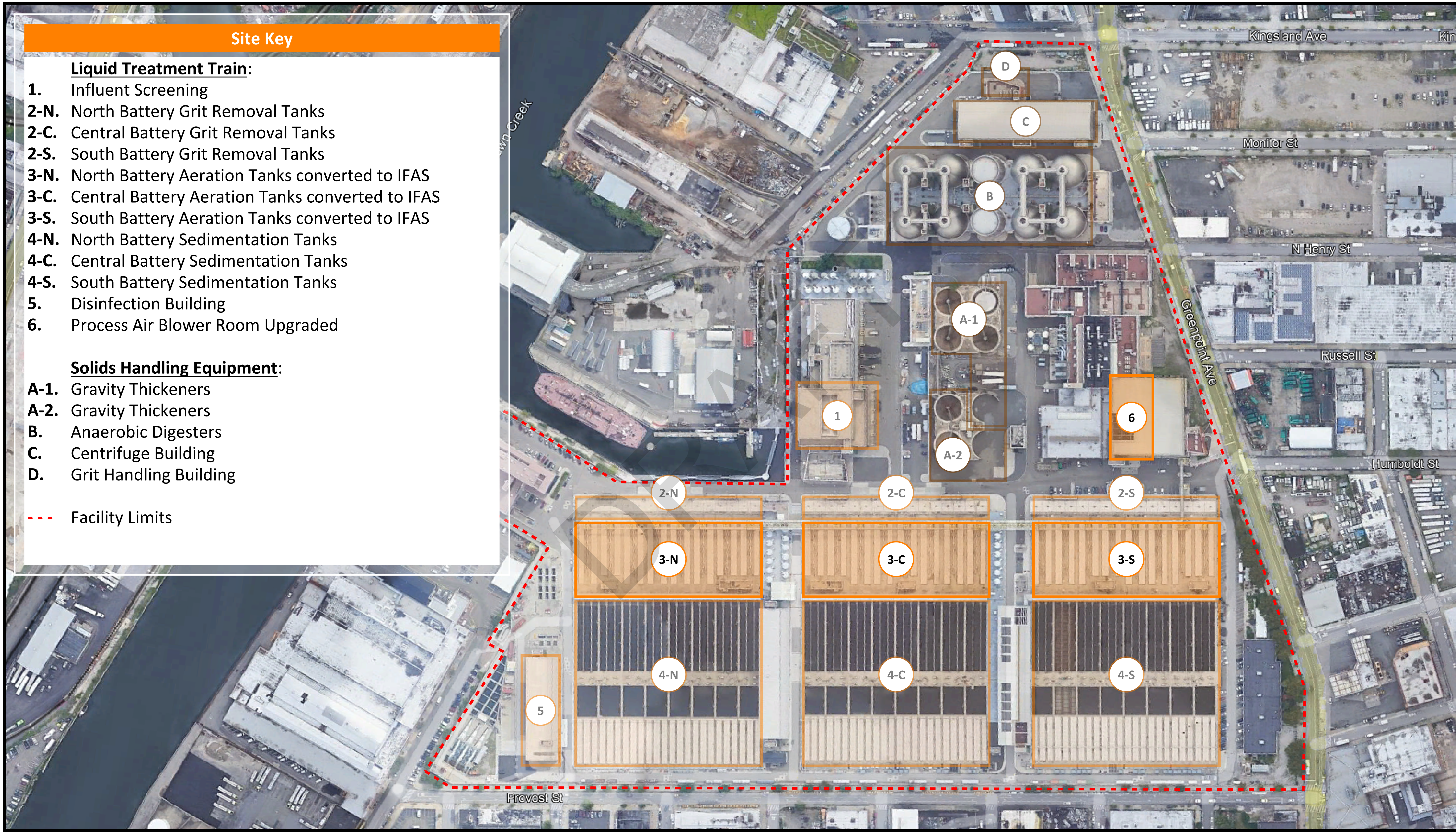

Figure E

Newtown Creek WRRF Conceptual Layout: Implementation of IFAS

Appendix A

Technical Memorandum 1 – Historical Operations and Performance Data Evaluation

THE CITY OF NEW YORK

NYC DEPARTMENT OF ENVIRONMENTAL PROTECTION

1429-ENGSVC-S-NC-008

BNR Feasibility Study for the Newtown Creek WRRF

TM 1 – Historical Operations and Performance Data Evaluation

March 31, 2022

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1. EXECUTIVE SUMMARY

The purpose of this technical memorandum (TM) is to summarize a review of historical plant operations and performance data for the NC WRRF, a high-rate conventional activated sludge WRRF owned and operated by DEP. This memorandum will document historical plant operations between 2015 and 2021 and will form the basis for the evaluation of the potential for BNR operations, which will be completed in subsequent project tasks. This TM will also include a review of regulatory drivers and programmatic considerations that will be considered during the BNR alternative analysis.

Evaluation Summary

Based on the historical operations and performance data review, the following conclusions can be made:

- **Influent Quality Data**

Historically observed NC WRRF influent data is very consistent and represents a low to medium strength wastewater. Mass loading peaking factors are also consistent and fall within expected ranges for Maximum Month, (MM), maximum week (MW), and maximum day (MD) conditions for a WRRF of this size. **Tables ES-1** and **ES-2** summarize yearly average raw influent concentrations and mass loadings for all key parameters.

Table ES-1: Yearly Average Influent Flow and Concentrations – 2015 to 2021

Year	Average Flow and Concentrations							
	Influent Flow, MGD	COD, mg/L	$cBOD_5$, mg/L	TSS, mg/L	NH3, mg/L-N	TKN mg/L	TP, mg/L	PO4, mg/L
2015	213	300	164	159	30	17	4.2	2.5
2016	211	341	166	158	30	21	4.1	2.5
2017	211	337	170	159	31	21	4.0	2.5
2018	220	---	170	165	31	20	3.8	2.4
2019	207	---	159	169	32	21	4.1	2.4
2020	190	---	140	148	28	18	4.0	2.2
2021 (Partial)	193	---	120	136	26	16	3.1	2.0
Avg (2015-2019)	213	326	166	162	31	20	4.1	2.5
Avg (2020-2021)	191	---	130	142	27	17	3.5	2.1

Table ES-2: Yearly Average Influent Loadings – 2015 to 2021

Year	Yearly Average Loadings						
	COD, lbd	$cBOD_5$, lbd	TSS, lbd	TKN, lbd	NH3, lbd	TP, lbd	PO4, lbd
2015	533,138	286,832	281,410	51,638	29,891	7,846	4,327
2016	578,330	287,406	277,744	52,390	35,781	6,928	4,184
2017	568,828	292,865	278,397	52,282	36,178	6,697	4,221
2018	---	302,274	298,793	54,805	35,083	6,894	4,233
2019	---	269,828	285,863	53,468	34,470	7,393	4,322
2020	---	222,560	236,634	43,231	28,015	6,273	3,473
2021 (Partial)	---	189,372	219,443	39,305	24,330	4,632	2,953
Avg (2015 to 2019)	560,099	287,841	284,441	52,917	34,281	7,152	4,257
Avg (2020 to 2021)	---	205,966	228,038	41,268	26,172	5,452	3,213

- **Plant Performance – Liquid Treatment Train**

A review of the liquid treatment data indicates that the WRRF is performing very well, with consistent process control and excellent effluent quality. Aerator effluent mixed liquid suspended solids (MLSS) concentrations have been very consistent through the data set, with an average value of 1,400 mg/L. Solids Retention Time (SRT) has also been very consistent, with an average value of approximately 1.5 days. Effluent quality in terms of $cBOD_5$ and TSS has been excellent and well below permit limits, with average values of 15 mg/L or below for both parameters. The removal rates for $cBOD_5$ and TSS is averaging approximately 93% removal for both parameters and appears to be well below the monthly and weekly limits.

In terms of nitrogen removal, the WRRF does not appear to nitrify, with effluent NO_3-N and NO_2-N concentrations below 2 mg/L year-round. This is expected given low SRT operation. Historical effluent Total Nitrogen (TN) concentrations and loadings average to approximately 17 mg/L-N and 30,500 lbd, respectively. This equates to an average yearly TN removal rate of approximately 41%.

- **Plant Performance – Solids Handling Treatment Train**

Available data for the solids handling train suggests that the plant has fair performance. A mass balance around sludge thickening indicates solids capture rates of approximately 80%, which is suboptimal performance for mechanical thickening but does not appear to be negatively impacting activated sludge performance. Anaerobic digestion is operating with more than sufficient HRTs for mesophilic anaerobic digestion, and a mass balance around the unit process suggests that volatile destruction is routinely as high as 60%. The amount of biogas produced per pound of volatile sludge destroyed ranges from 10.5 to almost 20 CF/lb of volatile destroyed, with an average long-term value of approximately 15 CF/d.

The full-plant process model calibration effort that will follow this initial data review task will help validate and confirm the observed historical plant operations and performance data. Particular attention will be paid to matching influent flows and mass loadings, as well as sludge production and the mass balance surrounding anaerobic digestion. Once the process model is calibrated, Arcadis will propose a set of influent flows and mass loadings which will represent **Current Conditions**. Once complete and agreed upon with all project stakeholders, Arcadis will develop a set of influent flows and loadings to represent the **Future Condition** based upon population and water usage projections provided by the DEP.

- **Regulatory Drivers**

The NC WRRF is one of six WRRFs that discharge to the East River, which is connected with the Long Island Sound, along with the Red Hook, Wards Island, Bowery Bay, Hunts Point, and Tallman Island WRRFs. The DEC issues and maintains individual SPDES permits for each of the facilities. However, nitrogen discharges to the East River are governed under a single aggregate 12-month rolling average in terms of total mass loading.

For the purposes of meeting the LIS TMDL established wasteload allocations for nitrogen discharge levels for the East River and the Long Island Sound, discharges from the Wards Island, Hunts Point, Bowery Bay, and Tallman Island WRRFs, as well as the Newtown Creek and Red Hook WRRFs, are aggregated and have a TN 12-month rolling average TMDL of 44,325 lbs/day, with an additional allowance for 2,143 lbs/day from CSOs and a total mass of 46,468 lbs/day. In in accordance with the LIS TMDL and the zoned wasteload allocations based on a point source's proximity to the Long Island Sound, the nitrogen loading discharged from the Newtown Creek and Red Hook WRRFs are assessed at 25% of their mass against the 12-month rolling average. Accordingly, 1 lb/day of TN discharged from these two WRRFs counts as 0.25 lb/day nitrogen to the East River based on their Zone 9 location established pursuant to the LIS TMDL.

- **Programmatic Considerations**

As part of OneNYC, the City's goal is to make the 14 in-City WRRFs have "net-zero" energy consumption and reduce GHG emission by 80%, by 2050. NC WRRF is the City's largest water resource recovery facility and its largest energy consumer. NC WRRF uses 124,412,700 kWh annually according to the NC WWTP Facility Energy Audit report (for FY 2010-2011), leading to annual electrical operating expense of $12.60 M/year (excluding labor and maintenance) and 36,000 MT of CO2 equivalence per year. The process air blowers account for 30,782,862 kWh annually (25% of plant consumption, 33% of process consumption), making it the single greatest consumer at the plant.

Any changes in process air requirements to facilitate BNR may have significant impacts to the electrical consumption for secondary treatment at the plant. The BNR Feasibility Study will track changes in electrical consumption and GHG emissions for each alternative.

2. INTRODUCTION AND PLANT BACKGROUND

The purpose of this technical memorandum is to summarize a review of historical plant operations and performance data for the NC WRRF, a high-rate conventional activated sludge wastewater treatment facility owned and operated by the DEP. This memorandum will document historical plant operations and form the basis for a full-plant process model calibration and the evaluation of the potential for future TN removal operations.

The WRRF is rated to treat 310 MGD on a 12-month rolling average basis and is required to treat a minimum of up to 700 MGD during wet weather operations. The WRRF is currently permitted under the DEC SPDES permit number NY0026204. **Table 1** summarizes the current permit requirements for flow, 5-day carbonaceous biochemical oxygen demand ($cBOD_5$), total suspended solids (TSS), ammonia (NH_3-N), fecal coliform, and total residual chlorine.

Table 1: NC WRRF SPDES Permit Requirements

Parameter	Limit Basis	Value	
Flow, MGD	12-Month Rolling Average	310 MGD	
$cBOD_5$	Monthly Average	25 mg/L	65,000 lbd
	Weekly Average	40 mg/L	100,000 lbd
TSS	Monthly Average	30 mg/L	78,000 lbd
	Weekly Average	45 mg/L	120,000 lbd
	Daily Maximum	50 mg/L	---
NH_3-N	Monthly Average	41 mg/L	---
Fecal Coliform	30-Day Geometric Mean	200/100 mL	
	7-Day Geometric Mean	400/100 mL	
Total Residual Chlorine	Daily Maximum	0.23 mg/L	

A site plan of the WRRF is shown in **Figure 1**. The current liquid treatment train of the WRRF consists of the following unit processes:

- Raw influent pumping from Manhattan Pump Station and Brooklyn/Queens Pump Station
- Raw influent screening and grit removal
- Step-feed activated sludge aeration basins (fully aerobic)
- Secondary clarification
- Effluent chlorination
- Effluent dechlorination

Treated effluent is then discharged to the East River. The solids treatment train consists of the following unit processes:

- Wasting from the Return Activate Sludge (RAS) system
- Mechanical thickening of WAS via thickened centrifuges
- Co-digestion of WAS and outside food waste vis mesophilic anaerobic digestion
- Marine hauling of digested sludge to outside facilities for dewatering and ultimate disposal

A simplified process flow diagram is shown in **Figure 2**.

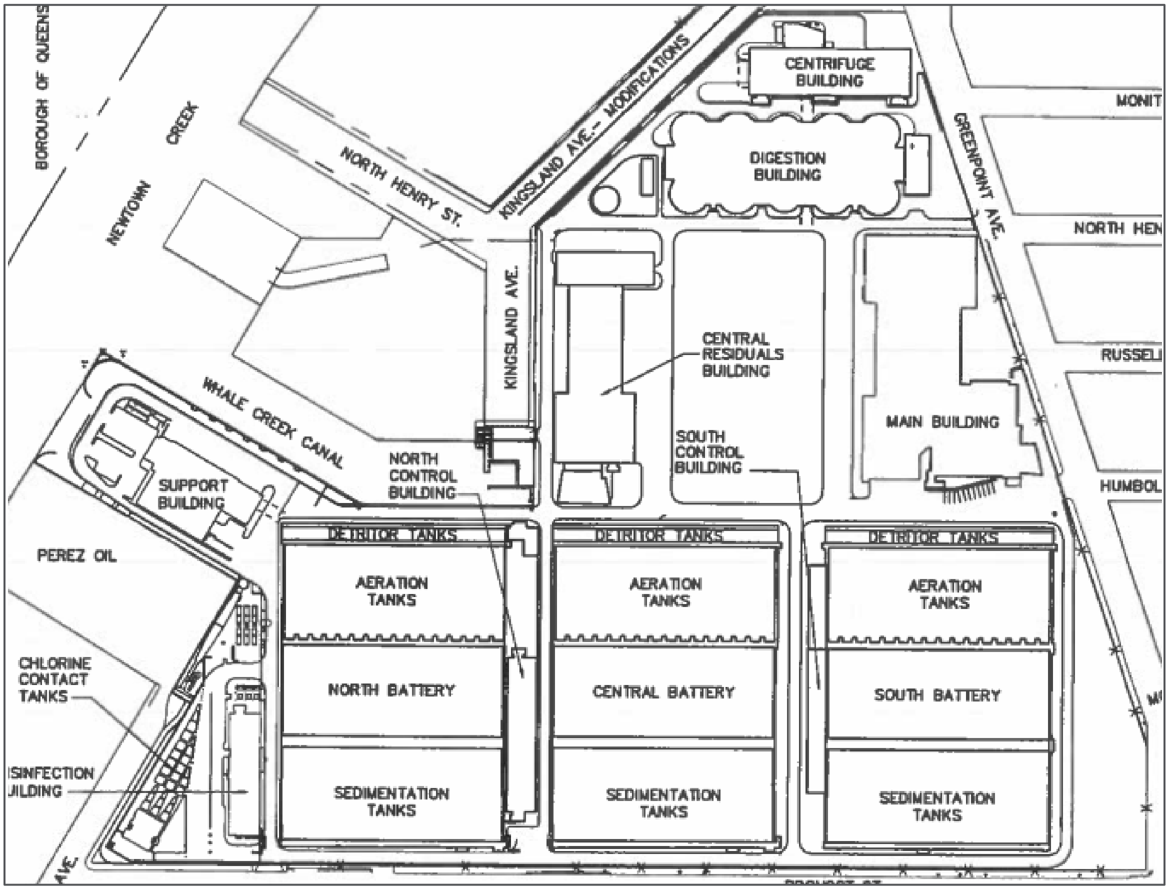

Figure 1: NC Site Plan

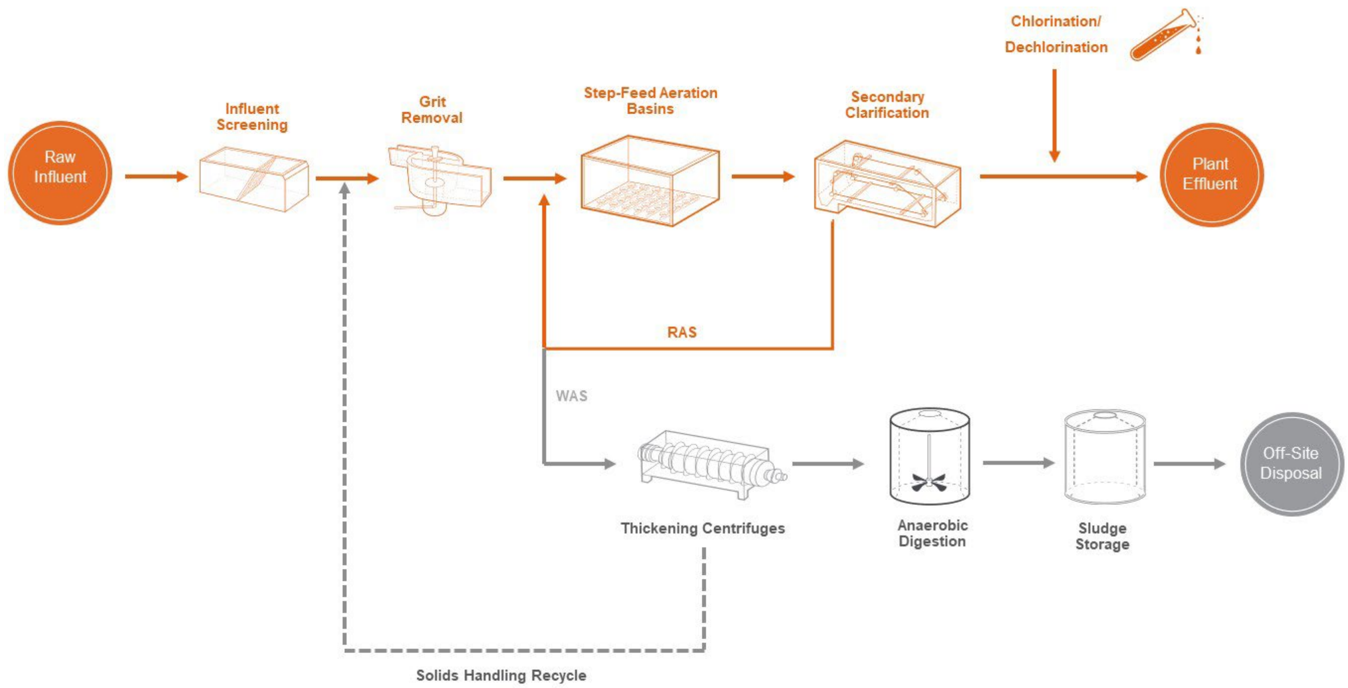

Figure 2: NC WRRF Simplified Process Flow Diagram

3. HISTORICAL OPERATIONS AND PERFORMANCE DATA

As an initial step in the evaluation of nitrogen removal potential at the NC WRRF, Arcadis reviewed and analyzed the previous six years of plant performance operations data (January 2015 to March 2021). The following sections of this technical memorandum summarize historical plant operations and performance, including influent flow and mass loadings, activated sludge operation and performance, final effluent quality, and solids handling operations and performance.

Please note that for the year 2020, there was an interruption of data collection for most parameters for roughly half a year starting in March 2020, presumably due to the COVID-19 pandemic.

3.1 Liquid Treatment Train

3.1.1 Raw Influent Flows, Concentrations and Loadings

Figure 3 summarizes daily average influent flow between January 2015 and March 2021. **Table 2** summarizes yearly average influent flow, as well as the maximum month (MM), maximum week (MW), and maximum data (MD) influent flow rates for each year. Also shown are the associated flow peaking factors for each condition.

As shown, average daily plant influent flow averaged approximately 213 MGD between 2015 and 2019, while 2020 saw a decrease in influent plant flow, with values closer to 191 MGD. The reduction of influent flow is likely caused by the reduction in office/commuters entering the offices and business of lower Manhattan, Brooklyn, and Queens. The associated peaking factors for MM, MW, and MD conditions are reasonable for a plant of this size, with average values of 1.11, 1.33 and 2.30, respectively.

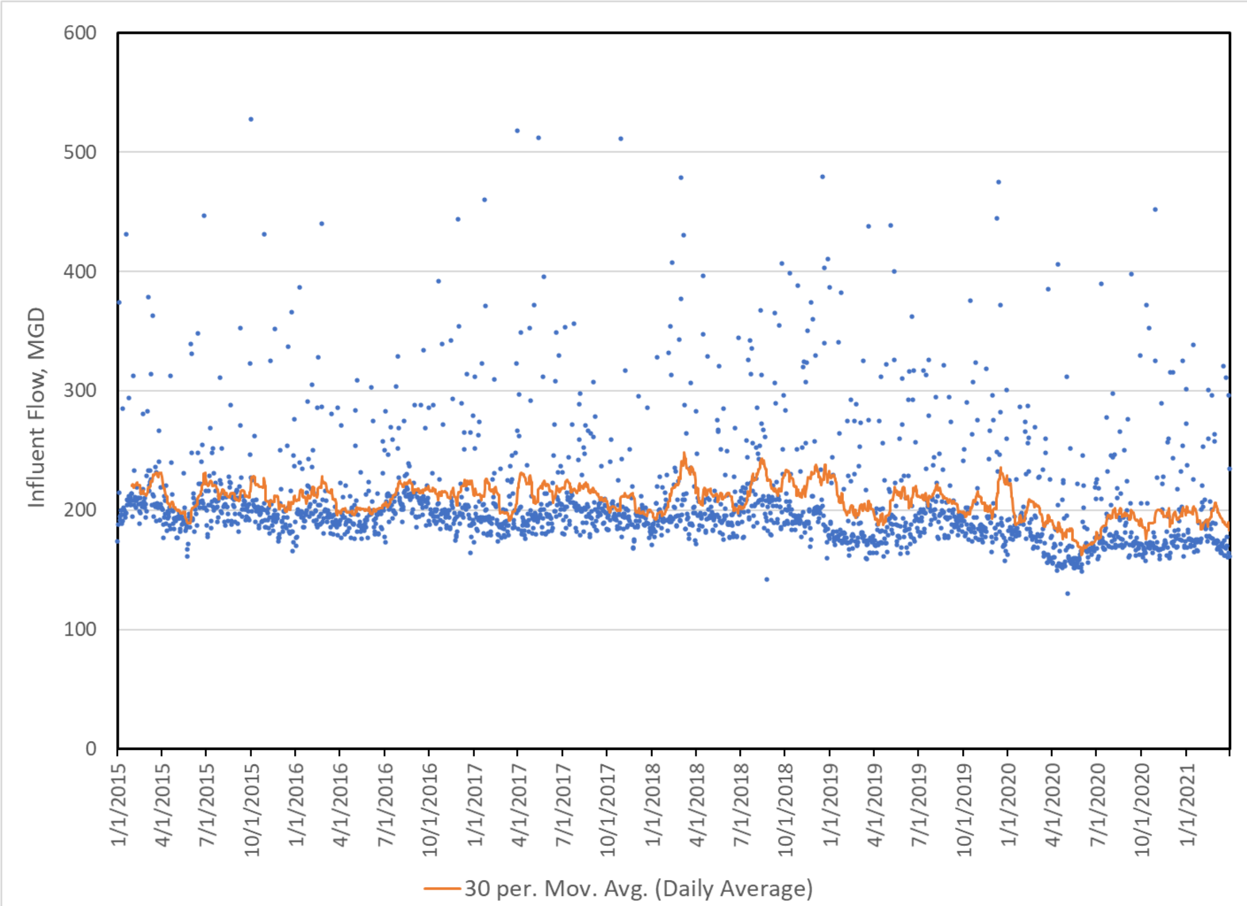

Figure 3: NC Influent Flow in MGD – 2015 to 2021

Table 2: Yearly Influent Flow and Peaking Factors – 2015 to 2021

Year	Influent Flow, MGD				Peaking Factors		
	AA	MM	MW	MD	MM	MW	MD
2015	213	232	280	528	1.09	1.31	2.48
2016	211	229	258	444	1.08	1.22	2.10
2017	211	231	287	518	1.09	1.36	2.45
2018	220	249	301	480	1.13	1.37	2.18
2019	207	236	288	475	1.14	1.40	2.30
2020	190	222	243	452	1.17	1.28	2.38
2021 (Partial)	193	206	222	339	1.07	1.15	1.76
Avg (2015-2019)	213	235	283	489	1.11	1.33	2.30
Avg (2020-2021)	191	214	233	396	1.12	1.22	2.07

Observed historical influent concentrations and loadings were analyzed based on a statistical analysis, whereby the influent data was screened (outliers removed) by assuming a log-normal distribution, calculating the standard deviation of the data set for each parameter, and removing data points where concentrations were greater than or less than two or three standard deviations of the mean. The average concentrations and loadings were calculated based on data that was within two standard deviations of the mean., MM, MW, and MD loadings were calculated based on data within three standard deviations of the mean.

It is important to note that there was limited data available for total chemical oxygen demand (COD), total phosphorus (TP), and ortho-phosphate (PO_4-P), with analysis being conducted twice per calendar month. As such statistical analysis was not performed for these parameters.

Figure 4 summarizes influent concentrations and loadings for COD. As shown, available data was limited, with concentration data available between 2015 and 2017.

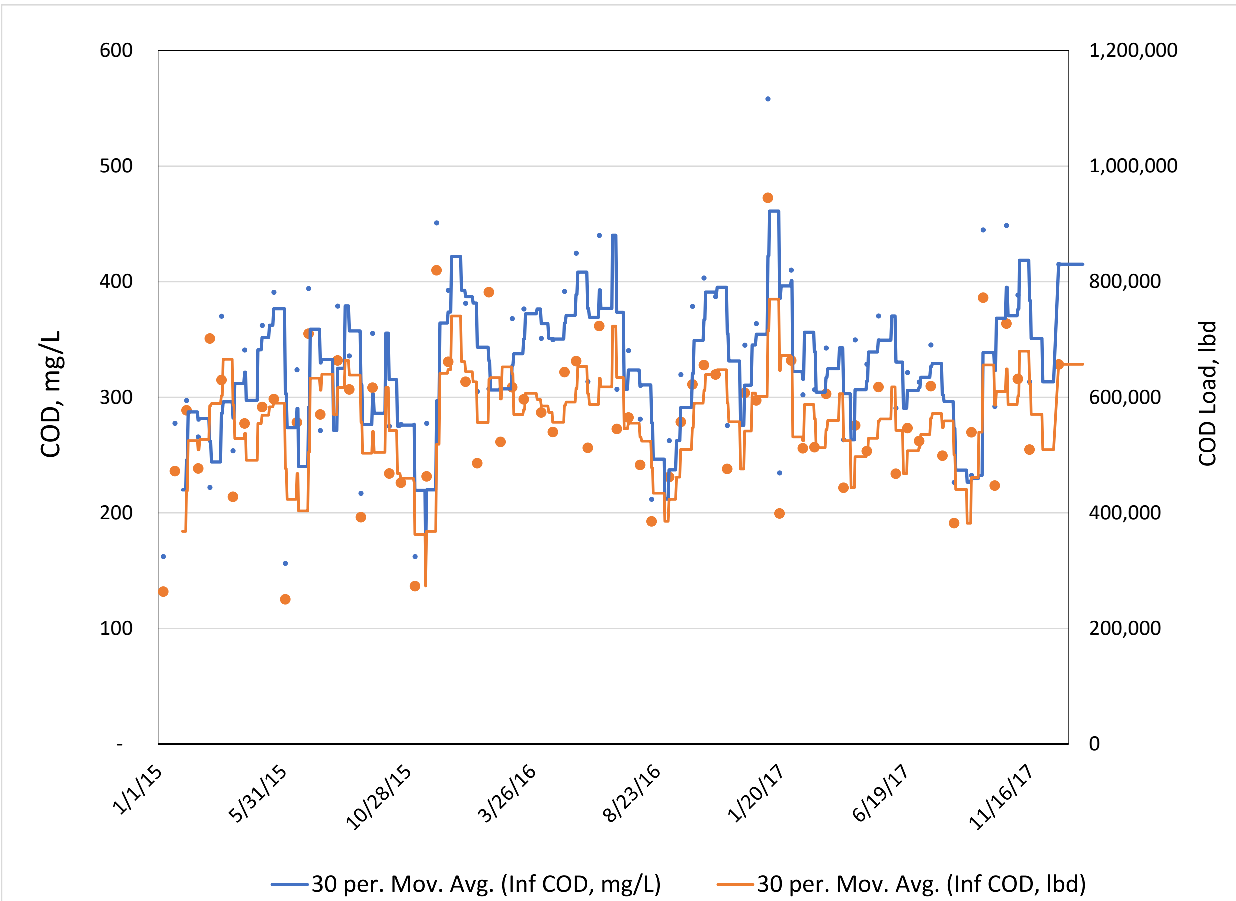

Figure 4: Influent COD Concentrations and Loadings– 2015 to 2017

Table 3: Yearly Influent COD Loadings and Peaking Factors – 2015 to 2021

Year	AA Concentration, mg/L	Loading, lbd				Peaking Factors		
		AA	MM	MW	MD	MM	MW	MD
2015	300	533,138	740,718	---	---	1.39	---	---
2016	341	578,330	723,204	---	---	1.25	---	---
2017	337	568,828	769,922	---	---	1.35	---	---
2018	---	---	---	---	---	---	---	---
2019	---	---	---	---	---	---	---	---
2020	---	---	---	---	---	---	---	---
2021 (Partial)	---	---	---	---	---	---	---	---
Avg (2015-2019)	326	560,099	744,615	---	---	1.33	---	---
Avg (2020-2021)	---	---	---	---	---	---	---	---

Figure 5 through **Figure 9** summarize observed influent concentrations and loadings for $cBOD_5$, TSS, TKN, NH_3-N, TP, and PO_4-P. **Table 4** through **Table** 8 summarize the statistically analyzed and screened influent concentrations, loadings, and loading peaking factors for all available influent parameters.

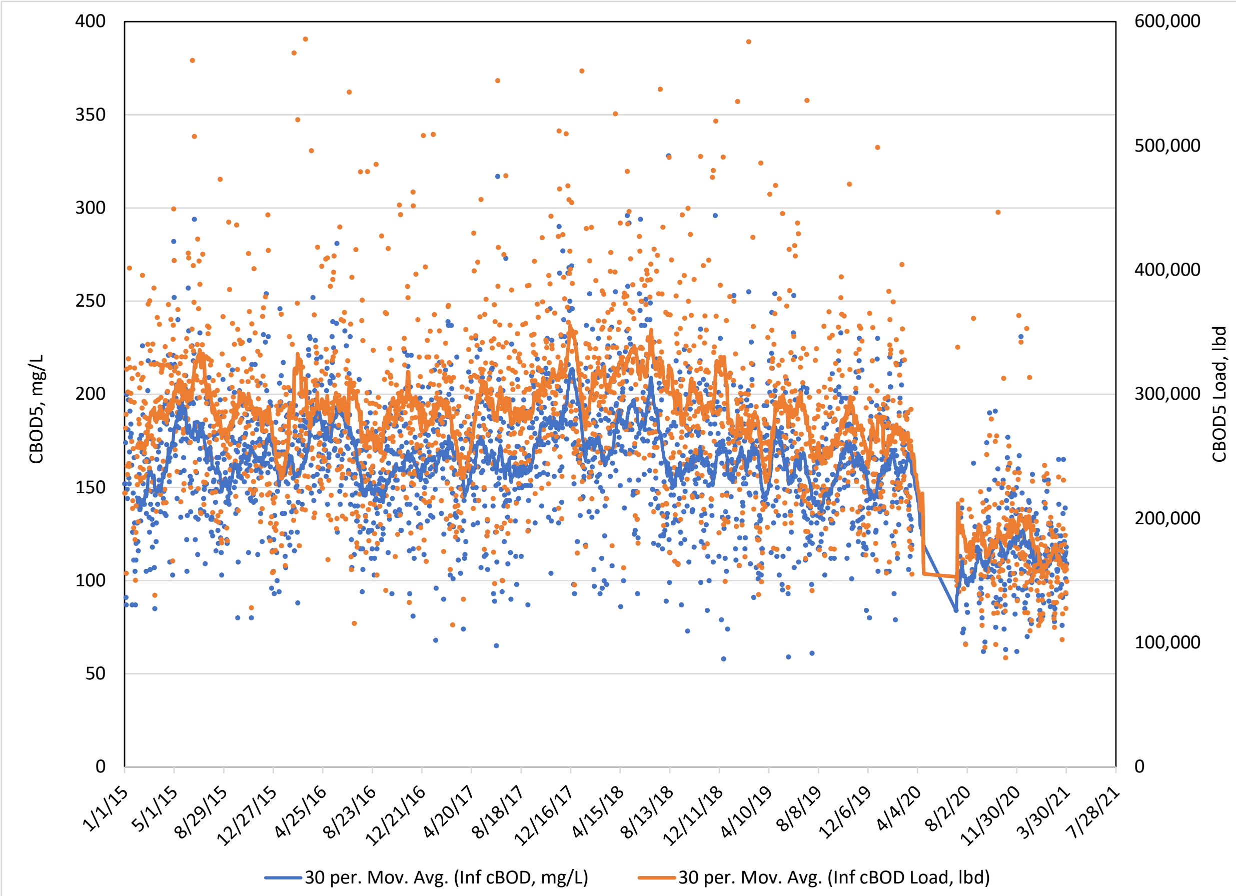

Figure 5: Influent cBOD5 Concentrations and Loadings– 2015 to 2021

Table 4: Yearly Influent cBOD$_5$ Loadings and Peaking Factors – 2015 to 2021

Year	AA Concentration, mg/L	Loading, lbd				Peaking Factors		
		AA	MM	MW	MD	MM	MW	MD
2015	164	286,832	329,748	389,667	568,855	1.15	1.36	1.98
2016	166	287,406	319,219	345,133	454,013	1.11	1.20	1.58
2017	170	292,865	347,513	406,395	509,786	1.19	1.39	1.74
2018	170	302,274	343,528	391,186	693,805	1.14	1.29	2.30
2019	159	269,828	300,381	378,638	745,154	1.11	1.40	2.76
2020	140	222,560	285,891	313,265	446,646	1.28	1.41	2.01
2021 (Partial)	120	189,372	200,804	215,440	324,997	1.06	1.14	1.72
Avg (2015-2019)	166	287,841	328,078	382,204	594,322	1.14	1.33	2.07
Avg (2020-2021)	130	205,966	243,348	264,353	385,821	1.17	1.27	1.86

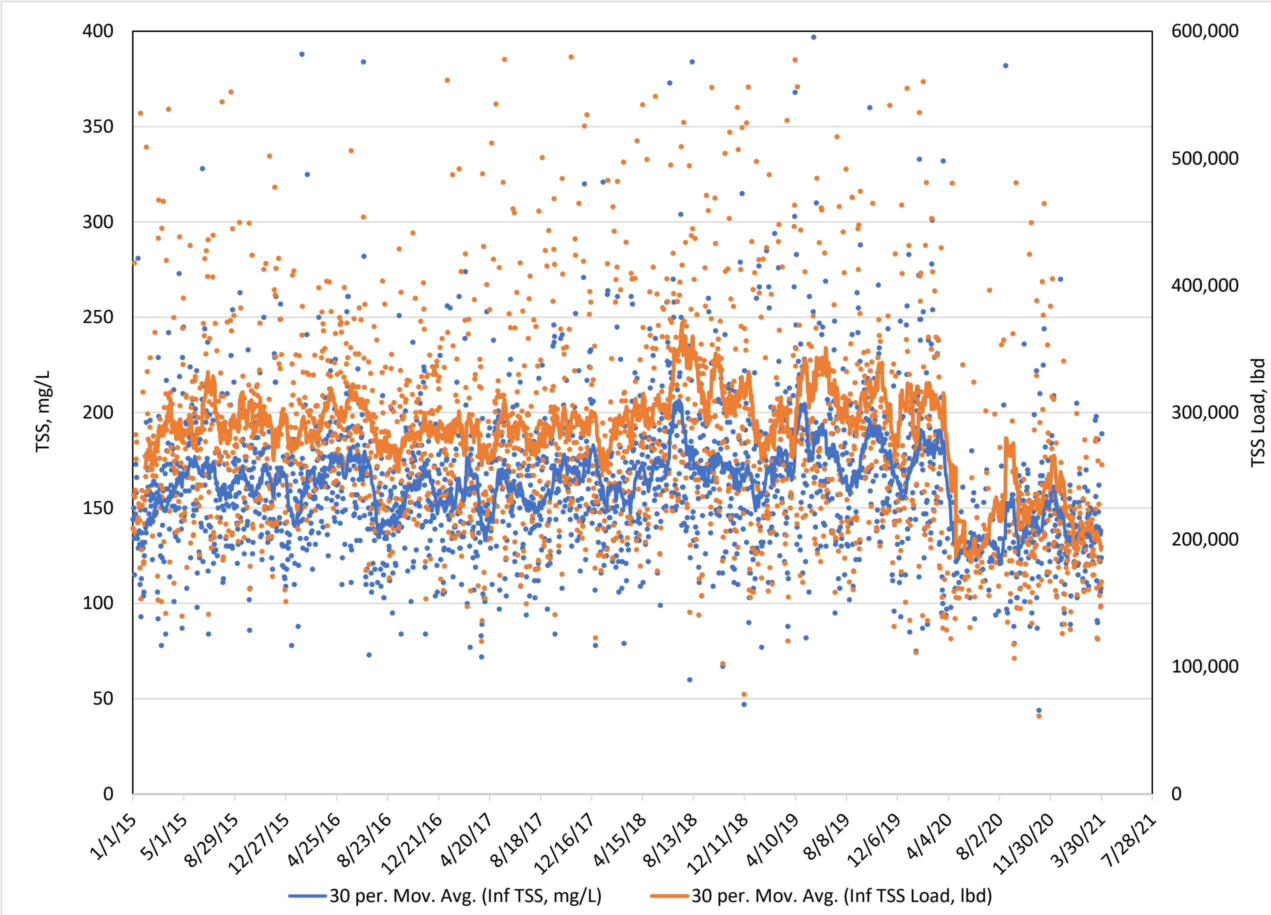

Figure 6: Influent TSS Concentrations, Loadings– 2015 to 2021

Table 5: Yearly Influent TSS Loading and Peaking Factors – 2015 to 2021

Year	AA Concentration, mg/L	Influent TSS, lbd				Peaking Factors		
		AA	MM	MW	MD	MM	MW	MD
2015	159	281,410	316,312	381,505	774,277	1.12	1.36	2.75
2016	158	277,744	318,328	358,615	774,819	1.15	1.29	2.79
2017	159	278,397	310,547	376,486	686,924	1.12	1.35	2.47
2018	165	298,793	350,181	400,977	749,409	1.17	1.34	2.51
2019	169	285,863	328,435	423,160	982,969	1.15	1.48	3.44
2020	148	236,634	323,970	391,962	733,055	1.37	1.66	3.10
2021 (Partial)	136	219,443	246,472	260,982	529,592	1.12	1.19	2.41
Avg (2015-2019)	162	284,441	324,761	388,149	793,680	1.14	1.36	2.79
Avg (2020-2021)	142	228,038	285,221	326,472	631,323	1.25	1.42	2.76

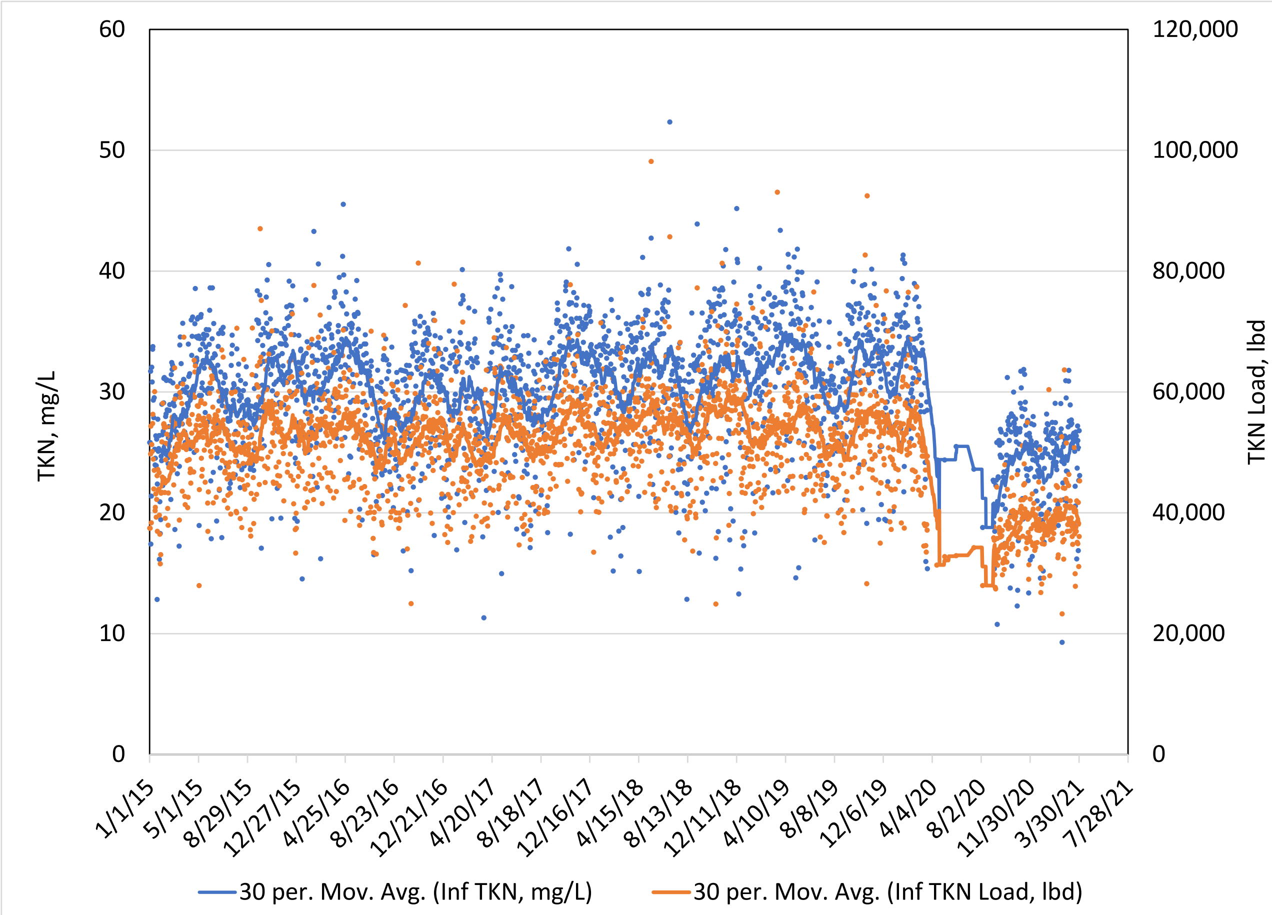

Figure 7: Influent TKN Concentrations and Loadings – 2015 and 2021

Table 6: Yearly Influent TKN Loading and Peaking Factors – 2015 to 2021

Year	AA Concentration, mg/L	Influent TKN, lbd				Peaking Factors		
		AA	MM	MW	MD	MM	MW	MD
2015	30	51,638	59,101	64,476	87,056	1.14	1.25	1.69
2016	30	52,390	56,554	60,611	81,377	1.08	1.16	1.55
2017	30	52,282	58,688	63,628	77,884	1.12	1.22	1.49
2018	31	54,805	60,373	65,956	98,187	1.10	1.20	1.79
2019	32	53,468	58,070	62,612	93,086	1.09	1.17	1.74
2020	28	43,231	56,612	61,167	77,453	1.31	1.41	1.79
2021 (Partial)	25	39,305	41,833	47,628	63,655	1.06	1.21	1.62
Avg (2015-2019)	31	52,917	58,557	63,457	87,518	1.11	1.20	1.65
Avg (2020-2021)	27	41,268	49,222	54,397	70,554	1.19	1.31	1.71

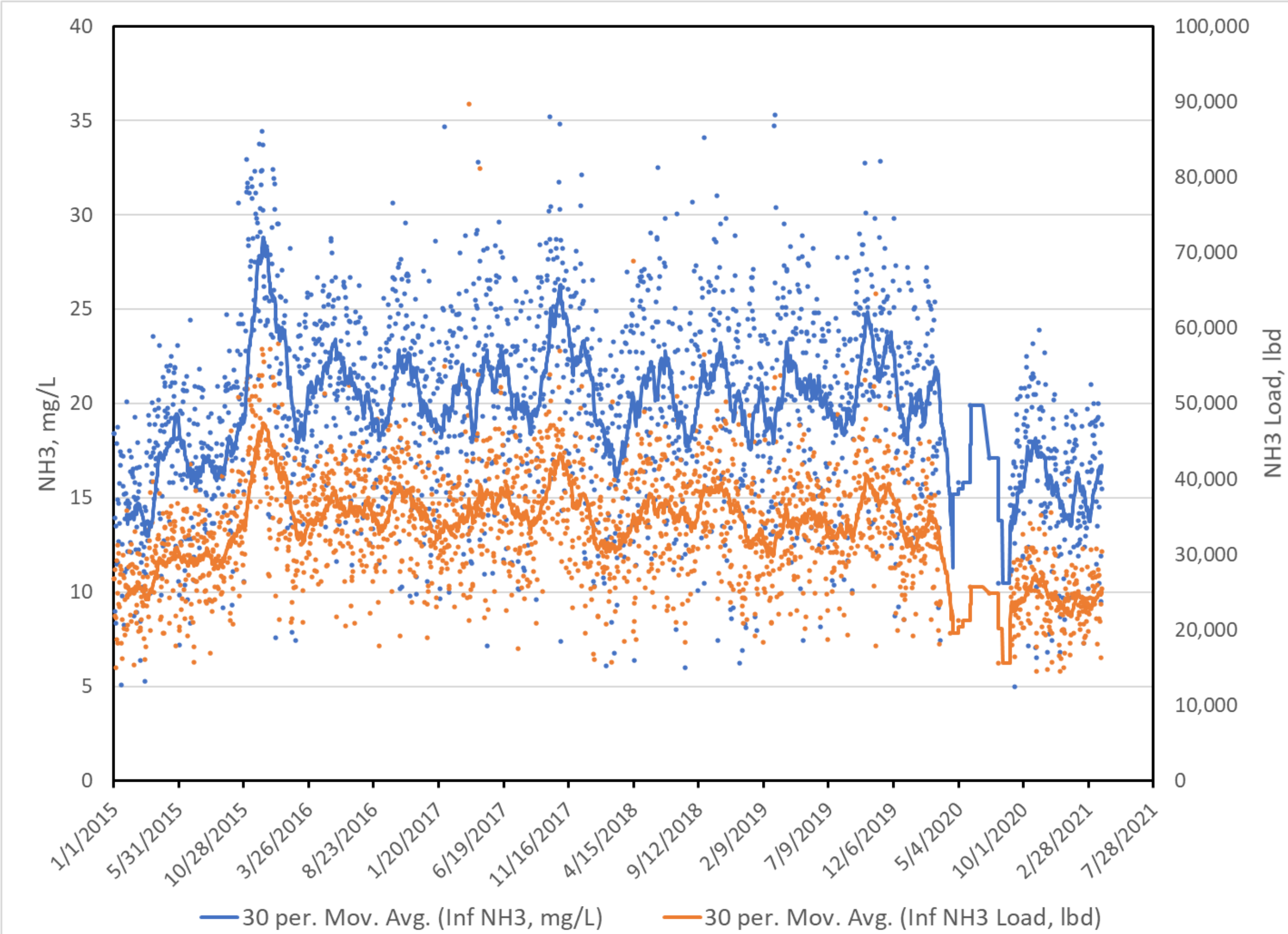

Figure 8: Influent Ammonia Concentrations and Loadings – 2015 and 2021

Table 7: Yearly Influent Ammonia Loading and Peaking Factors – 2015 to 2021

Year	AA Concentration, mg/L	Influent NH3, lbd				Peaking Factors		
		AA	MM	MW	MD	MM	MW	MD
2015	17	29,891	46,146	49,665	53,411	1.54	1.66	1.79
2016	21	35,781	46,437	47,969	57,900	1.30	1.34	1.62
2017	21	36,178	43,067	47,319	89,707	1.19	1.31	2.48
2018	20	35,083	39,303	42,975	68,864	1.12	1.22	1.96
2019	21	34,470	40,454	42,879	64,502	1.17	1.24	1.87
2020	18	28,015	35,292	38,421	44,944	1.26	1.37	1.60
2021 (Partial)	16	24,330	25,119	27,015	39,828	1.03	1.11	1.64
Avg (2015 to 2019)	20	34,281	43,081	46,161	66,877	1.27	1.36	1.94
Avg (2020 to 2021)	17	26,172	30,206	32,718	42,386	1.15	1.24	1.62

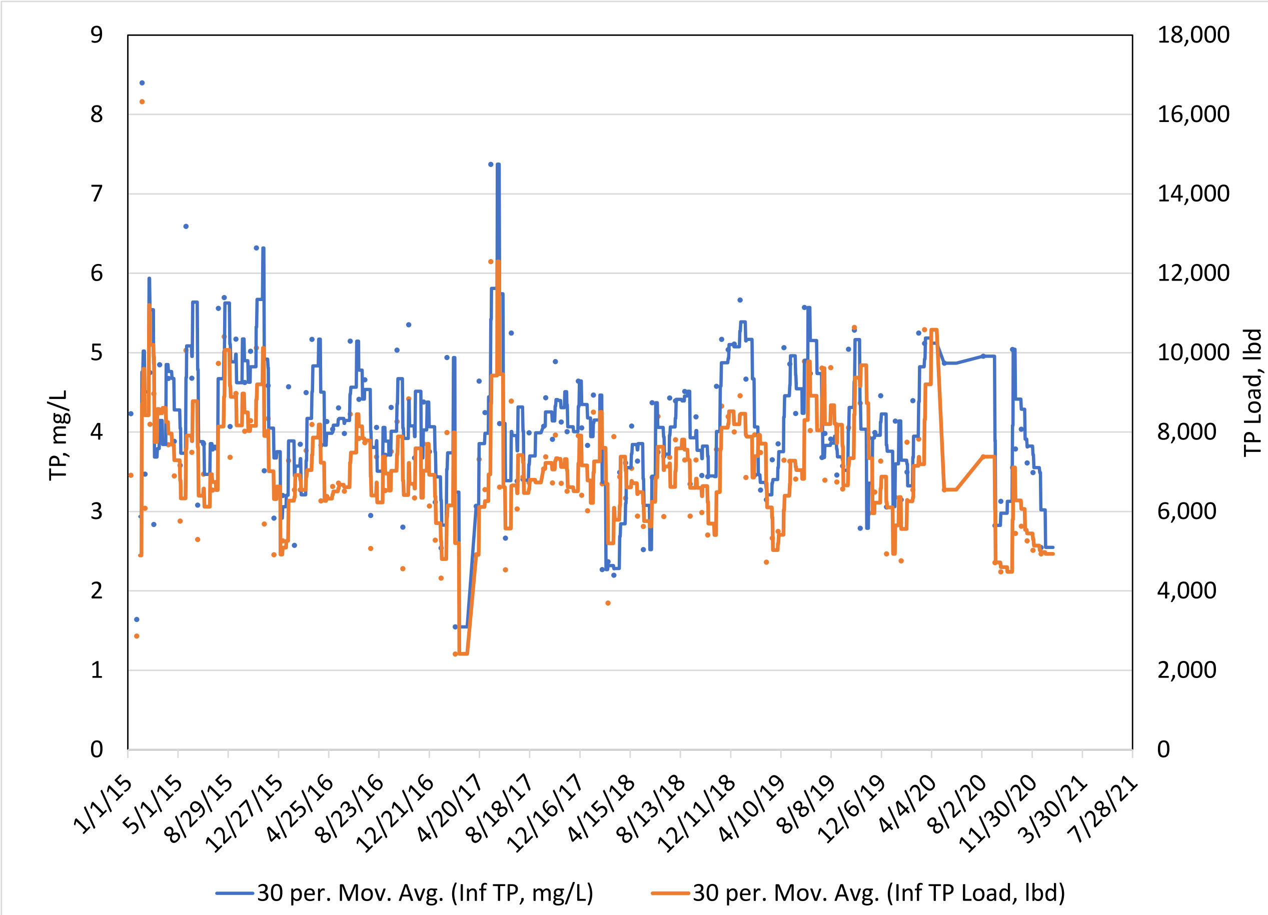

Figure 9: Influent Total Phosphorus Concentrations and Loadings – 2015 to 2021

Table 8: Yearly Influent Total Phosphorus Loading and Peaking Factors – 2015 to 2021

Year	AA Concentration, mg/L	Influent TP, lbd				Peaking Factors		
		AA	MM	MW	MD	MM	MW	MD
2015	4.23	7,846	11,202	---	---	1.43	---	---
2016	4.10	6,928	8,454	---	---	1.22	---	---
2017	3.97	6,697	12,299	---	---	1.84	---	---
2018	3.83	6,894	8,525	---	---	1.24	---	---
2019	4.14	7,393	9,783	---	---	1.32	---	---
2020	3.99	6,273	10,580	---	---	1.69	---	---
2021 (Partial)	3.09	4,632	5,126	---	---	1.11	---	---
Avg (2015 to 2019)	4.06	7,152	10,053	---	---	1.41	---	---
Avg (2020 to 2021)	3.54	5,452	7,853	---	---	1.44	---	---

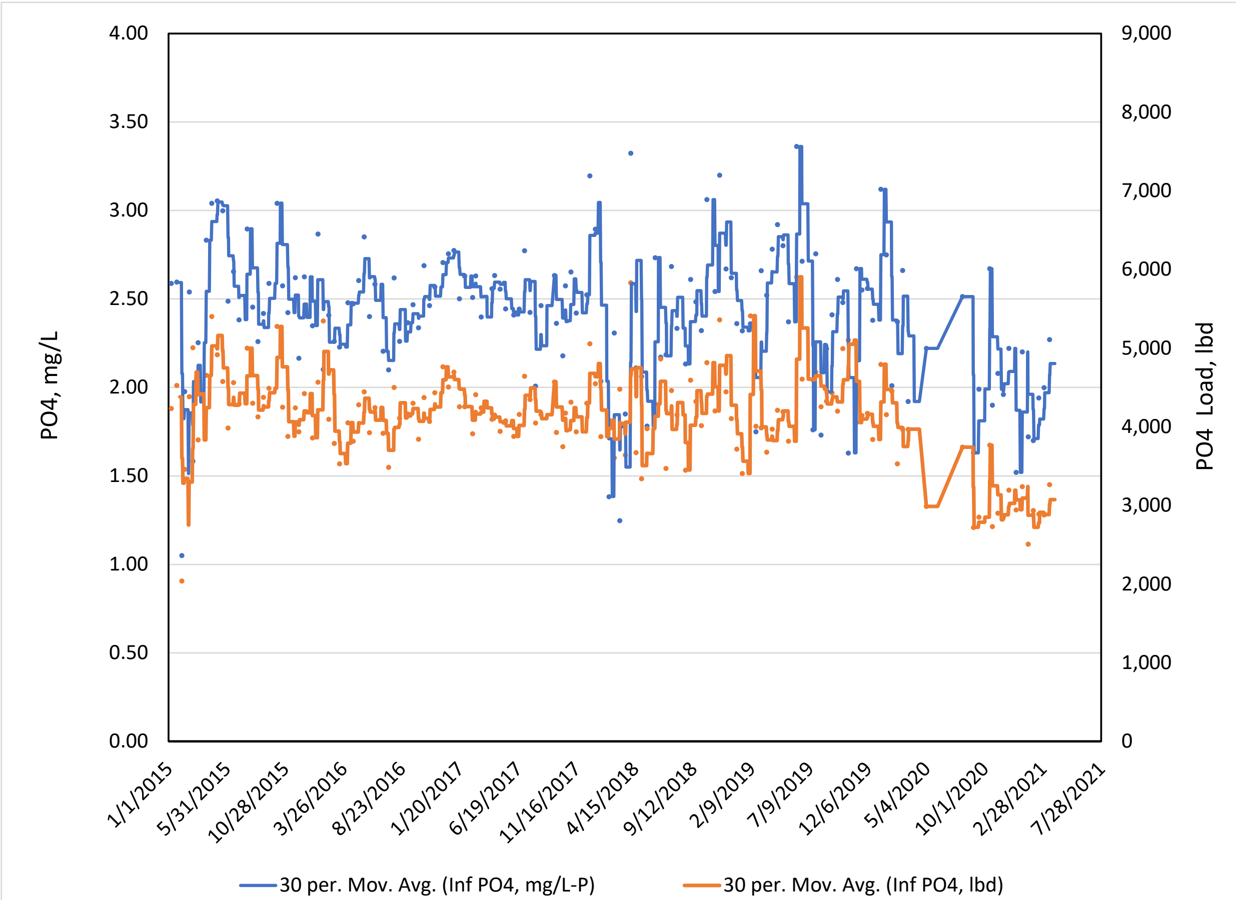

Figure 10: Influent Ortho-Phosphate Concentrations and Loadings – 2015 to 2021

Table 9: Yearly Influent Ortho-Phosphate Loading and Peaking Factors – 2015 to 2021

Year	AA Concentration, mg/L	Influent TP, lbd				Peaking Factors		
		AA	MM	MW	MD	MM	MW	MD
2015	2.5	4,327	5,276	---	---	1.22	---	---
2016	2.5	4,184	4,957	---	---	1.18	---	---
2017	2.5	4,221	4,679	---	---	1.11	---	---
2018	2.4	4,233	4,903	---	---	1.16	---	---
2019	2.4	4,322	5,905	---	---	1.37	---	---
2020	2.2	3,473	4,794	---	---	1.38	---	---
2021 (Partial)	2.0	2,953	3,241	---	---	1.10	---	---
Avg (2015 to 2019)	2.5	4,257	5,144	---	---	1.21	---	---
Avg (2020 to 2021)	2.1	3,213	4,017	---	---	1.25	---	---

Table 10 and **Table 11** summarize the yearly average concentrations and loadings for all key raw influent parameters.

Table 10: Yearly Average Influent Concentrations – 2015 to 2021

Year	Average Concentrations						
	COD, mg/L	$cBOD_5$, mg/L	TSS, mg/L	NH3-N, mg/L	TKN, mg/L	TP, mg/L	PO4-P, mg/L
2015	300	164	159	17	30	4.2	2.5
2016	341	166	158	21	30	4.1	2.5
2017	337	170	159	21	31	4.0	2.5
2018	---	170	165	20	31	3.8	2.4
2019	---	159	169	21	32	4.1	2.4
2020	---	140	148	18	28	4.0	2.2
2021 (Partial)	---	120	136	16	26	3.1	2.0
Avg (2015 to 2019)	326	166	162	20	31	4.1	2.5
Avg (2020 to 2021)	---	130	142	17	27	3.5	2.1

Table 11: Yearly Average Influent Loadings – 2015 to 2021

Year	Yearly Average Loadings						
	COD, lbd	$cBOD_5$, lbd	TSS, lbd	TKN, lbd	NH3, lbd	TP, lbd	PO4, lbd
2015	533,138	286,832	281,410	51,638	29,891	7,846	4,327
2016	578,330	287,406	277,744	52,390	35,781	6,928	4,184
2017	568,828	292,865	278,397	52,282	36,178	6,697	4,221
2018	---	302,274	298,793	54,805	35,083	6,894	4,233
2019	---	269,828	285,863	53,468	34,470	7,393	4,322
2020	---	222,560	236,634	43,231	28,015	6,273	3,473
2021 (Partial)	---	189,372	219,443	39,305	24,330	4,632	2,953
Avg (2015 to 2019)	560,099	287,841	284,441	52,917	34,281	7,152	4,257
Avg (2020 to 2021)	---	205,966	228,038	41,268	26,172	5,452	3,213

Figure 11 and Table 12 summarize effluent wastewater temperature between 2015 and 2021. As shown in **Table 12** the yearly average effluent wastewater temperature averages to 21 degrees C, with maximum 30 day and minimum 7 day running average values of 26 and 16 degrees C, respectively.

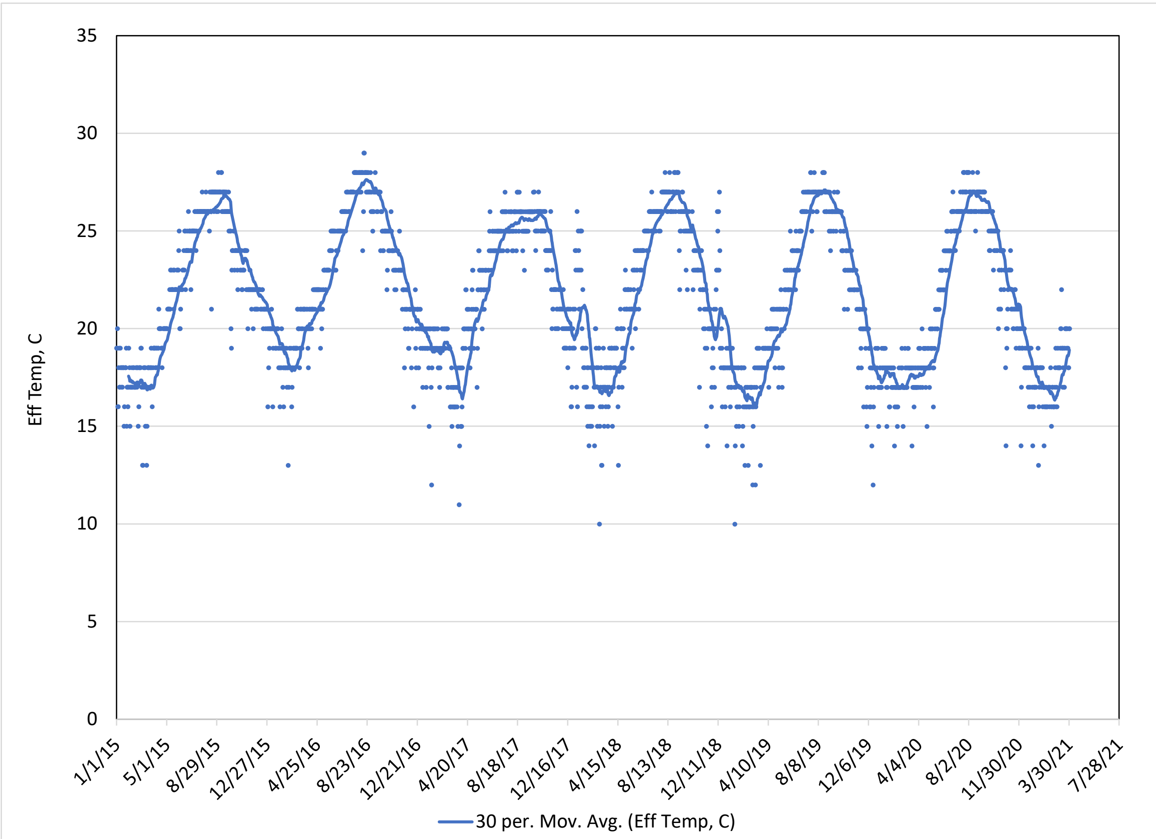

Figure 11: Effluent Wastewater Temperature – 2015 to 2021

Table 12: Yearly Effluent Temperature – 2015 to 2021

Year	Effluent Temperature (°C)		
	Annual Average	Minimum 7 day	Maximum 30 day
2015	21	15	27
2016	22	15	27
2017	22	16	26
2018	21	17	27
2019	22	16	27
2020	21	17	27
2021 (Partial)	17	15	18
Average	**21**	**16**	**26**

3.1.2 Biological Treatment

This section summarizes historical operations and performance of the biological treatment train, comprised of the step-feed aeration basins and secondary clarifiers. The data includes mixed liquor suspended solids (MLSS) concentrations, mixed liquor volatile suspended solids (MLVSS) concentration, return activated sludge (RAS) TSS concentrations, solids retention time (SRT), sludge volume index (SVI), process aeration, and final effluent quality.

3.1.2.1 Return Activated Sludge Flow

Figure 12 summarizes historical RAS flow between 2015 and 2021. As shown, historical RAS rates provided by the DEP appear to be the same for much of the data set.

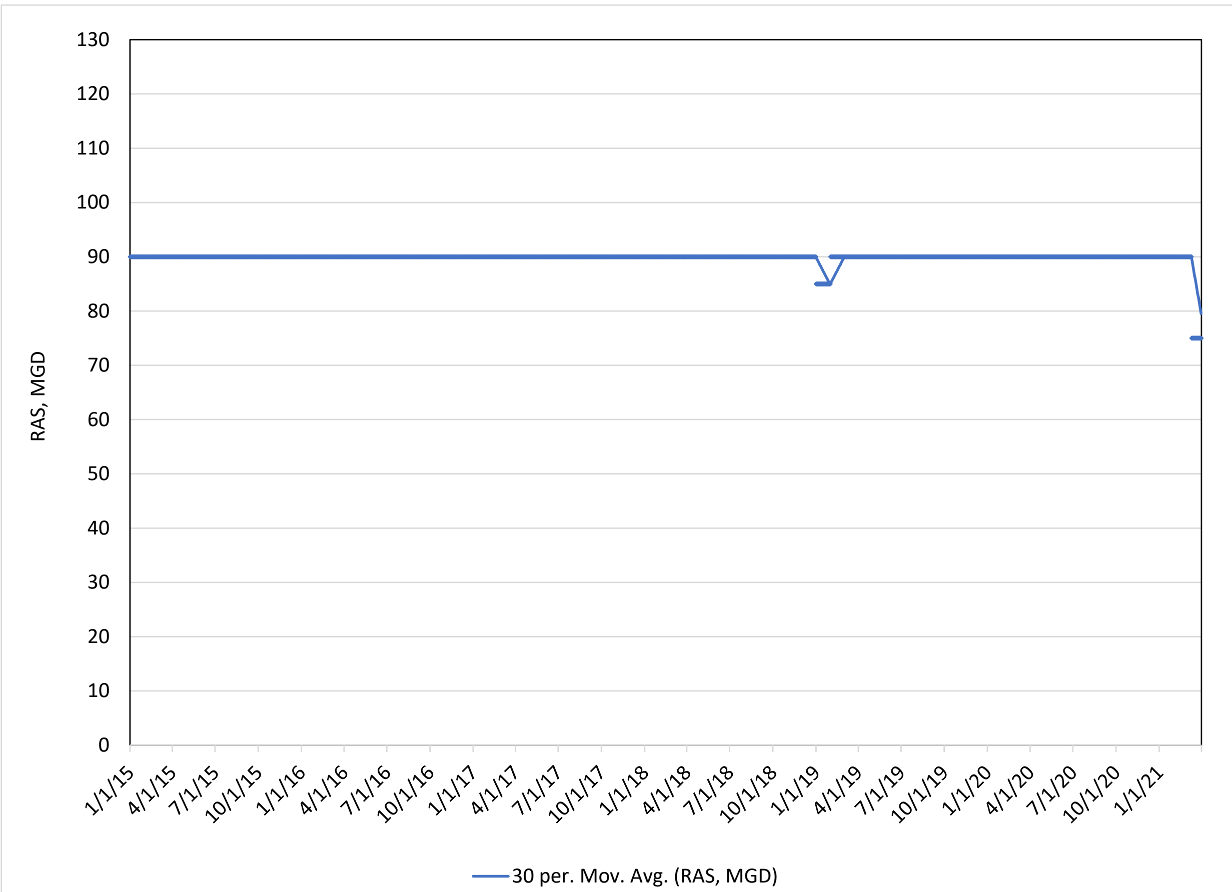

Figure 12: Return Activated Sludge Flow - 2015 to 2021

3.1.2.2 Aerator Effluent MLSS/MLVSS, RAS TSS and Solids Retention Time

Historical aerator effluent MLSS and MLVSS concentrations for the North, Central, and South aeration basins batteries are summarized in **Figure 13** through **Figure 16**. As shown, there is consistency in aerator effluent MLSS and MLVSS concentrations across all batteries, with average concentrations of 1,400 mg/L and 1,180 mg/L, respectively, between 2015 and early 2020. MLSS concentrations have decreased in 2020 and 2021, likely due to the decrease in plant loadings associated with the pandemic.

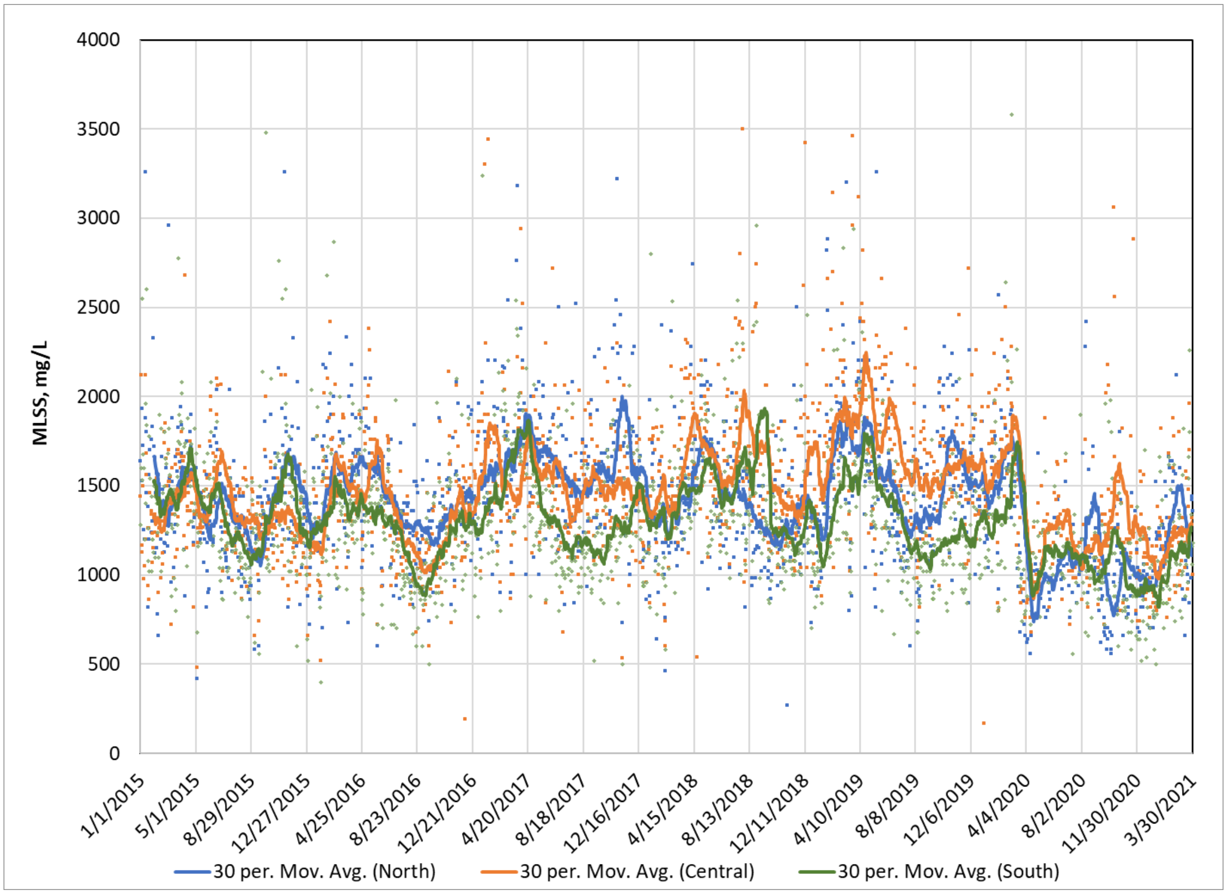

Figure 13: Aerator Effluent MLSS Concentrations – 2015 to 2021

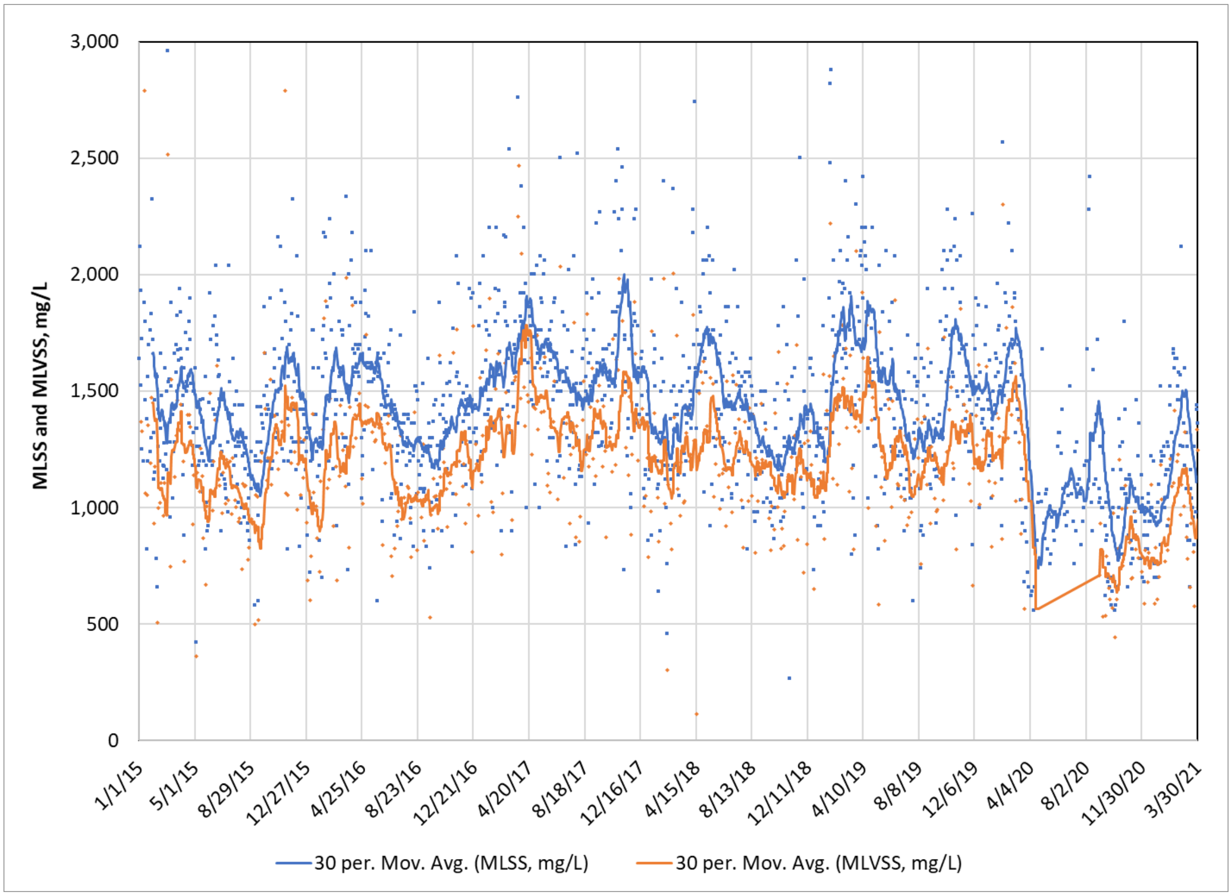

Figure 14: North Battery Aerator Effluent MLSS and MLVSS Concentrations – 2015 to 2021

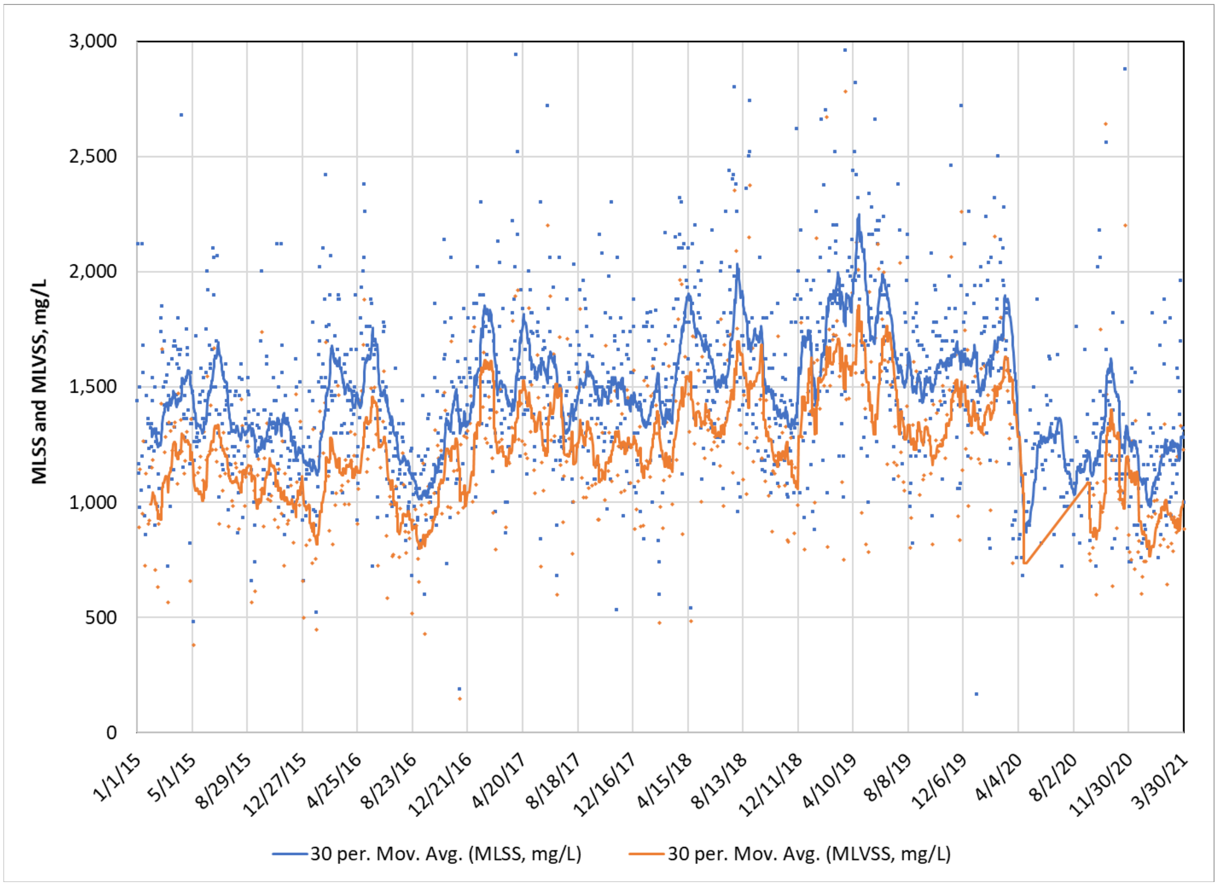

Figure 15: Central Battery Aerator Effluent MLSS and MLVSS Concentrations - 2015 to 2021

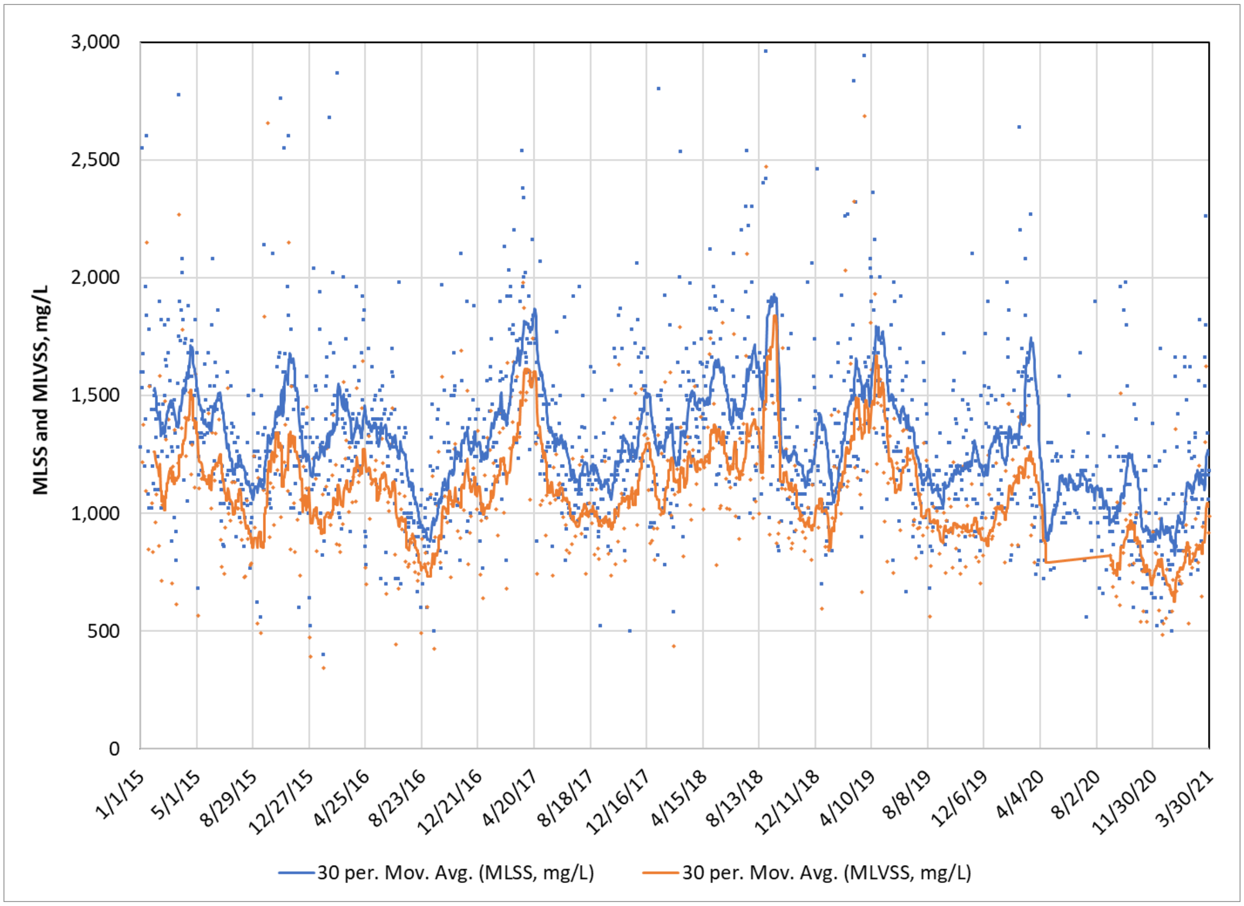

Figure 16: South Battery Aerator Effluent MLSS and MLVSS Concentrations - 2015 to 2021

Figure 17 summarizes historical RAS TSS concentrations for all three aeration batteries. As shown, there is relative consistency between measurements through the historical data set. Average concentrations for all three batteries range from 3,000 mg/L to 4,500 mg/L, with a combined average historical TSS concentration of 3,350 mg/L.

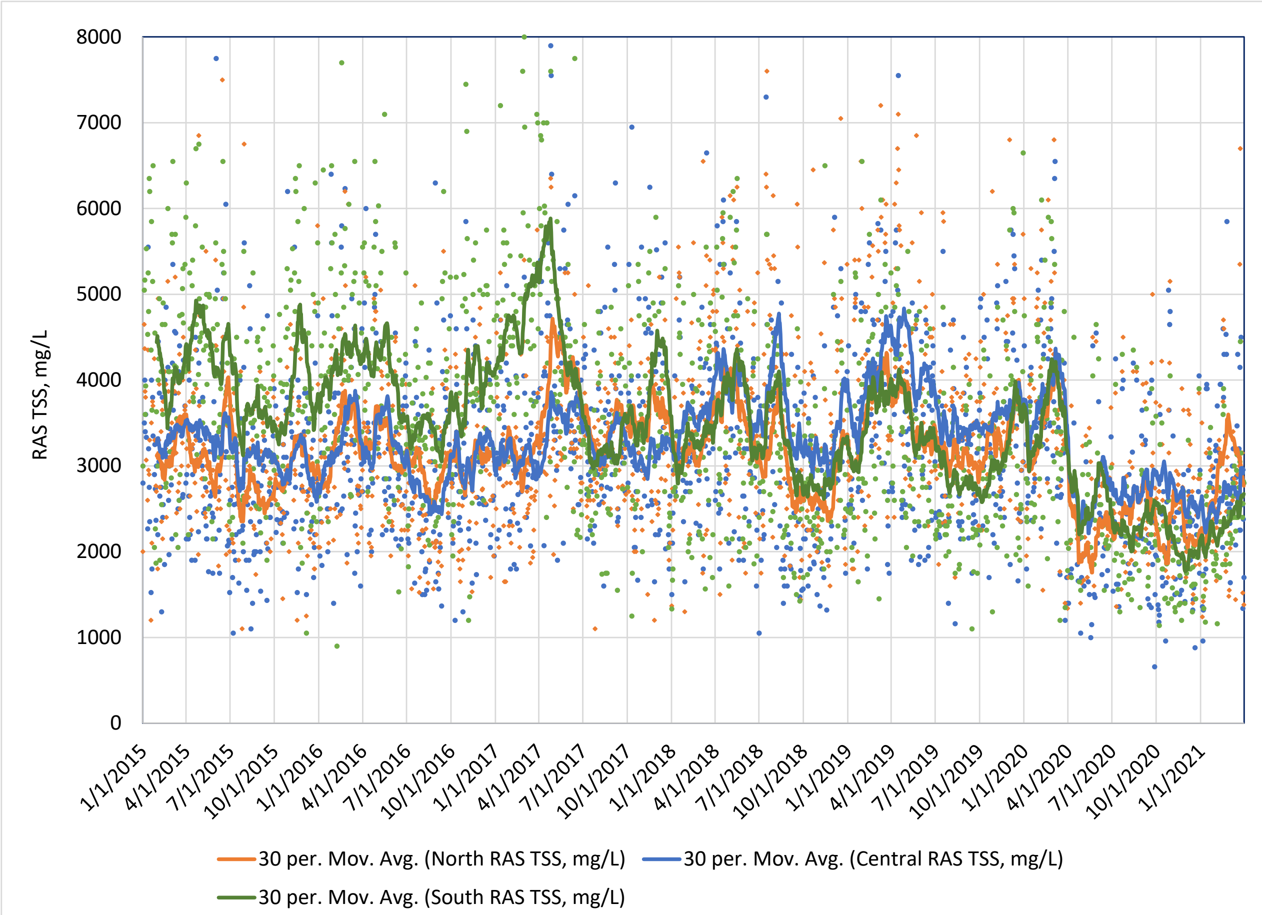

Figure 17: RAS TSS Concentrations - 2015 to 2021

Figure 18 summarizes historical WAS loadings from all three aeration batteries. These loadings were calculated based on observed WAS flow rates for each battery and the associated RAS TSS concentrations. As shown, total WAS loadings for the WRRF ranged from approximately 300,000 lbd to 450,000 lbd prior to early spring of 2020. Observed WAS loadings decreased to between 150,000 lbd and 250,000 lbd, likely due to the observed decreased in plant flow and loading during the COVID-19 pandemic.

Table 13 summarizes yearly average thickened WAS loadings, as well as the yearly average influent $cBOD_5$ and TSS loading and a calculation of observed sludge yield in terms of lbs of WAS per lbs of influent loading. As shown, observed sludge yields in terms of both influent $cBOD_5$ and influent TSS are consistent through the available data set, even during the decrease in observed influent loadings in 2020 and 2021.

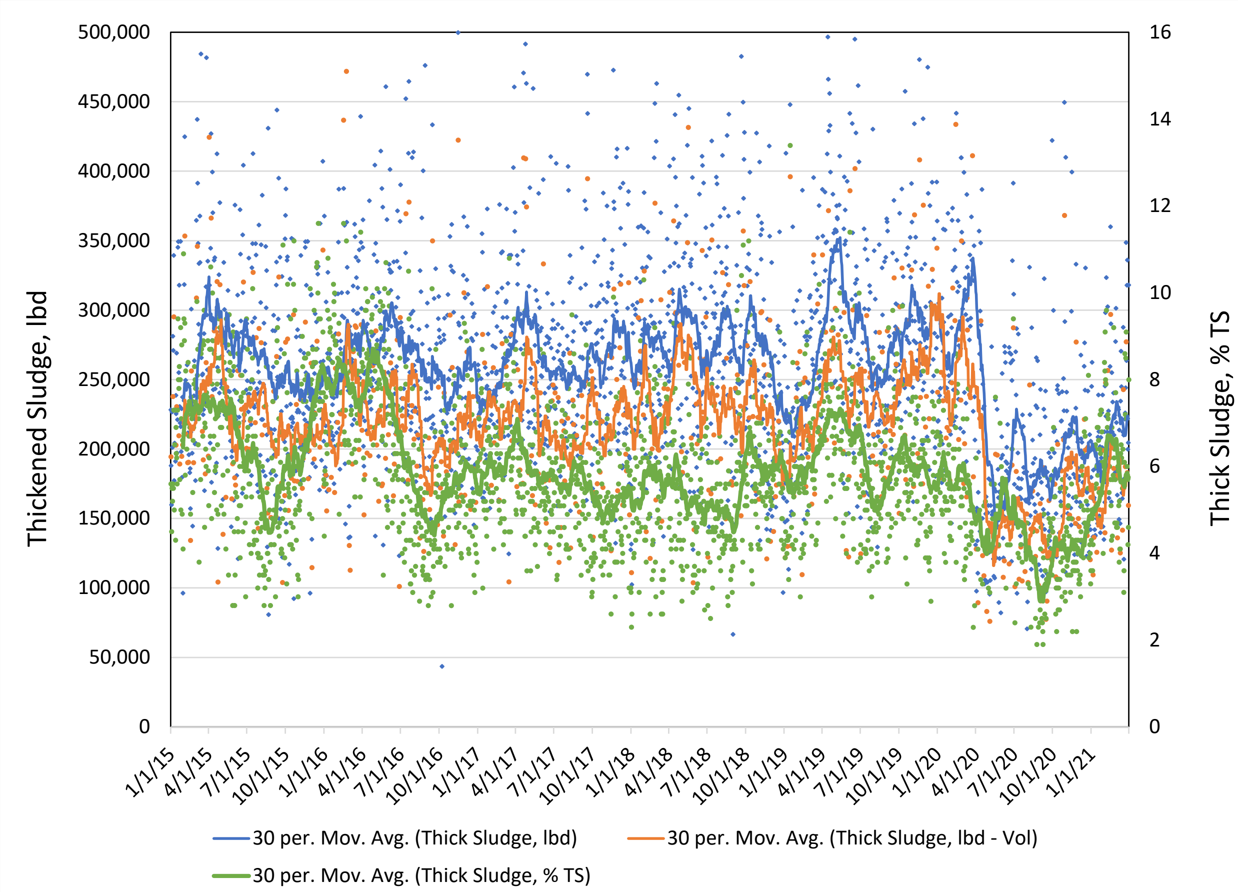

Figure 18: TWAS Loadings - 2015 to 2021

Table 13: Yearly TWAS Loadings and Observed Sludge Yield – 2015 to 2021

Year	Thickened Sludge, lbd	Observed Sludge Yield			
		Influent $cBOD_5$, lbd	lbd TWAS/lbd $cBOD_5$	Influent TSS, lbd	lbd TWAS/lbd TSS
2015	262,006	286,000	0.92	277,500	0.94
2016	263,779	287,700	0.92	289,000	0.91
2017	265,049	291,100	0.91	281,900	0.94
2018	273,278	295,800	0.92	300,800	0.91
2019	280,300	263,800	1.06	287,400	0.98
2020	215,597	227,200	0.95	238,900	0.90
2021 (Partial)	212,394	198,500	1.07	198,600	1.07
Avg (2015 to 2019)	268,883	284,880	0.95	287,320	0.94
Avg (2020 to 2021)	213,996	212,850	1.01	218,750	0.99

A clarifier mass balance was performed to better ensure that observed solids concentrations and flow rates around the activated sludge process are reliable. Clarifier influent loading was calculated based on influent flow, RAS flow, and aerator effluent MLSS concentrations. Clarifier effluent loading is comprised of the daily RAS solids loading, WAS loading, and effluent TSS loading. **Figure 19** summarizes the clarifier balance between 2015 and 2021.

Based on the mass balance it is likely that reported RAS rates are not accurate and only approximately values of daily RAS flow rates. The full-plant process model calibration effort in later project tasks will work to better identify what these flow rates are between 2015 and 2021.

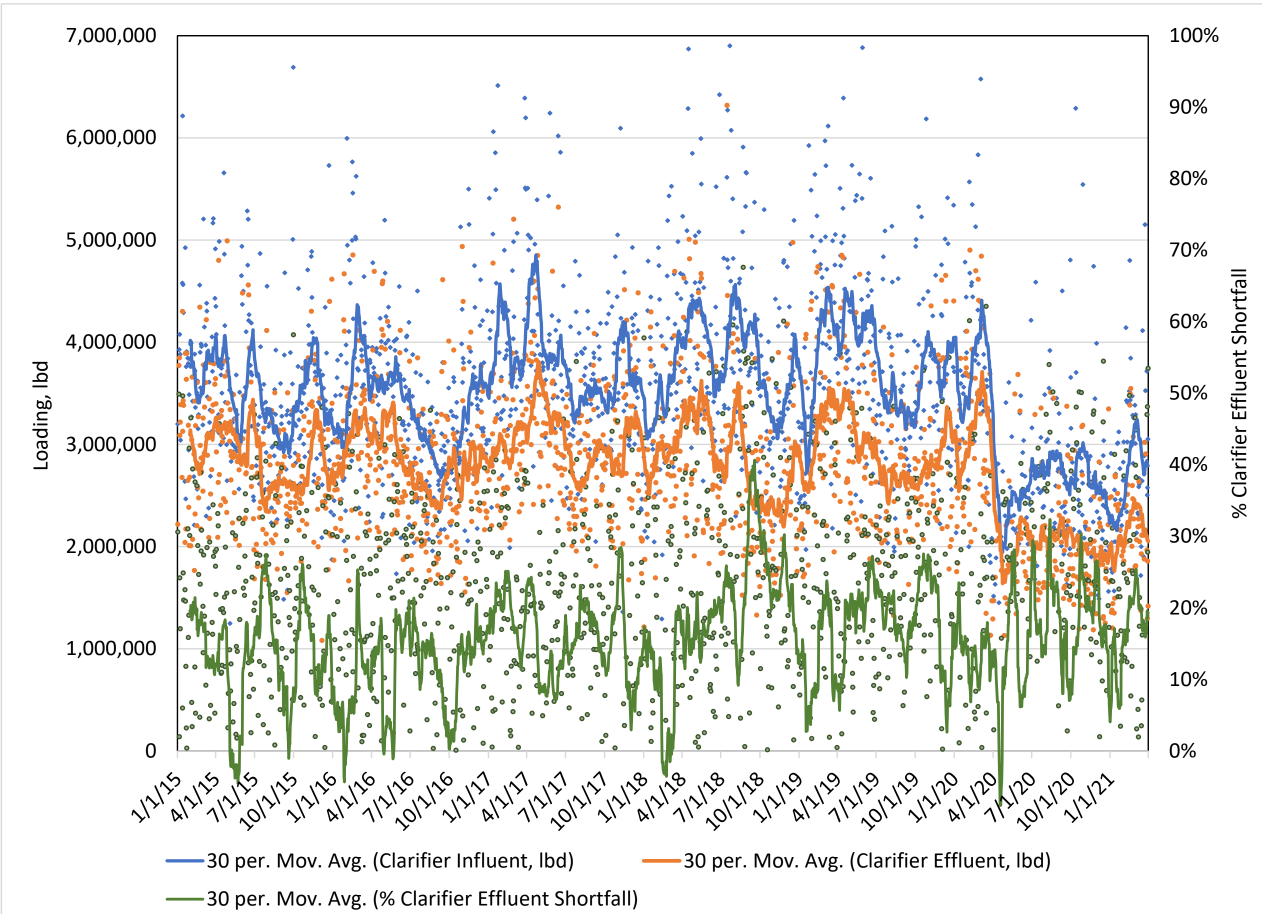

Figure 19: Secondary Clarifier Mass Balance – 2015 to 2021

Figure 20 summarizes total SRT between 2015 and 2021, and was based on observed average MLSS concentrations, the reported number of aeration basins in service, and observed WAS loadings. As shown, SRT control at the WRRF if very consistent, with values ranging between 1.25 and 1.75 days on a 30-day moving average basis between 2015 and early 2020. There is a sharp increase in SRT observed in late spring 2020, with values increasing to above 2 days before coming back down below 1.5 days in late 2020 and early 2021.

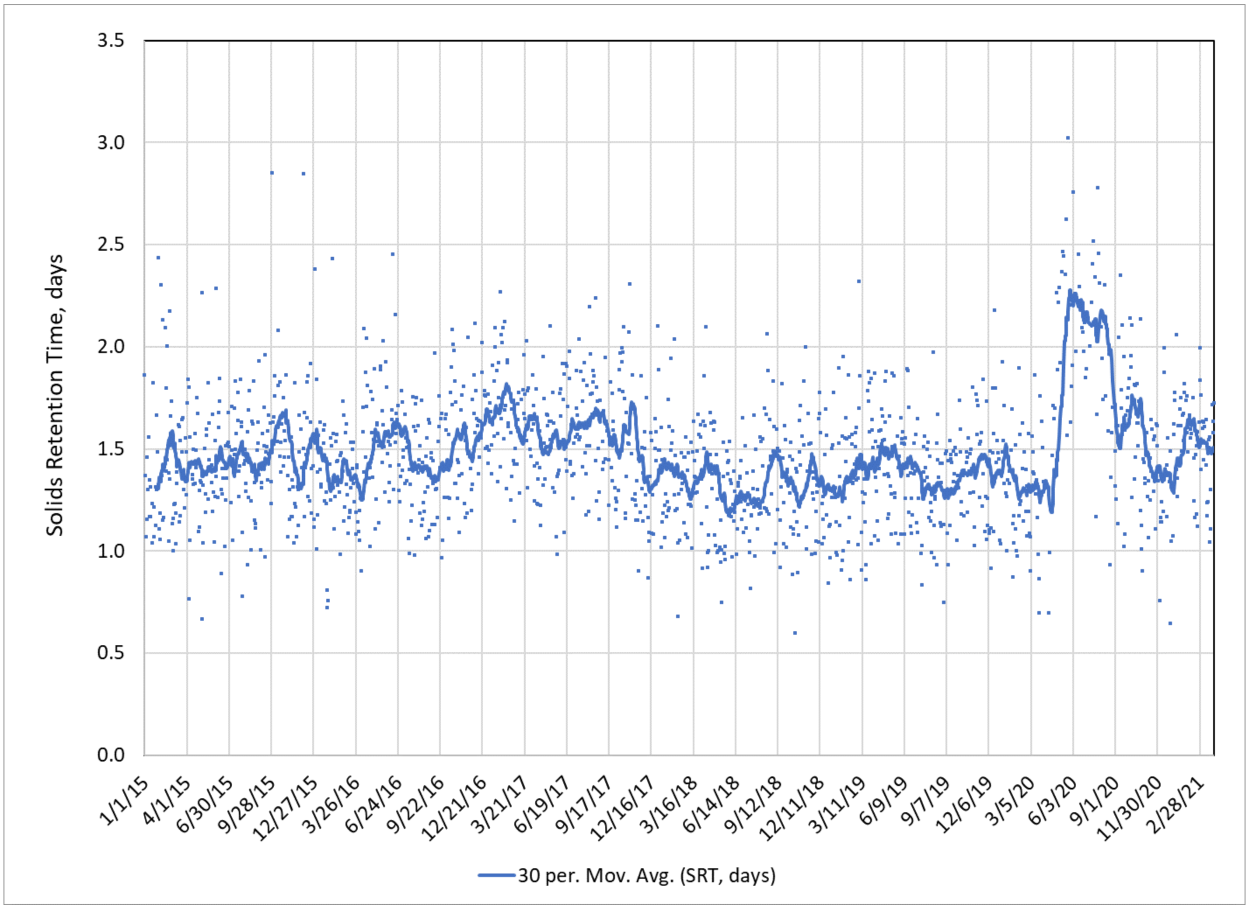

Figure 20: Solids Retention Time – 2015-2021

3.1.2.3 Sludge Volume Index and Process Aeration

Sludge volume index (SVI) is a measure of sludge settleability and is calculated based on the sludge volume after 30 minutes divided by the grams of MLSS (g/l). **Figure 21** and **Table 14** summarize historical observed SVI between 2015 and early 2021. Aside from two periods of decreased sludge settleability in early fall 2017 and fall/winter of 2019/2020, SVI values are excellent at an average value of 97 mL/g and a 75th percentile value of less than 120 mL/g.

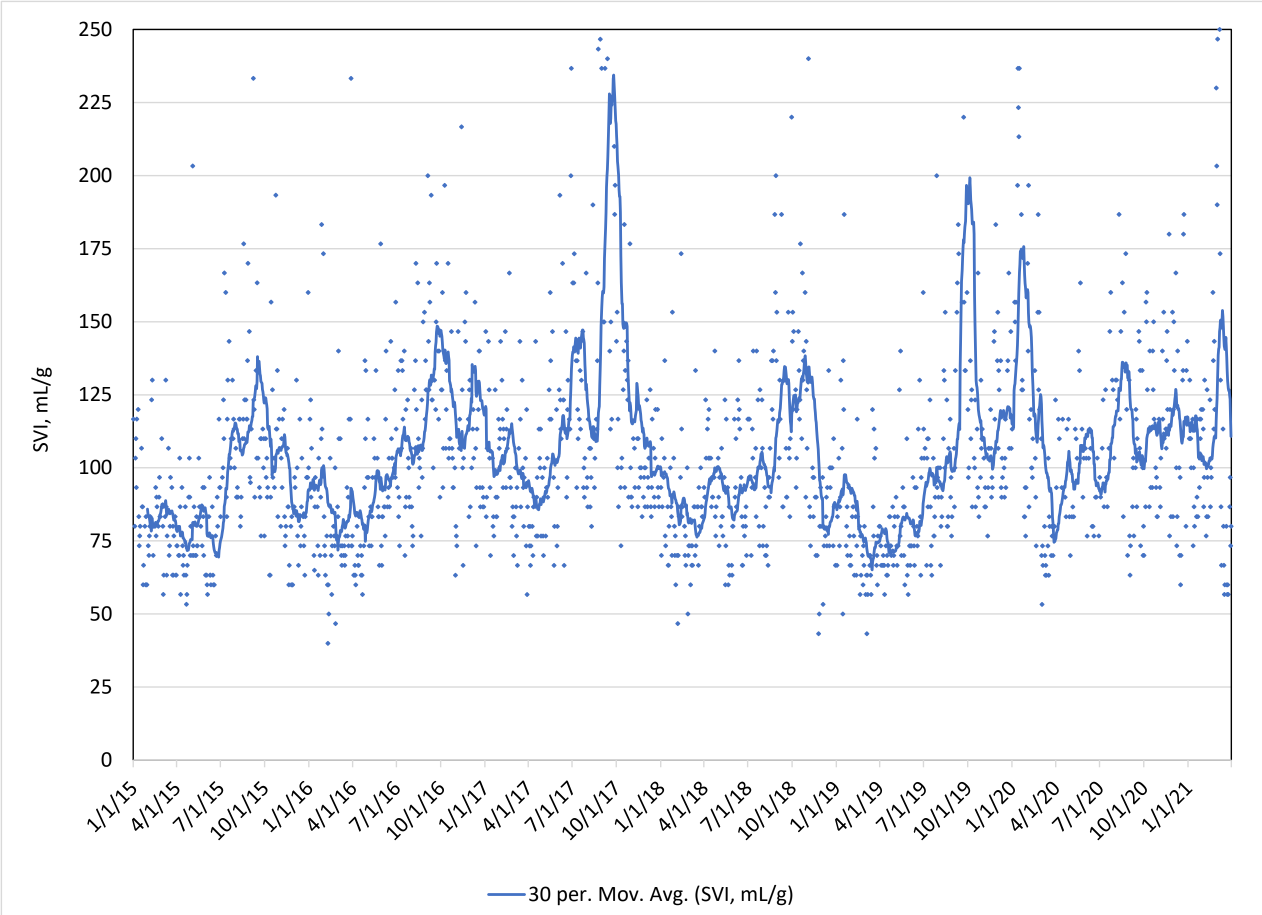

Figure 21: Sludge Volume Index – 2015 to 2021

Table 14: SVI Summary – 2015 to 2021

Parameter	SVI, mL/g
Average	97
95th Percentile	173
90th Percentile	147
75th Percentile	117

Process air flow rates to the activated sludge process and average dissolved oxygen (DO) concentrations are summarized in **Figure 22**, shown in terms of standard cubic feet per minute (SCFM) and mg/L. As shown, applied airflow rates to the activated sludge process are very consistent through the data set, with an average airflow rate of approximately 167,000 scfm. DO concentrations were available for three aeration basins, one in each of the three batteries, with two values per day – one in the AM and another in the PM. **Figure 22** summarizes the average daily value for all three basins across the data set. As shown, there is consistency between the aeration basins over time. However, there does appear to be significant variability in the concentrations over time.

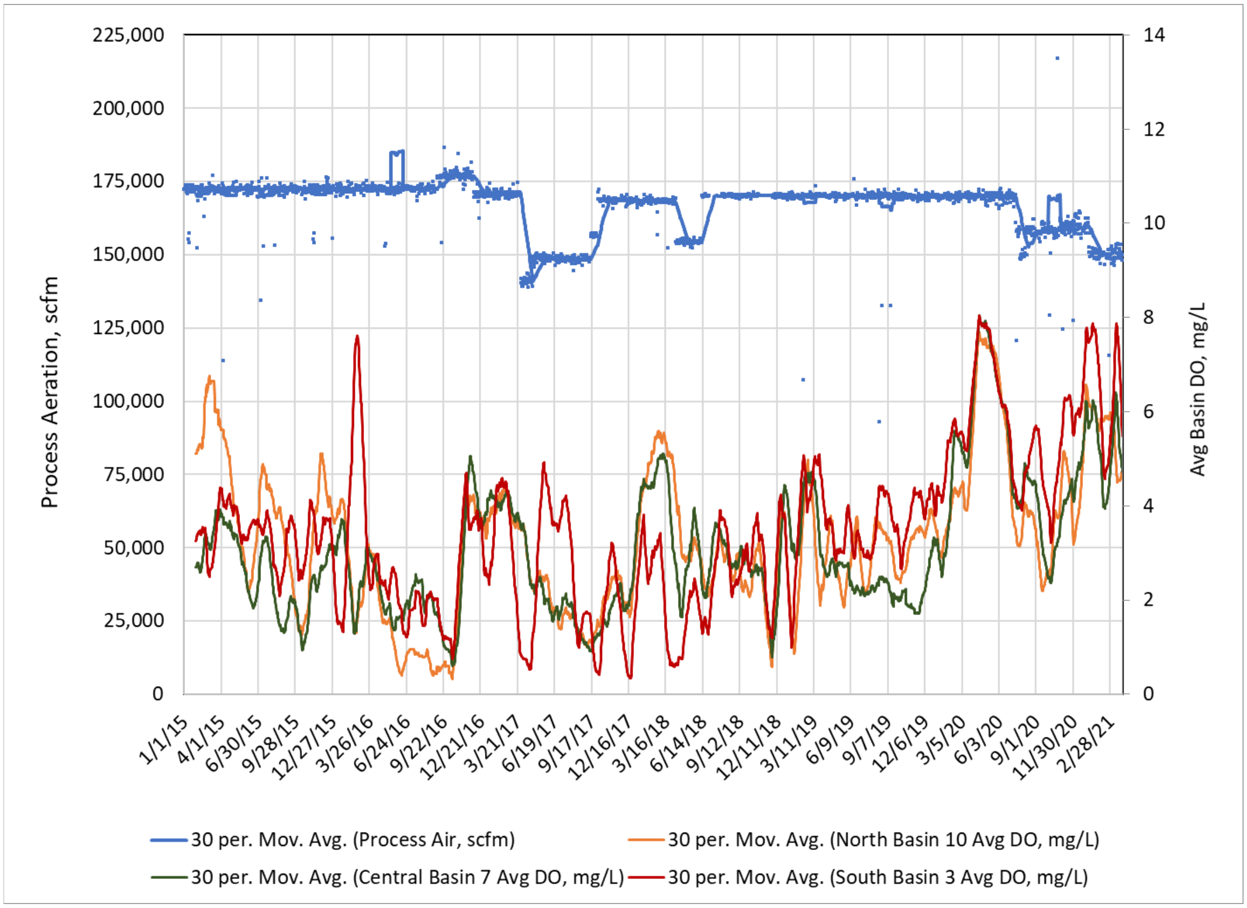

Figure 22: Process Aeration and Dissolved Oxygen Concentrations – 2015 to 2021

3.1.2.4 Final Effluent Quality

Effluent $cBOD_5$ and TSS concentrations are summarized in **Figure 23**. As shown, historical effluent quality is excellent, with 30-day running average values for both parameters routinely below 15 mg/L.

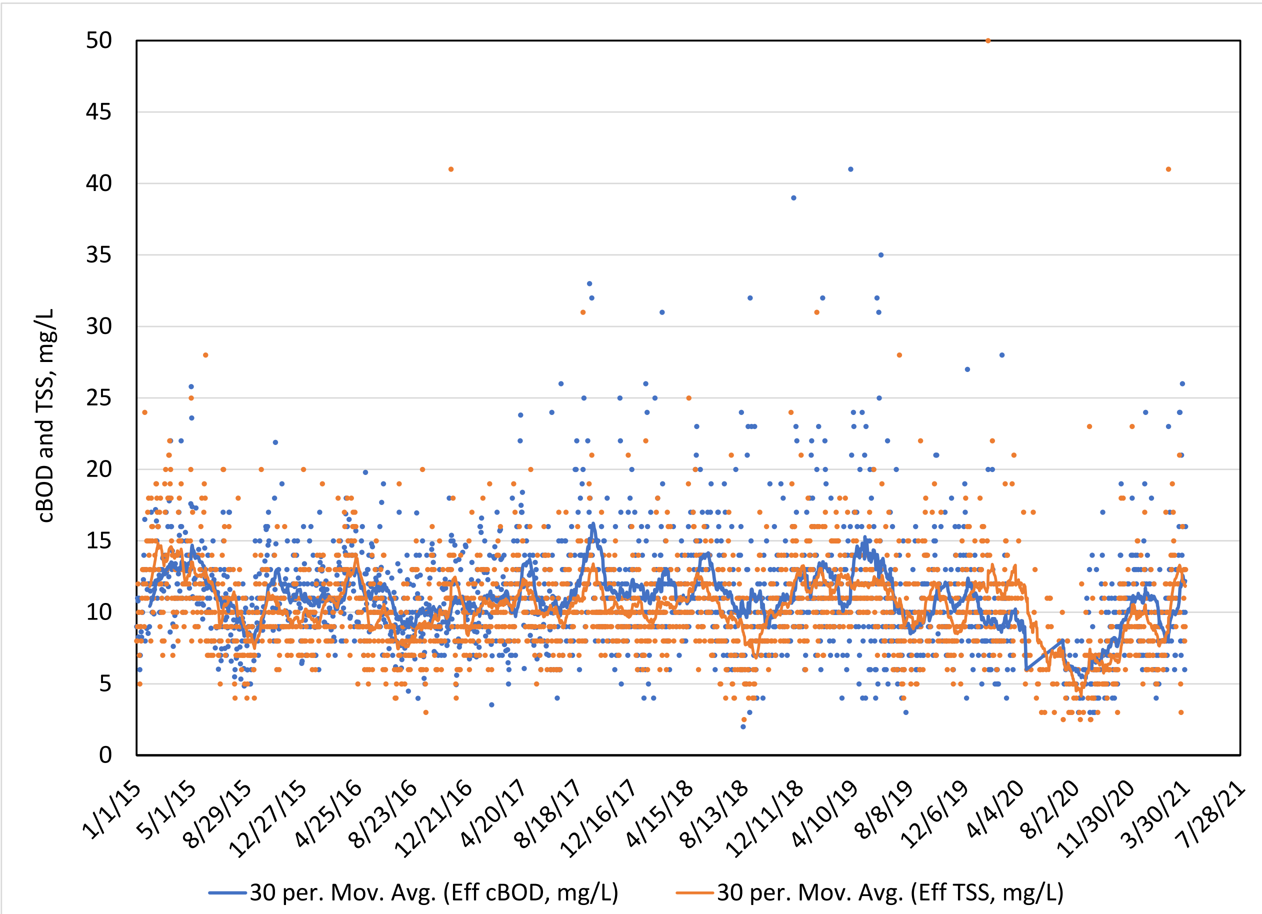

Figure 23: Final Effluent $cBOD_5$ and TSS Concentrations – 2015 to 2021

Effluent inorganic nitrogen concentrations (NH_3-N, NO_3-N, and NO_2-N) are summarized in **Figure 24**. As a WRRF that operates with a short SRT, the plant is not intended to and does not significantly nitrify, with effluent NO_3-N and NO_2-N both routinely below 2.0 mg/L-N.

Figure 25 summarizes effluent TN concentrations and loadings. Historical effluent TN concentrations range between 15 mg/L-N and 25 mg/L-N, with an historical average concentration of approximately 18 mg/L-N. Effluent TN loadings typically range between 25,000 lbd and 35,000 lbd, with an historical average load of approximately 30,500 lbd across the data set. **Table 15** summarizes yearly average influent TKN and effluent TN concentrations. As shown the average removal rate for nitrogen is approximately 41% between 2015 and 2021.

Figure 26 summarizes effluent TP and PO_4-P concentrations between 2015 and 2021. As shown, effluent TP concentrations vary between 2 and 4 mg/L, with effluent PO_4-P concentrations ranging from 1.0 mg/L to 2.0 mg/L on average.

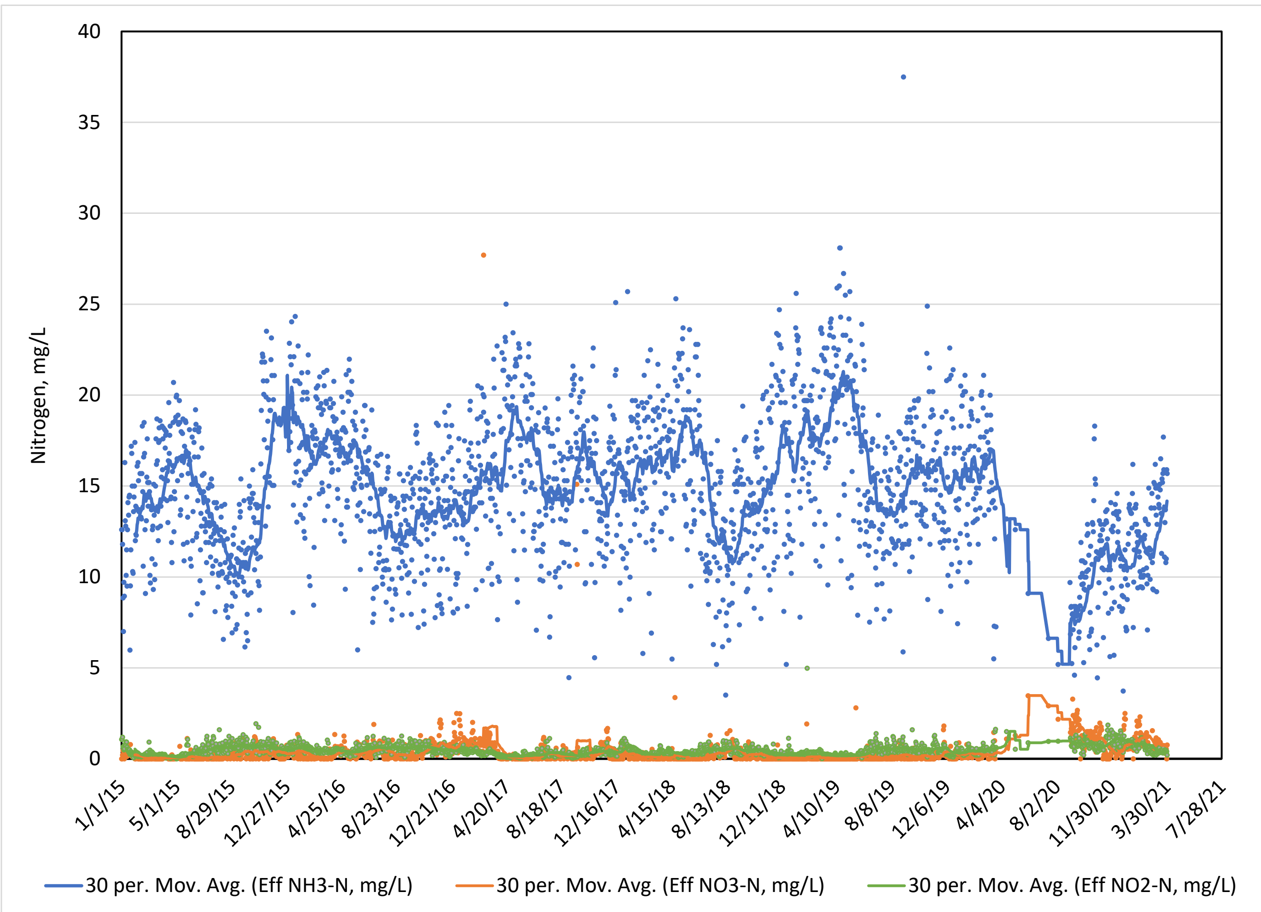

Figure 24: Final Effluent Inorganic Nitrogen Concentrations – 2015 to 2021

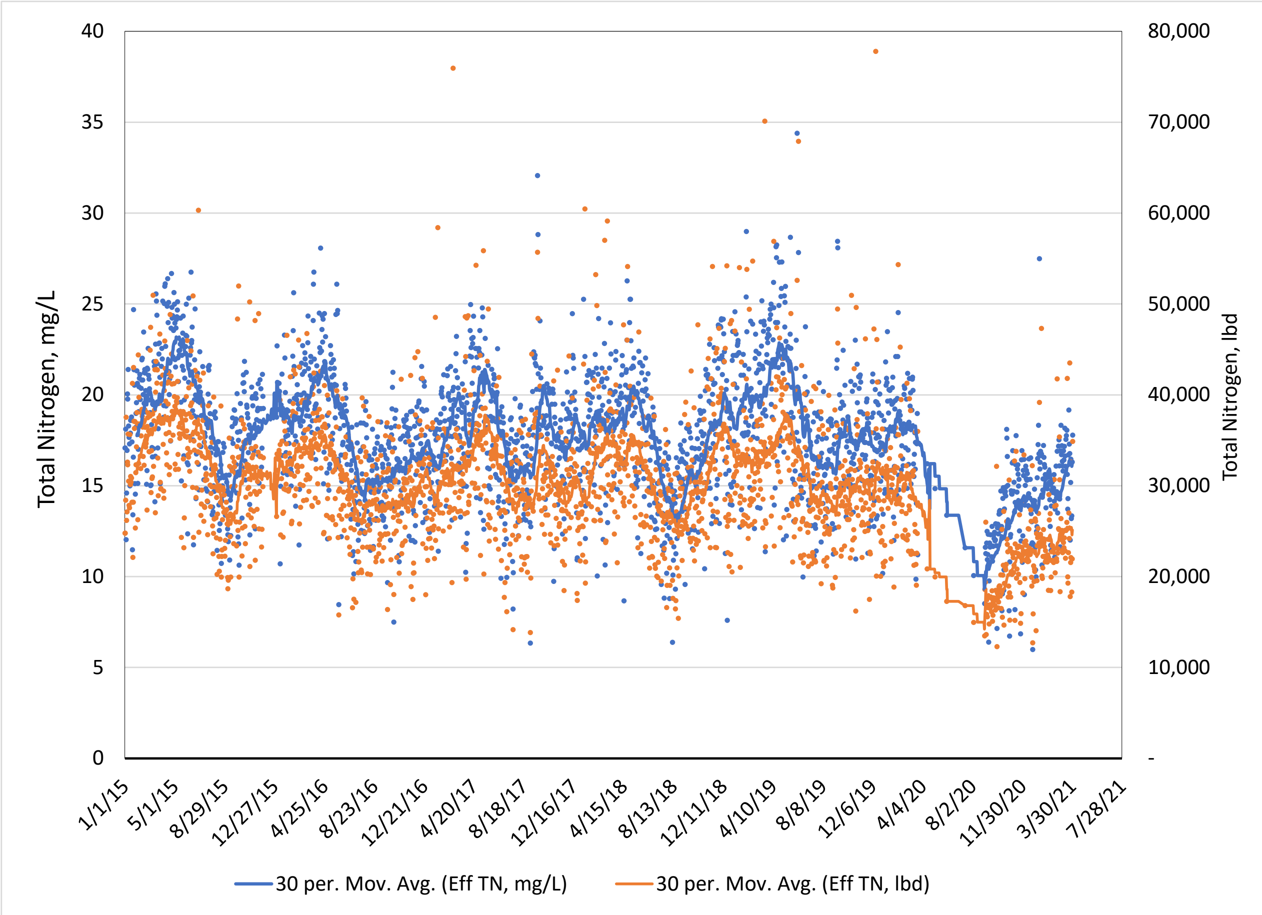

Figure 25: Final Effluent TN Concentrations and Loading – 2015 to 2021

Table 15: Yearly Average Influent TKN and Effluent TN Concentrations – 2015 to 2021

Year	Inf TKN, mg/L	Effluent TN, mg/L	TN Removal, %
2015	29.5	18.9	36%
2016	30.2	17.6	42%
2017	30.4	18.0	41%
2018	31.0	17.4	44%
2019	31.9	18.7	41%
2020	27.2	15.0	45%
2021 (Partial)	24.8	15.4	38%
Avg (2015-2019)	30.6	18.1	41%
Avg (2020-2021)	26.0	15.2	41%

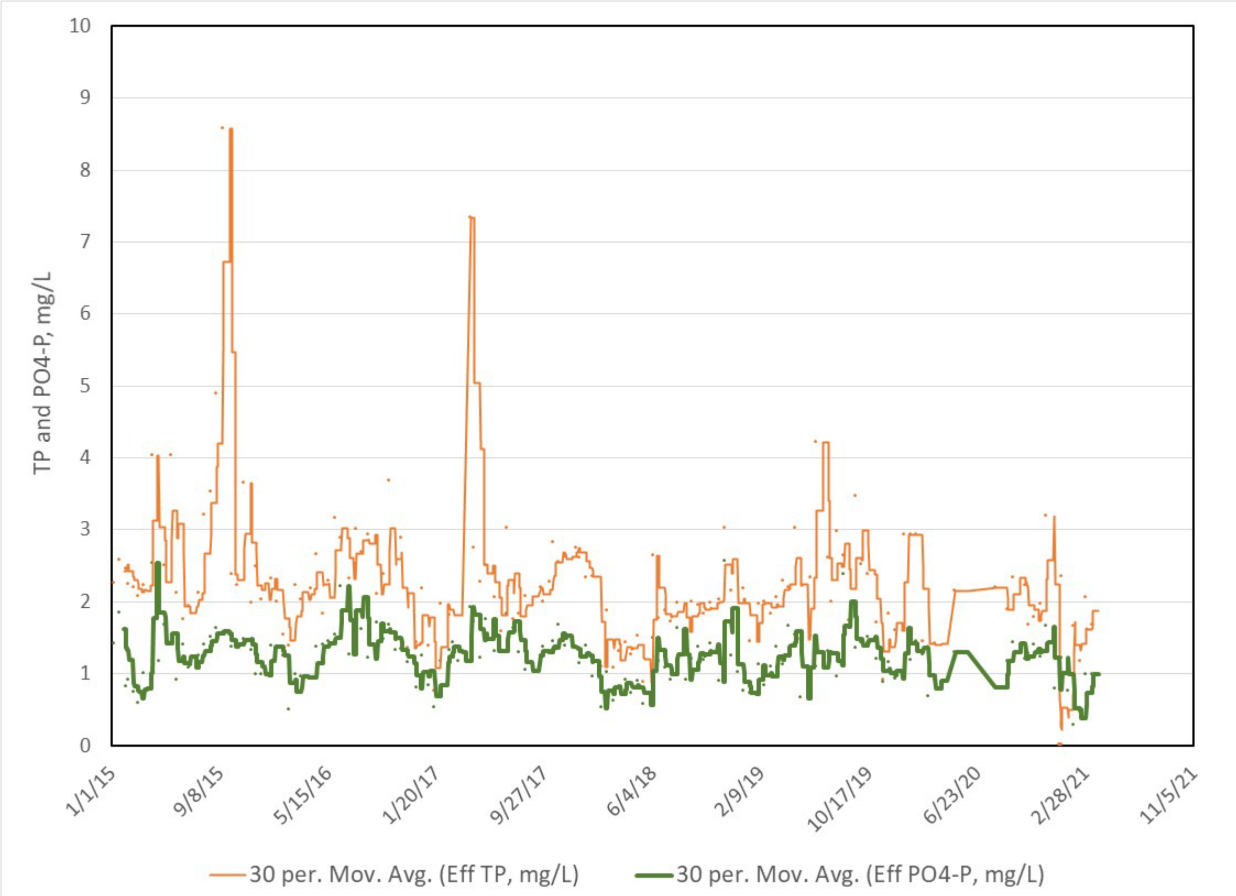

Figure 26: Final Effluent TP and PO_4-P Concentrations – 2015 to 2021

Table 16: Yearly Average Effluent Concentrations – 2015 to 2021

Year	Yearly Average Effluent Concentrations									
	COD, mg/L	cBOD5, mg/L	TSS, mg/L	TN, mg/L	TKN, mg/L	NH3, mg/L-N	NO3, mg/L-N	NO2, mg/L-N	TP, mg/L	PO4-P, mg/L
2015	84	11.4	11.2	18.9	18.2	13.9	0.2	0.5	2.9	1.3
2016	65	10.7	10.0	17.6	16.6	15.0	0.4	0.5	2.3	1.4
2017	66	11.6	10.7	18.0	17.1	15.7	0.5	0.3	2.4	1.3
2018	---	11.4	10.3	17.4	16.9	15.3	0.2	0.4	1.8	1.1
2019	---	11.6	11.2	18.7	18.1	16.6	0.1	0.4	2.2	1.2
2020	---	8.8	9.1	15.0	13.6	12.4	0.4	0.4	2.1	1.2
2021 (Partial)	---	10.8	10.3	15.4	13.9	12.4	0.9	0.6	1.7	0.8
Avg (2015-2019)	72	11.3	10.7	18.1	17.4	15.3	0.3	0.4	2.3	1.3
Avg (2020-2021)	---	9.8	9.7	15.2	13.7	12.4	0.7	0.5	1.9	1.0

3.2 Solids Handling Treatment Train

For the solids handling treatment train, the historical data set included data for WAS, thickened sludge, digested sludge, and anaerobic digestion biogas production. **Table 17** summarizes yearly average loadings for both total solids and volatile solids for WAS, thickened sludge, and digested sludge between 2015 and 2021.

Table 17: Yearly Averages for Solids Handling – 2015 to 2021

Year	WAS, lbd		Thickened Sludge, lbd		Digested Sludge, lbd	
	Total	Volatile	Total	Volatile	Total	Volatile
2015	336,100	289,240	262,006	225,477	96,300	65,300
2016	331,700	276,637	263,779	219,991	123,600	83,200
2017	331,800	278,046	265,049	222,109	132,600	91,200
2018	362,800	308,367	273,278	232,276	137,800	93,900
2019	349,600	303,452	280,300	243,300	138,300	95,000
2020	250,900	206,471	215,597	177,420	110,200	74,500
2021 (Partial)	234,000	198,356	212,394	180,041	87,900	56,700
Avg (2015-2019)	342,400	291,148	268,882	228,631	125,720	85,720
Avg (2020-2021)	242,450	202,414	213,996	178,731	99,050	65,600

3.2.1 Waste Activated Sludge

As shown previously, **Figure 27** summarizes historical WAS loadings from all three aeration batteries. These loadings were calculated based on observed WAS flow rates for each battery and the associated RAS TSS concentrations. As shown, total WAS loadings for the WRRF ranged from approximately 300,000 lbd to 450,000 lbd prior to early spring of 2020. Observed WAS loadings decreased to between 150,000 lbd and 250,000 lbd, likely due to the observed decreased in plant flow and loading during the COVID-19 pandemic.

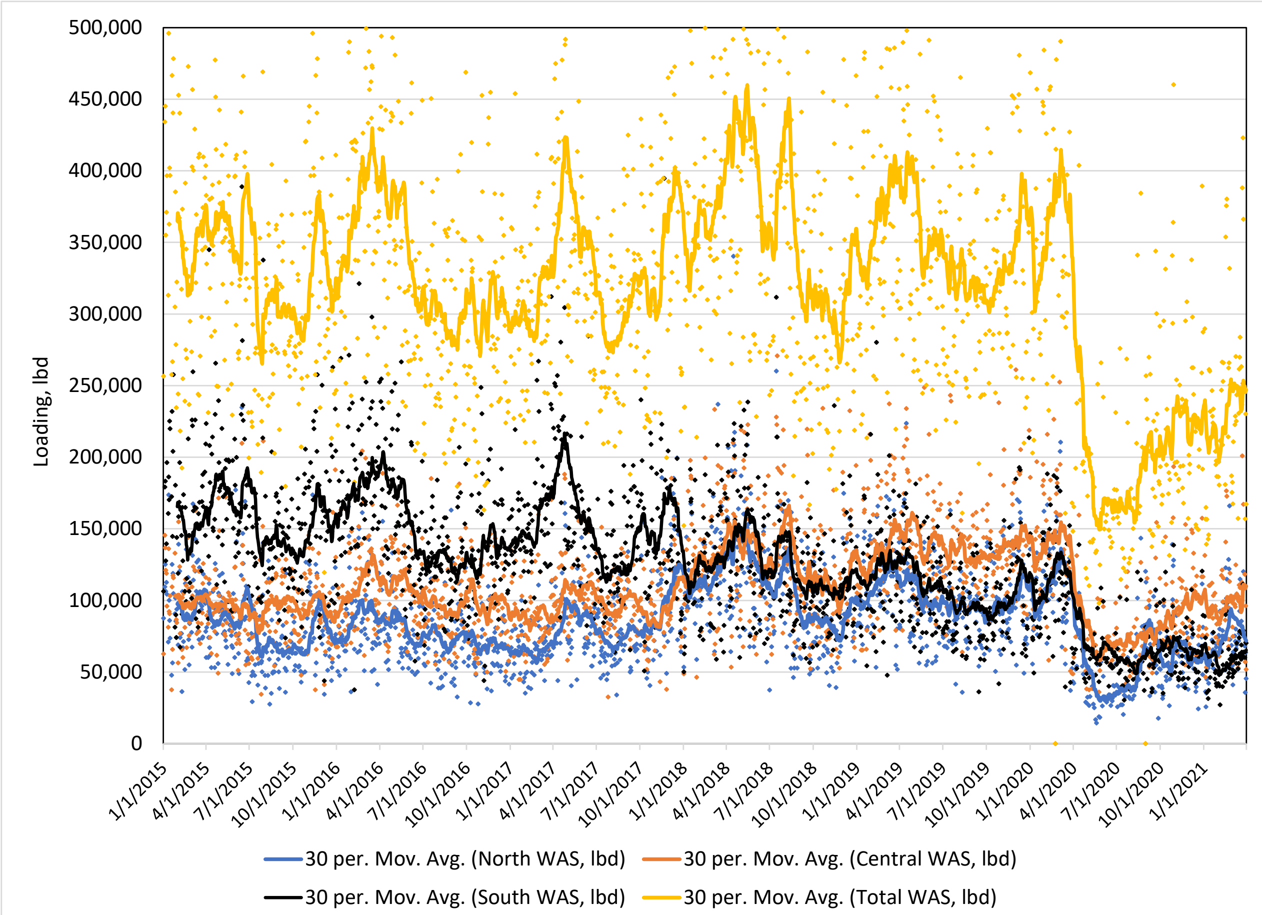

Figure 27: Observed Daily WAS Loadings – 2015 to 2021

3.2.2 Sludge Thickening

Figure 28 summarizes thickened sludge loading from the dewatering centrifuges, both in terms of total solids and volatile solids. Total thickened sludge ranges from 250,000 lbd to 350,000 lbd, with an approximate average mass of 258,000 lbd between 2015 and 2021. Thickened sludge solids content ranges from 4% to almost 9% across the entire data set, with an approximate average content of 6%.

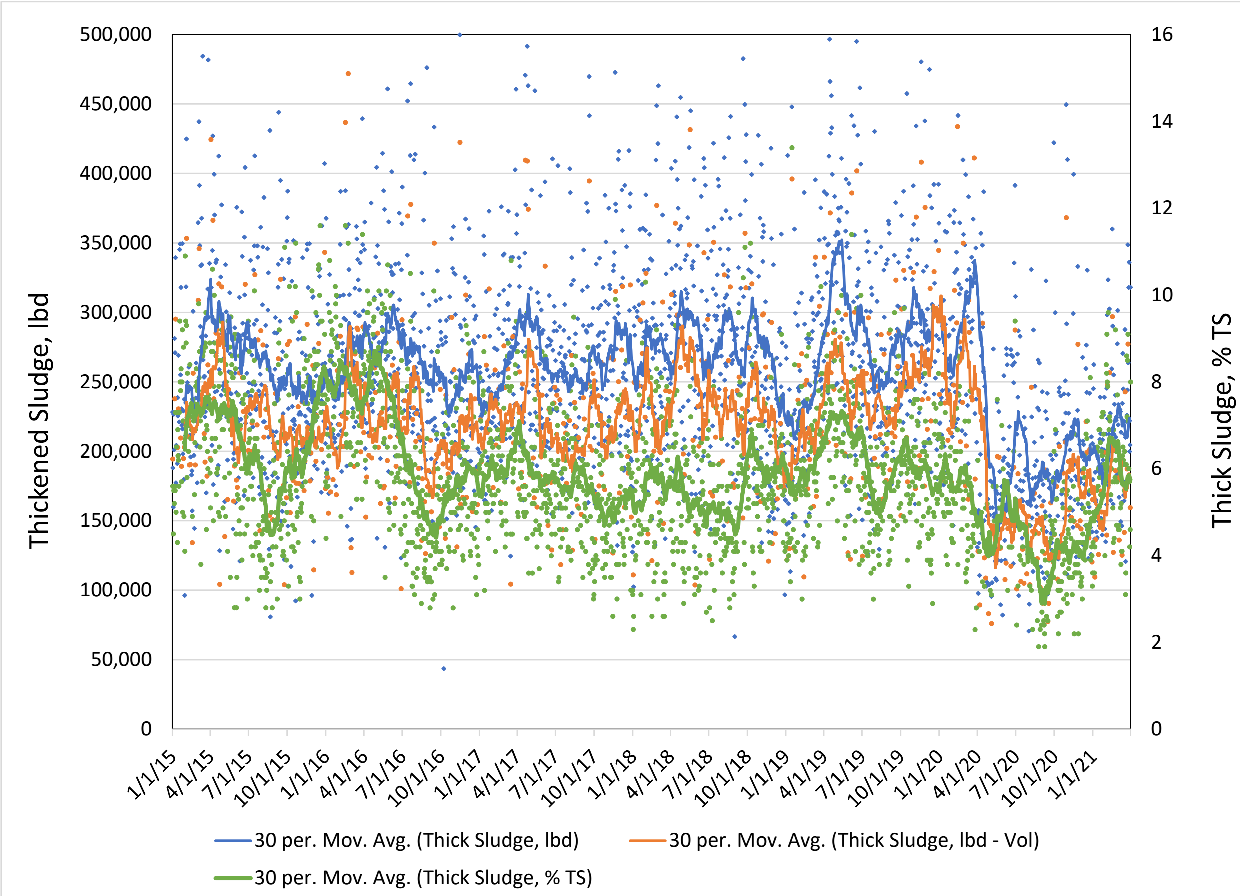

Figure 28: Thickened Sludge Loading and % TS – 2015 to 2021

Figure 29 and **Table 18** summarize thfickened sludge loading and total WAS loading between 2015 and 2021, as well as thickener feed TSS concentrations and centrate TSS concentrations. Based upon the available data the thickening centrifuges achieve approximately 79% solids capture based upon reported WAS loadings and thickened WAS loadings. Solids capture rates based upon feed solids and centrate solids show similar rates, with an average of approximately 70% between 2015 and 2019.

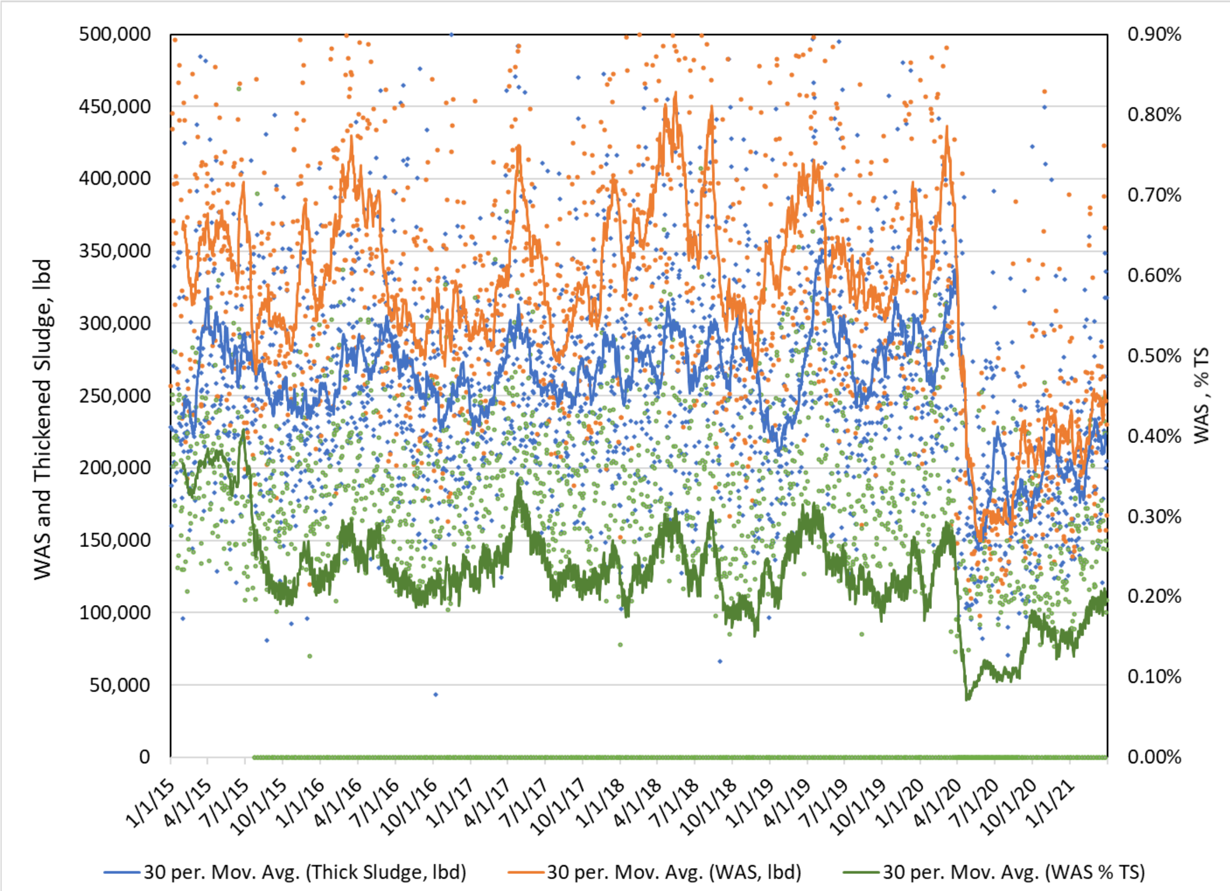

Figure 29: WAS and Thickened Sludge Loadings– 2015 to 2021

Table 18: Yearly Average WAS and Thickened Sludge Loadings – 2015 to 2021

Year	WAS, lbd	Thick Feed TSS, mg/L	TWAS, lbd	Centrate, mg/L	Solids Capture, %	
					Mass Based	Feed/Centrate TSS Based
2015	336,100	3,884	262,006	1,254	78%	68%
2016	331,700	3,759	263,779	1,140	80%	70%
2017	331,800	4,096	265,049	1,169	80%	71%
2018	362,800	3,845	273,278	1,018	75%	74%
2019	349,600	3,831	280,300	1,177	80%	69%
2020	250,900	2,211	215,597	601	86%	73%
2021	234,000	2,752	212,394	734	91%	73%
Avg (2015 to 2019)	342,400	3,883	268,883	1,152	79%	70%
Avg (2020 to 2021)	242,450	2,481	213,996	668	88%	73%

3.2.3 Anaerobic Digestion

Figure 30 through **Figure 33** summarize operations and performance of anaerobic digestion. **Figure 30** summarizes digester feed volumes and digester hydraulic retention time (HRT), calculated based on daily thickened sludge volume, reported food waste volumes, and available digester volume with one unit out of service. As shown, anaerobic digester HRTs are considerable, with values routinely between 25 and 50 days, with an average HRT of approximately 41 days. It is important to note that the anaerobic digestion process accepts food waste from outside third-party sources as a way to increase the production of biogas. Based upon the available data this practice began in late 2016 and has been active to present. The average volume of food waste directed to anaerobic digestion is approximately 19,500 gpd.

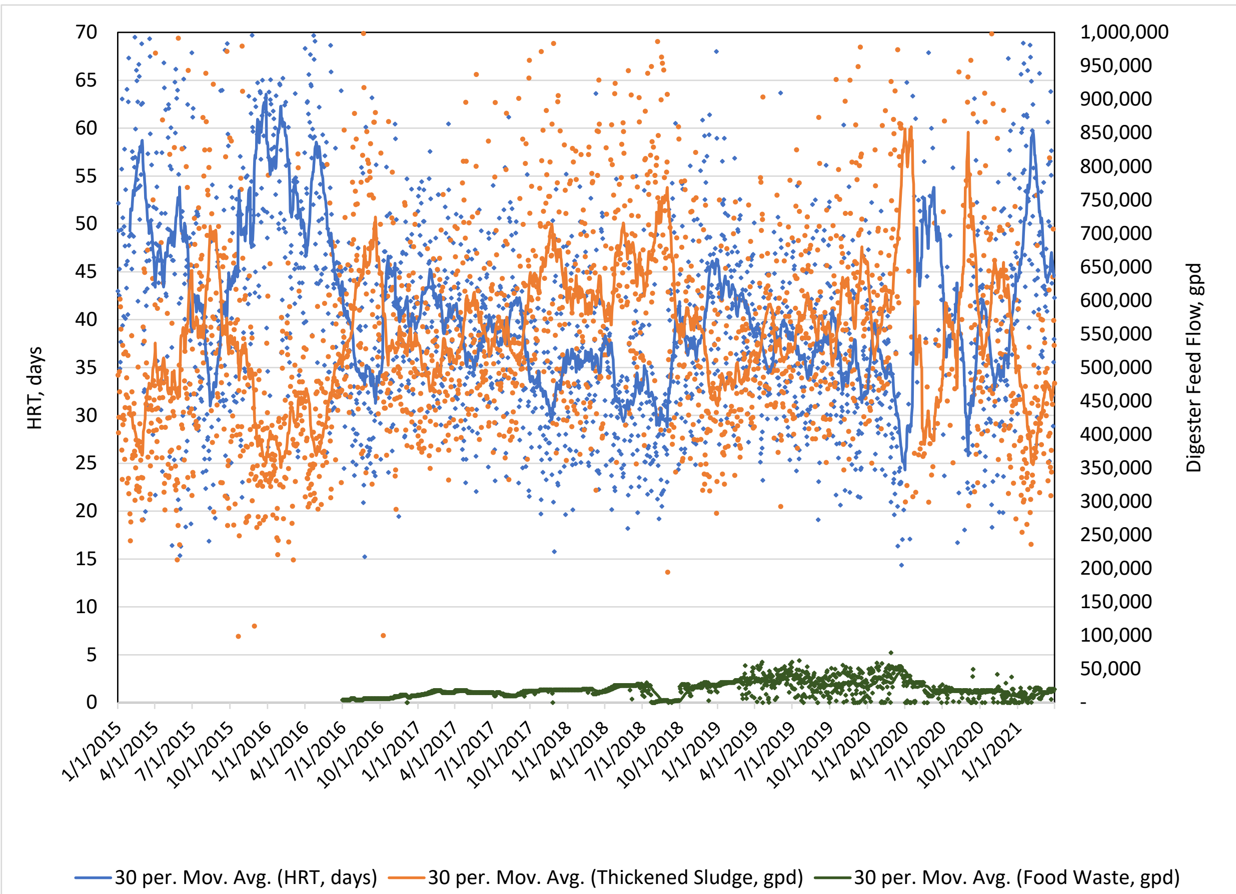

Figure 30: Anaerobic Digester HRT– 2015 to 2021

As shown in **Figure 31** and **Figure 32**, an evaluation of thickening sludge volatile solids load and digested sludge volatile loading shows significant volatile solids destruction on a volatile mass loading basis, with values between 45 and 70%, with an approximate average of 60%. **Figure 33** summarizes the mass of volatile sludge destroyed in the digestion process and the amount of biogas produced, which averages to approximately 1,700,000 CF/day.

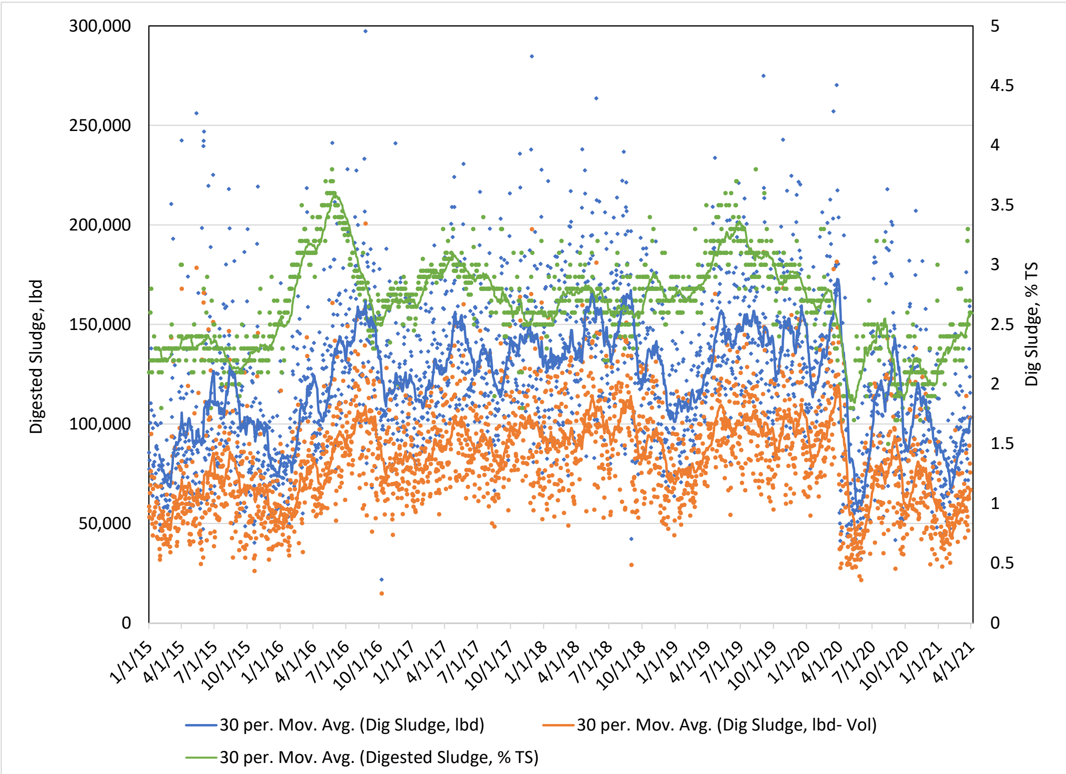

Figure 31: Digested Sludge Loading and % TS – 2015 to 2021

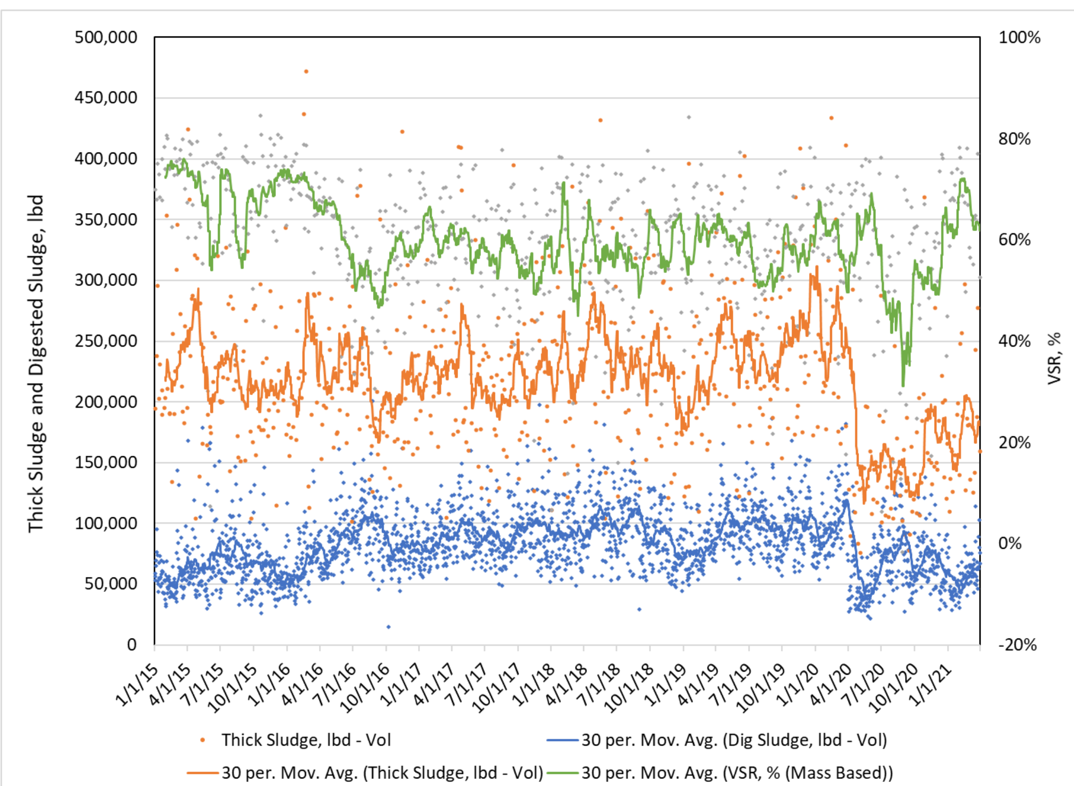

Figure 32: Digester Volatile Solids Reduction – 2015 to 2021

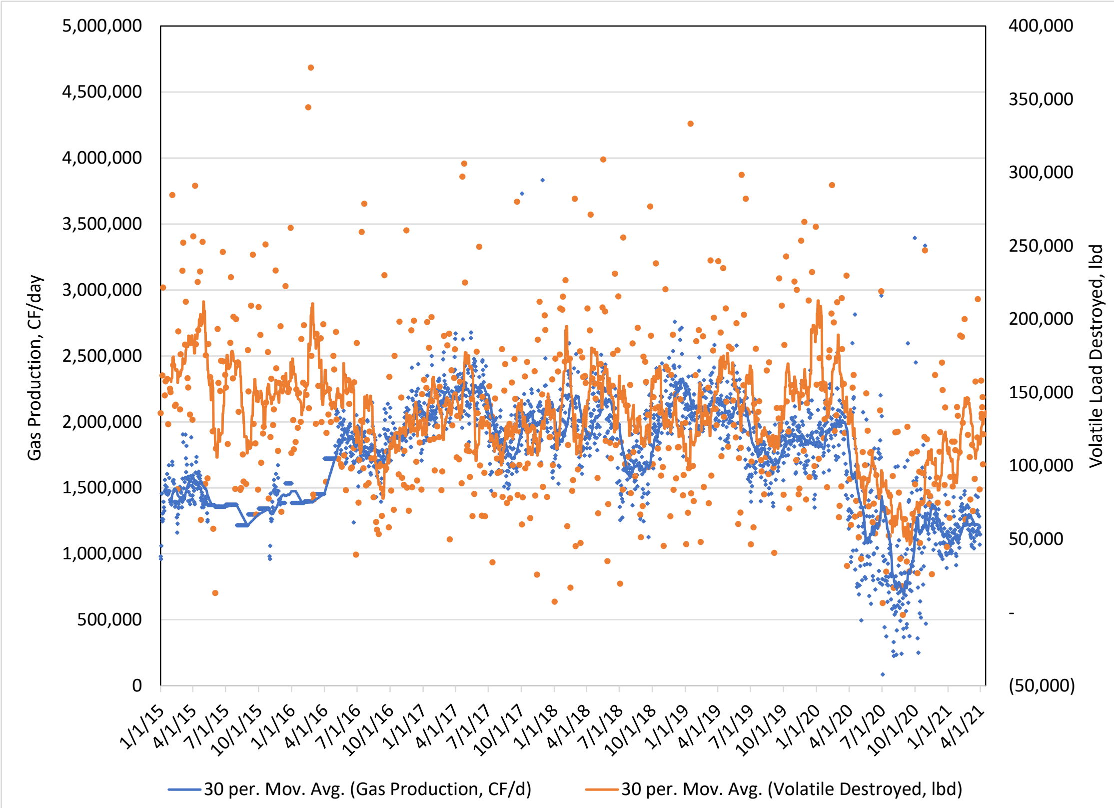

Figure 33: Volatile Solids Reduction and Biogas Production – 2015 to 2021

Table 19 summarizes the yearly average mass of volatile sludge destroyed in anaerobic digestion, along with VSR, daily biogas production, and the ratio of gas production to mass of volatiles destroyed. As shown, the amount of biogas produced per pound of volatile sludge destroyed ranges from 10.5 to almost 20 CF/lb of volatile destroyed, with an average long-term value of approximately 15 CF/d. Typical values for mesophilic anaerobic digestion range from 12 to 18 CF/lb volatile destroyed.

Table 19: Digester Biogas Production – 2015 to 2021

Year	Volatile Sludge Destroyed, lbd	VSR, %	Gas, CF/d	Gas Produced, CF/lb Vol Removed
2015	158,094	69%	1,393,852	10.7
2016	135,517	60%	1,750,959	15.2
2017	132,648	58%	2,068,767	18.5
2018	139,870	58%	1,969,734	20.3
2019	146,737	58%	1,945,997	16.2
2020	100,979	55%	1,326,563	10.5
2021 (Partial)	121,501	67%	1,205,556	11.2
Avg (2015-2019)	142,573	61%	1,825,862	16.2
Avg (2020-2021)	111,240	61%	1,266,060	10.9

4. REGULATORY DRIVERS AND PROGRAMMATIC CONSIDERATIONS

The primary goal of this BNR study is to identify practical and implementable plant enhancements that will achieve additional nitrogen removal to help the DEP reduce effluent nitrogen loading. This section summarizes the regulatory and programmatic drivers applicable to BNR that should be considered for each alternative.

- Regulatory Drivers
  - Nitrogen
- Programmatic Considerations
  - Energy
  - Greenhouse Gas emissions

4.1 Regulatory Drivers

NC WRRF discharges treated effluent to the East River under a SPDES permit (see **Table 1** in **Section 2**). The focus of the Study is to identify practical and implementable plant enhancements that may achieve BNR and help the DEP further reduce nitrogen loading to the East River. The analysis will consider operational impacts from Phosphorus, however there are no regulatory requirements for Phosphorus.

Previous studies determined that it was not effective to reduce total nitrogen discharge from the NC WRRF compared to reducing the total nitrogen discharge from the UER WRRFs. Given the advancement of nitrogen removal systems/technologies, this BNR study takes a fresh look at the potential options to further reduce the total nitrogen discharge from the NC WRRF.

4.2 Programmatic Considerations

As part of OneNYC, a vision was established to make the 14 in-City wastewater treatment plants have "net-zero" energy consumption and reduce GHG emission by 80%, by 2050. While the goal of the BNR Study is to identify practical and implementable plant enhancements that will achieve BNR, our team will monitor impacts to electrical consumption and GHG emissions. Each design alternative considered will show impacts to both electrical consumption and GHG from the existing systems baseline performance.

4.2.1 Energy Consumption Reduction

NC WRRF is the City's largest water resource recovery facility and its largest energy consumer. NC WRRF uses 124,412,700 kWh annually according to the NC WWTP Facility Energy Audit report (FY 2011-2012), leading to annual electrical operating expense of $12.60 M/year (excluding labor and maintenance) and 36,000 MT of CO_2 equivalence per year. The process air blowers account for 30,782,862 kWh annually (25% of plant consumption, 33% of process consumption), water resource recovery facility, making it the single greatest consumer at the plant.

The primary cause for the high electrical consumption within secondary treatment is aeration, where blowers are in constant operation to aerate the flow within the tanks. Although efforts are made to match air supply with biological demand, NC WRRF does not have an effective DO control system, with the blowers being operated manually according to DO probes installed throughout the 12 Aeration Tanks. While this practice is not uncommon, it tends to result in the facility operating the blowers at close to a constant rate. A constant rate blower operation typically over-aerates the process and results in a higher concentration of dissolved oxygen (DO), especially during low organic loading times (i.e., nonpeak hours). According to the SOGR ECM Integration Report, the average dissolved oxygen within the aeration tanks is 5.2 mg/L.

As part of the BNR alternatives analysis, our study will estimate the electrical consumption impacts for each alternative. Additional aeration, beyond the capacity of the existing blowers, may be required and will increase electrical consumption. Our team will track electrical consumption ramifications for all alternatives studied and utilize the most efficient technologies possible while developing the facility planning level design and cost estimate.

4.2.2 GHG Emissions Reduction

Reducing GHG emissions by 80% from FY 2005 baseline by 2050 is a key programmatic driver for the New York City government, according to the OneNYC Plan released in 2015. The water and wastewater treatment systems are responsible for nearly 20% of the city government emissions. Considering the methodology adopted by the DEP, NC WRRF GHG emissions are measured in ton CO_2eq and come from the following sources:

- Electricity
- Natural Gas
- Fuel Oil
- Biogas flared/fugitive emissions
- Process (N_2O)

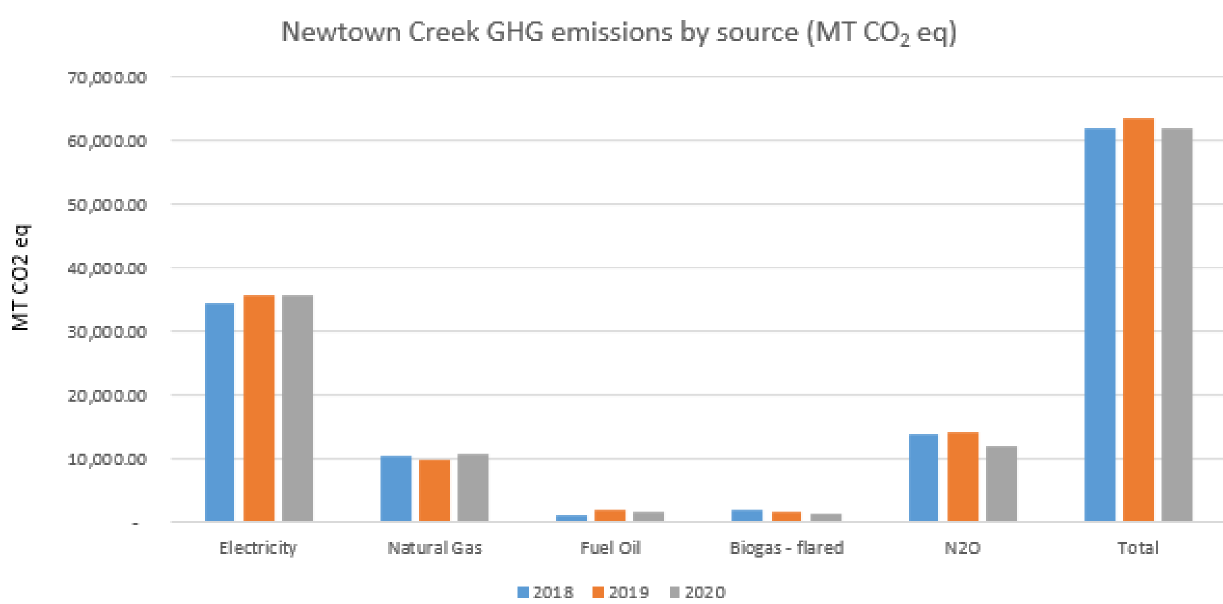

Figure 34: NC WRRF GHG Emissions by Source – 2017 to 2020

Figure 34 illustrates the GHG emissions in CO2 equivalence by source according to the 2021 DICE data provided by DEP. Electricity represents 56% of the total GHG emissions for NC WRRF. As part of the BNR alternatives analysis, our study will estimate the change in GHG emission relative to the plant's current performance.

5. CONCLUSIONS

Based on the historical operations and performance data review the following conclusions can be made:

- **Influent Quality Data**

Historically observed WRRF influent data is very consistent and represents a low to medium strength wastewater, which is expected for the size of the collection system and the influence of stormwater during wet weather. Historical influent loading peaking factors are also consistent among parameters and fall within expected ranges for MM, MW, and MD conditions for a WRRF of this size. The impact of COVID-19 on the influent loadings is apparent and expected based on the significant reduction in commuter population and subsequent business activities in NYC during the pandemic.

- **Plant Performance – Liquid Treatment Train**

Based upon a review of the data the WRRF appears to be performing very well, with consistent process control and excellent effluent quality. SRT control has been very consistent, with an average value of approximately 1.5 days. Effluent quality in terms of $cBOD_5$ and TSS has also been consistent and well below permit limits. In terms of nitrogen removal, the WRRF does not appear to nitrify, with effluent NO_3-N and NO_2-N concentrations below 2 mg/L year-round. This is expected given low SRT operation with fully aerobic aeration basins. Historical effluent TN concentrations and loadings average to approximately 17 mg/L-N and 30,500 lbd, respectively. This equates to an average yearly TN removal rate of approximately 41%.

Sludge settleability is also excellent, with a long-term average SVI value below 100 mL/g and a 75th percentile value below 120 mL/g. With these ranges of SVI values it is not anticipated that the facility should have effluent quality issues during wet weather flows.

- **Plant Performance – Solids Handling Treatment Train**

In terms of the solids handling treatment train, the available data suggests fair performance, though a mass balance around sludge thickening suggests solids capture rates of approximately 80% which is suboptimal. Anaerobic digestion is operating with more than sufficient HRTs for mesophilic anaerobic digestion and a mass balance around the unit process suggests that volatile destruction is routinely as high as 60%. The amount of biogas produced per pound of volatile sludge destroyed ranges from 10.5 to almost 20 CF/lb of volatile destroyed, with an average long-term value of approximately 15 CF/d.

The full-plant process model calibration effort that will follow this initial data review task will help validate and confirm the observed historical plant operations and performance data. Particular attention will be paid to matching influent flows and mass loadings, as well as sludge production and the mass balance surrounding anaerobic digestion.

Once the process model is calibrated Arcadis will propose a set of influent flows and mass loadings which will represent **Current Conditions**. Once complete and agreed upon with all project stakeholder Arcadis will work to develop a set of influent flows and loadings to represent the **Future Condition** based upon population and water usage projections provided by DEP.

Appendix B

Technical Memorandum 2 – Existing Condition Assessment of Aeration Tanks and Associated Systems

ARCADIS Design & Consultancy for natural and built assets

THE CITY OF NEW YORK

NYC DEPARTMENT OF ENVIRONMENTAL PROTECTION

1429-ENGSVC-S-NC-008

BNR Feasibility Study for the Newtown Creek WRRF

TM 2 – Existing Condition Assessment of Aeration Tanks and Associated Systems

March 31, 2022

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1. EXECUTIVE SUMMARY

This Technical Memorandum (TM) focuses on the condition assessment of the Aeration Tank and associated systems at NC WRRF. Subsequent TMs will capture hydraulic limitations and analysis of current design and operation conditions as compared to Ten State Standards and TR-16.

In 2020, a comprehensive condition assessment was developed under the Office of the Agency Chief Engineer (OACE) at NC WRRF. During that assessment, physical scores and ratings for all assets at the facility were assigned according to DEP's *Asset Condition Assessment and Risk Scoring Framework* .

Our team conducted a visual inspection of the Aeration Tanks and associated tanks/ structures/ systems on July 14, 2021, where we aimed to confirm the previous scores and rating given and identify changes in condition. Our team did not open any electrical panels or interrupt plant operations to inspect the interior mechanisms of tanks, wet wells, and other assets. The goal was to perform an evaluation without requiring any maintenance of plant operations (MOPO).

Table 1-1 shows a comparison summary of the average score for all assets across the North, Central, and South batteries. A detailed write-up of the condition noted in the field during our assessment for all key systems associated with the liquid stream treatment at the Newtown Creek facility are included in Section 3. Those sections include site photographs taken during our assessment to better substantiate the scores assigned.

Table 1-1: Summary of Newtown Creek WRRF 2020/2021 Condition Assessment Scores

System	Discipline	Primary Asset	2020 Rating	2021 Rating
Grit Removal	Process Mechanical	Pumps	Good	Fair to Good [1]
Grit Removal	Process Structural	Tanks	Good	Good
Aeration	Process Structural	Tanks	Good	Good
Aeration	Process Mechanical	Process Air	Good	Fair to Good [2]
RAS/WAS	Process Mechanical	RAS Pumps	Good	Fair to Good [3]
RAS/WAS	Process Mechanical	WAS Pumps	Good	Good
Skimmings Removal	Process Mechanical	Scum Collection	Good	Fair to Good [2]

System	Discipline	Primary Asset	2020 Rating	2021 Rating
Sediment Tanks	Process Mechanical	Collectors and Drives	Good	Good
Sediment Tanks	Process Structural	Tanks	Good	Good
North Control Building	Structural	Building	Good	Good
North Control Building	Electrical	Electrical Distribution	Fair to Good	Good[4,5,6]
South Control Building	Structural	Building	Good	Good
South Control Building	Electrical	Electrical Distribution	Good	Good
Blowers	Process Mechanical	Blowers	Good	Good

1. North Battery Grit Pumps were considered in good condition in 2020. During the 2021 assessment, our team downgraded the North Battery grit pumps to fair condition due to observed leakage and continued deterioration.
2. The actuators on the sluice gates associated with the Aeration and Settling Tanks are presenting significant issues for plant operations. The Rotork actuators seem to be having issues with water infiltration, which is causing failures within the unit. We noted several failed actuators with several others displaying clear signs of water infiltration inside.
3. RAS Pump #3 has significant leakage during our assessment. That individual pump has been downgraded to fair condition.
4. Motor Control Center MCC-18-01-03 was considered in fair condition. During our 2021 inspection, we upgraded the score of this asset to good condition due to proper maintenance.
5. Automatic Transfer Switch ATS-18-02 was considered in fair condition. During our 2021 inspection, we upgraded the score of this asset to good condition due to proper maintenance.
6. UPS in North Control Building were scored in fair condition in 2020 and 2021.

Conclusions and Recommendations

Based on the Condition Assessment, the existing aeration tanks and associated systems at NC WRRF do not require any major capital improvements at this time. The only capital improvements to be considered under the BNR Study will be process-driven, where the existing systems do not have the requisite capacity to facilitate BNR. Below are the recommendations by discipline based on our findings:

Structural:

- Each Grit Tank, Aeration Tank, and Sediment Tank were evaluated. While conditions within the tanks were unable to be inspected, our assessment and discussions with plant staff confirmed the results of the 2020 inspection. The tanks are considered in good condition.

  - Capital improvements to the Grit, Aeration, and/or Settling tanks are not necessary to facilitate BNR unless additional capacity is required. This will be determined during the BNR alternative analysis.

- The North and South Control Buildings were evaluated, and both considered to be in good condition. Capital improvements to improve the conditions are not needed at this time.
- The tunnel system and lower level of each Control Building was evaluated. While some settling cracks were noted, they've been repaired already, and the tunnel/lower level is considered in good condition. No capital improvement projects are recommended at this time.

Electrical:

- The electrical distribution system for the Aeration Tanks is primarily housed within the North and South Control Building Electrical Rooms. Assets in both areas are in good condition per the 2020 and 2021 assessments, with a handful of assets being upgraded in conditions scores due to improvements made in the last 18 months.
  - Capital improvements to the electrical distribution system are not necessary to facilitate BNR unless additional capacity is required. This will be determined during the BNR alternative analysis.
- UPS within the North Control Building was scored in fair condition. The internal components show signs of age.
  - DEP could consider a capital improvement to replace the two North Battery UPS's.

Process Mechanical:

- Grit pumps are beginning to show signs of deterioration in the North Battery. The Central Battery has a handful of pumps where leakage was noted during our assessment. It is possible both systems will need capital improvements within the next 5-10 years.
  - It is recommended that the North Battery grit pumps be considered under the Capital Improvement Plan for NC WRRF.
- Grit Collector mechanisms and drives were mostly inaccessible. No issues were reported by plant staff during either the 2020 or 2021 assessment. The assets are considered in good condition.
  - Capital improvements to improve condition of the collector mechanisms and drives are not required.
- The process mechanical equipment associated with the Aeration Tanks were mostly inaccessible, including mixers, diffusers, and the spray water system. Our team relied on the 2020 scores for those assets. Process air piping and butterfly valves located above the tank, where evaluated and confirmed the assets are in good condition.
  - At this time, no capital improvement projects to improve condition within the Aeration Tanks and process mechanical equipment is required. Some BNR alternatives may require additional capacity, in particular of the aeration system, which will be evaluated under the BNR alternatives analysis.

  - Rotork actuators associated with the tanks were noted by the plant to be a "headache". It is recommended that the Rotork actuators be considered under the Capital Improvement Plan for NC WRRF.
- RAS/WAS Pumps and associated valves/piping were considered in good condition. It is worth noting that the pumps did show some signs of deterioration not previously noted during the 2020 assessment. Our team recorded leaks from several of the pumps, which can lead to corrosion issues.
  - At this time, no capital improvement projects to improve condition of the RAS/WAS pumps is required. Some BNR alternatives may require changes to the RAS/WAS system, which will be explored during the BNR alternatives analysis.
- Collector mechanisms and drives are in good condition. No issues were reported by plant staff during either the 2020 or 2021 assessment.
  - Capital improvements to improve condition of the collector mechanisms and drives are not required.
- Other systems including seal water, polymer, and spray water systems were all scored in good condition. No capital improvements on these systems are needed at this time.
- Our team evaluated the centrifuges since adjustments to the Aeration Tanks could have impacts on WAS conditions and flows. The centrifuges are considered in good condition.
  - Capital improvements to the sludge dewatering system are not required due to their condition. DEP is already considering more optimal alternatives, such as gravity belt thickeners. Each BNR alternative to be evaluated will consider impacts to the sludge handling systems and DEP's programmatic drivers.

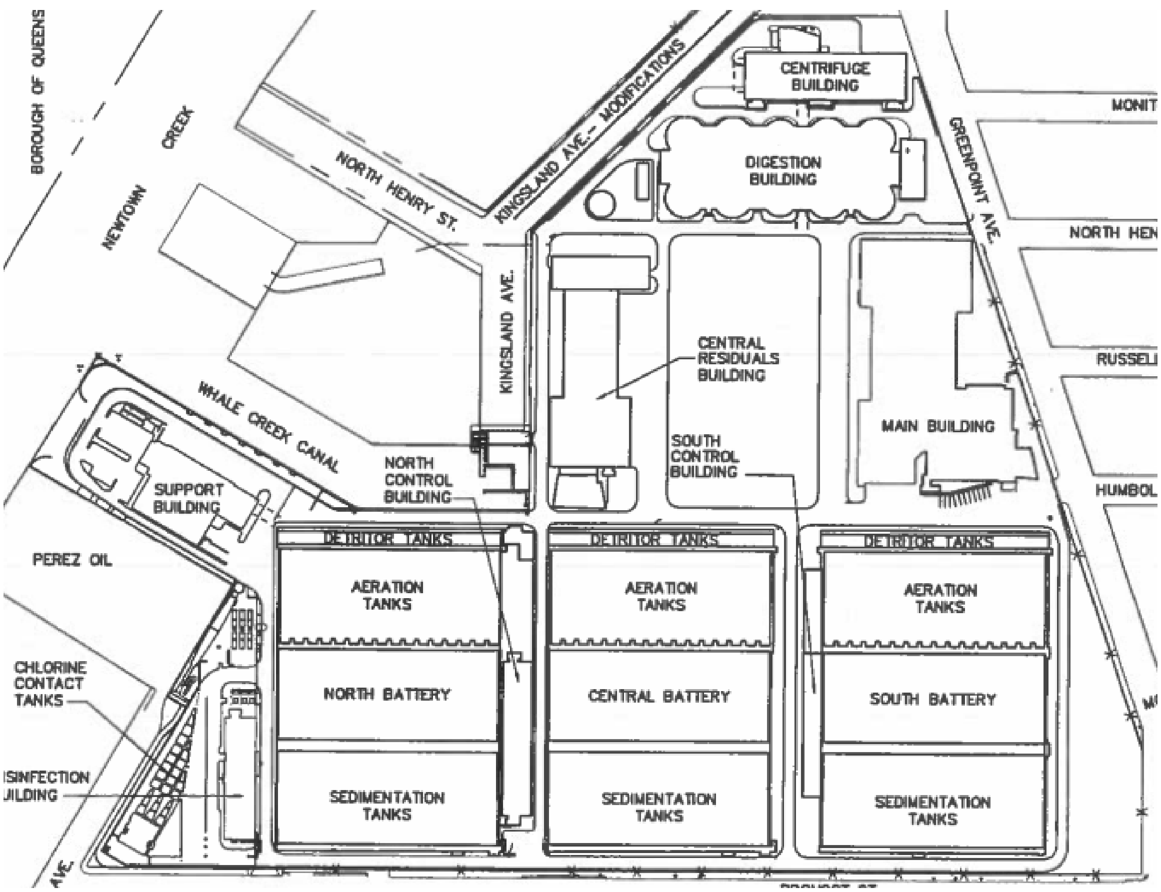
2. INTRODUCTION

This TM will note the condition of critical equipment associated with the Aeration Tanks at NC WRRF to determine the viability BNR at the Plant. Leveraging the available condition data from the OACE's asset management's 2020 condition assessment, this TM will validate and/or note key condition differences between the 2020 assessment and the one conducted under this task order. The primary goal of this TM is to capture the state of good repair for all critical systems associated with the Aeration Tanks and identify condition related limitations as our team explores the facility's potential for BNR.

2.1 Overview of Existing Facilities

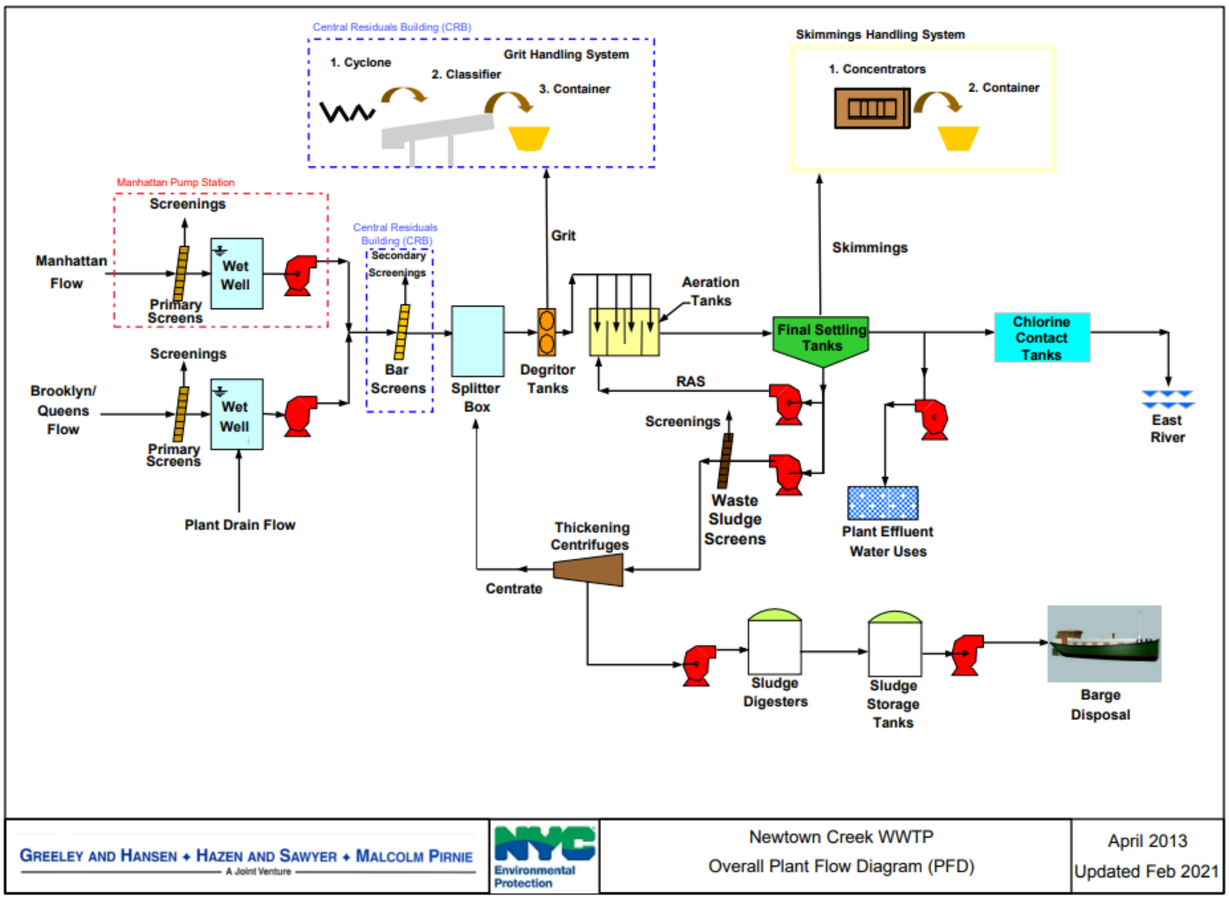
NC WRRF is the largest of the 14 plants and sits on 53 acres of contiguous property in the Greenpoint section of Brooklyn where it is bounded on the North by the Newtown Creek Canal. The existing facility has been in operation since 1967 and has a service area of approximately 25.4 square miles in parts of Brooklyn, Queens, and Manhattan. NC WRRF is permitted to provide full Secondary Treatment up to 310 MGD dry weather flow (DWF) and minimum of 700 MGD during wet weather.

Figure 2-1 : Newtown Creek WRRF Site Plan



Flow from the Manhattan Pump Station and Brooklyn/Queens Pump Station is pumped to the Influent Splitter box that feeds the North, Central, and South Batteries (8 grit tanks and 4 aeration tanks per battery). Unlike the other 13 facilities within New York City, NC WRRF has no primary settling tanks. Instead, Detritors Tanks were constructed in front of the Aeration Tanks to remove as much of the grit as possible before the flow enters the Aeration Tanks.

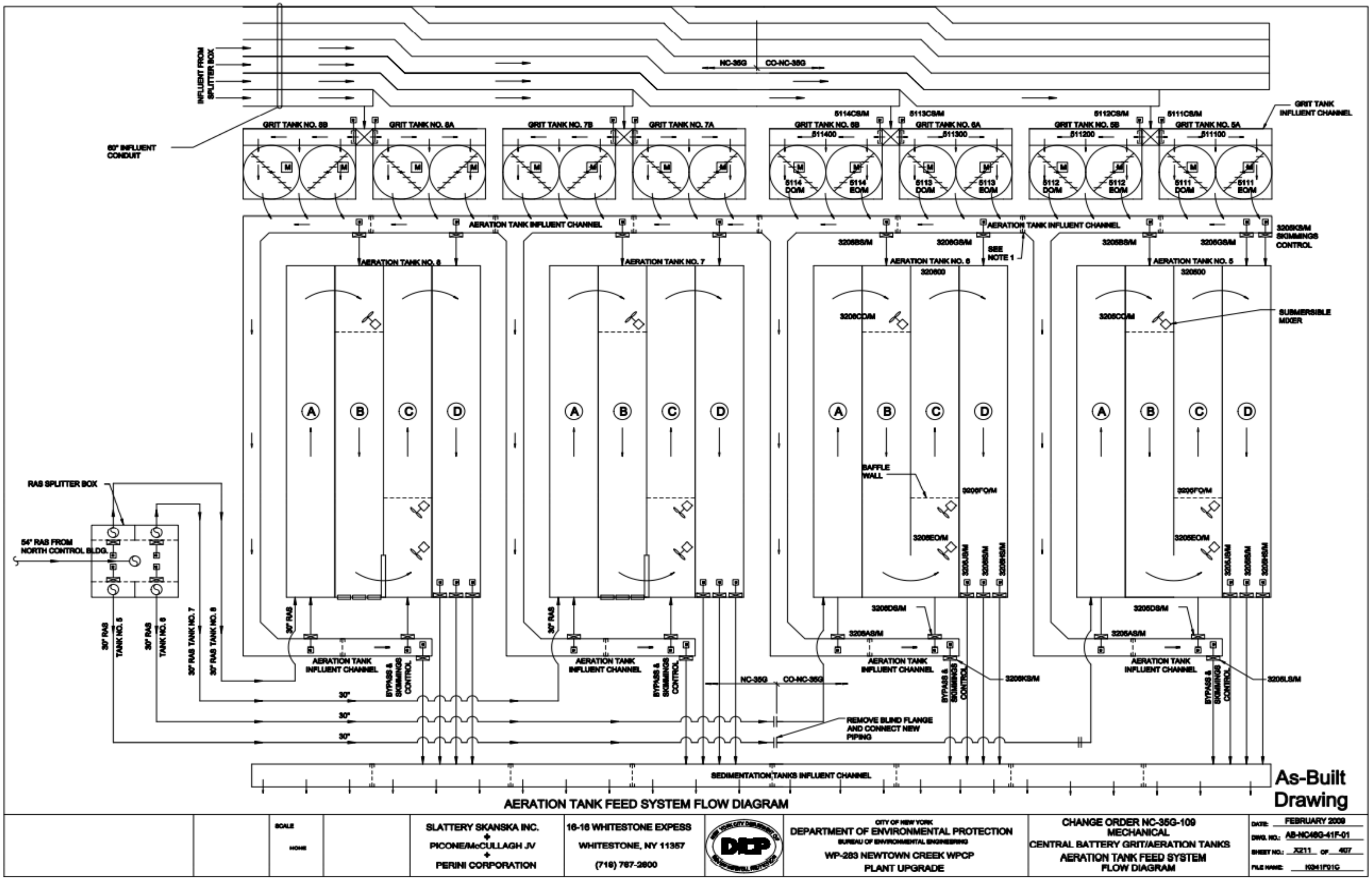
Figure 2-2 : Newtown Creek WRRF Process Flow Diagram



Secondary treatment is accomplished at the Plant using a step-feed activated sludge process, comprised of step-feed aeration and final sedimentation. Each Aeration Tank has 4 passes (Pass A, B, C, and D), and the degritted wastewater may be added at the head of each pass. Each pass is divided into zones, and each zone is equipped with a grid of diffused air equipment. Aeration Tank effluent flow is discharged through gates at the end of Pass D directly into an Aeration Tank effluent channel.

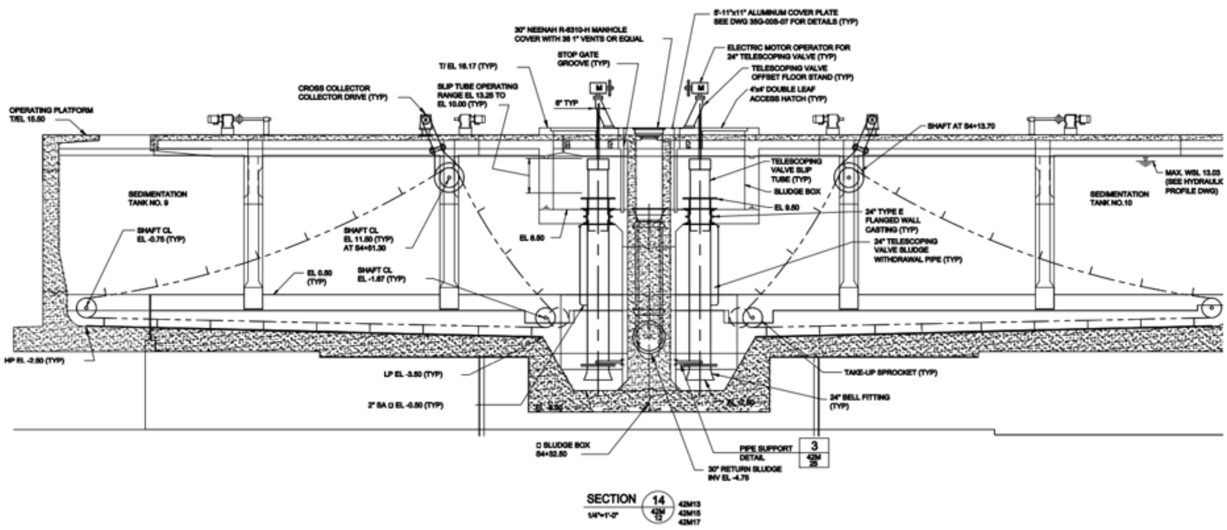
Polymer can be added at the end of Pass D of each Aeration Tank to enhance the settleability of the activated sludge. Dilute polymer solution added to the effluent is mixed completely in the Aeration Tank effluent channel prior to flowing into the final settling tanks. Flocculation zones in the head of the final settling tanks allow for additional contact of the biomass prior to settling.

Figure 2-3 : Newtown Creek WRRF Aeration Tank Step Feed Flow Diagram



In the final settling tanks, skimmings and sludge are collected via chain and flights driven by longitudinal and cross collectors. Skimmings, also known as scum or grease, is pushed north atop the tanks where a sluice gate permits flow into a skimmings collection trough and ultimately to a skimming wet well for each battery. Meanwhile, sludge is collected along the bottom of the sediment tanks through a telescoping valve and flows into a common return activated sludge (RAS) wet well for each battery. From that wet well, RAS is pumped to the head of Pass A for each Aeration Tank while wasted activated sludge (WAS) pumps a portion of the solids to the Sludge Handling Facility to maintain mixed liquor suspended solids (MLSS) concentration within the tanks.

Figure 2-4: Newtown Creek WRRF Aeration Tank RAS Collection



The RAS, WAS, and spray water for each Battery can be chlorinated using the sodium hypochlorite stored in the Control Buildings. These measures help control formation of bulking filamentous organisms and Nocardia foam, both of which can cause series operational issues.

The process air blower system, including the air filters and the air blowers, are located in the south addition of the Main Building. The air blowers are located in the Blower Room on the first floor of the Main Building. The outside air is pulled into the filter room through the louvers, passes through the filters, and enters a filtered air plenum. Each blower has a 42-inch blower intake that connects to the filtered plenum, and a 42-inch blower discharge that connects to one of the two 96-inch air mains. The process air blower system provides air to various locations for all three batteries (North, Central and South Batteries) including the aeration tanks, the final settling tanks, the grit tanks' influent channels, the aeration tanks' influent and effluent channels, and the final settling tanks' influent channels.

3. ASSET CONDITION ASSESSMENT

The inspection for NC WRRF was conducted in November of 2019 with additional plant interviews and data review extending into 2020 when the final scores were provided to DEP. These condition scores, available for review in Attachment B, will be called the 2020 Condition Assessment for the remainder of the TM. Given how recently the assessment was conducted, the 2020 physical condition assessment scores will serve as the backbone of our assessment.

3.1 Inspection Approach and Project Team

The team performed a non-invasive visual inspection of the Aeration Tanks and associated tanks/structures/systems. Our team did not open any electrical panels or stop plant operations to inspect the interior mechanisms of tanks, wet wells, and other assets. The goal was to perform an evaluation without requiring any maintenance of plant operations (MOPO). As a result of this inspection method, there are several assets that were not fully inspected during the asset condition assessment as they were inaccessible. In these instances, scores were supported by interviews with knowledgeable plant staff that could identify condition, ongoing performance issues, or recent work on the system. The list of inspectors is included in the table below.

Table 3-1 : Newtown Creek WRRF 2021 Condition Assessment Inspectors

Name	Company	Discipline
Brian Barkwill, PE	Arcadis	Mechanical
Izzy Begum	Arcadis	Mechanical
Ali Faris PE	Entech	Electrical
Borzoo Makouei	Entech	Electrical
Osaze Amadasu, PE	Entech	Structural

Rather than computing a brand-new score for each asset, our team's approach was to consider the previous score and note changes, where applicable. This drastically reduced the effort of completing another full-scale assessment, which likely would have resulted in near identical scores due to the short time duration between the two assessments.

During our assessment, there were instances where some assets were completely replaced/refurbished since 2020, and our team noted their condition as improved. Conversely, there were assets that continued to depreciate/wear and our team noted their condition as worsened. Refer to Section 3.3 and 3.4 for the detailed write up on each discipline including field notes and site photographs. A summary of the results can be reviewed in Section 3.5.

3.2 Scoring Methodology

The DEP *Asset Condition Assessment and Risk Scoring Framework* provides for a systematic means to identify and group plant assets by varying state of good repair conditions and risk levels, to facilitate subsequent recommendation and prioritization of future capital projects. Each asset was reviewed according to the same criteria and a physical score on a scale of 1-5, where the following broadly summarizes a description of each:

1 – Excellent Condition

2 - Good Condition

3 - Fair Condition

4 - Poor Condition

5 – Very Poor Condition

3.3 2021 Condition Assessment of Assets at NC WRRF

Below is a detailed write up of the field inspection on July 14th, 2021. Our team's notes, site photographs and explanation for score adjustments are detailed in this section.

3.3.1 Primary Treatment

Primary Treatment assets are typically responsible for scum removal, grit, screenings, and initial solids capture prior to aeration (secondary treatment). As discussed in Section 1, of this Appendix, there are no primary settling tanks at the Plant. As a result, grit and scum removal are the only primary treatment systems evaluated under this assessment. Both systems send their collected flow over to Central Residuals for dewatering and hauling.

3.3.1.1 Grit Removal Systems

Key Process Mechanical Assets – Grit Tanks, Grit Uptake Shafts, and Grit Pumps

NC WRRF has 24 grit tanks (8 tanks per battery) to capture and remove grit. The grit tanks are fed via a 60" influent conduit through twelve uptake shafts. Each uptake shaft is equipped with two 3-ft wide (W) by 12-ft 6-in (H) high influent slide gates to isolate flow to each tank. To prevent settling in the influent channel, the area is aerated with four 3-inch air diffusers. Each grit tank is equipped with two circular grit collection mechanisms and a common grit collection hopper. Grit collected in the grit hoppers are transferred by grit pumps to cyclone degritters in the Central Residuals Building.

The tanks are completely covered, which did limit the team's ability to assess their condition; however, operations did not report any issues with the system. The upshafts, located just north of the grit tanks at the tank level and the grit pumps, which are directly below the tanks in the tunnel, were accessible.

Grit Tanks:

Grit tanks at NC WRRF are the first asset to receive flow from the facility's main sewage pumps. Accessibility limited our team to only be able to inspect the collector mechanism drive, aluminium cladding, and surface level concrete/masonry only. During our assessment, all the grit tanks were in operation and no issues were reported by the DEP. The 2020 assessment scored the grit tanks in good condition. The 2021 assessment team confirmed these scores although the structural inspector did note there was some non-process related concrete/masonry damage on the adjacent stairs and guardrail curb, which exhibit spalling.

Grit Uptake Shafts:

The grit uptake shafts were scored together with the grit tanks during the 2020 assessment. Our 2021 inspection confirmed these shafts are in good condition. The gates, mechanisms and structures are all in good condition and the plant reported no issues with these assets.

Grit Pumps:

There are 48 grit pumps (Morris Pumps – Series 6100 Type CT, recessed impeller), located directly below the grit tanks in the tunnel system, with two pumps per tank. The previous assessment considered them in good condition. During our 2021 assessment, we noted significant leakage from several grit pumps, which caused corrosion on the pumps/pump support. Operations has started replacing/refurbishing some of the pumps, and we noted a few brand-new pumps/pump components throughout the three batteries.

The North Battery grit pumps are considered in the worst condition across the three batteries. During our inspection, we noted several pumps where leakage was clearly visible from the pump (5126A0, 5121A0, 5120B0, 5123A0). There were several others where corrosion, likely caused by leaking, was starting to deteriorate the pump and pump support pad. The overall condition of the North Battery grit pumps is worse than recorded during the 2020 condition assessment. These pumps have been downgraded with fair condition. The facility will need to monitor these pumps more closely in the future as they approach poor condition and risk failure.

The central battery grit pumps were in better condition than the North Battery. There was evidence of leakage on a few pump pads, but it seems maintenance on the pumps may have resolved that issue short term, as the pump was in operation and no leak was noted. Overall, these pumps are still considered in good condition.

The South Battery Grit pumps were in the best condition of the three batteries. No issues were noted, and they are considered in good condition.

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Figure 3-1: Newtown Creek WRRF – Site Photographs of Grit Tanks and Grit Pumps

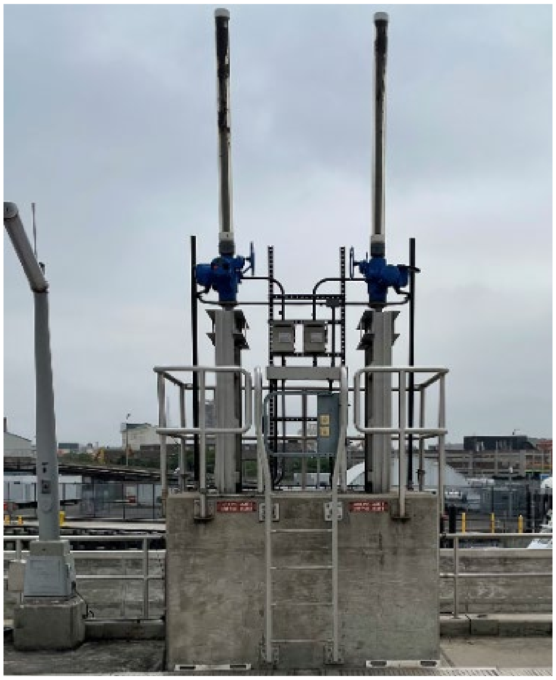

Photo 1- Grit uptake shaft, with two sluice gates, permits flow into one of two grit tanks. Shafts are in good condition.

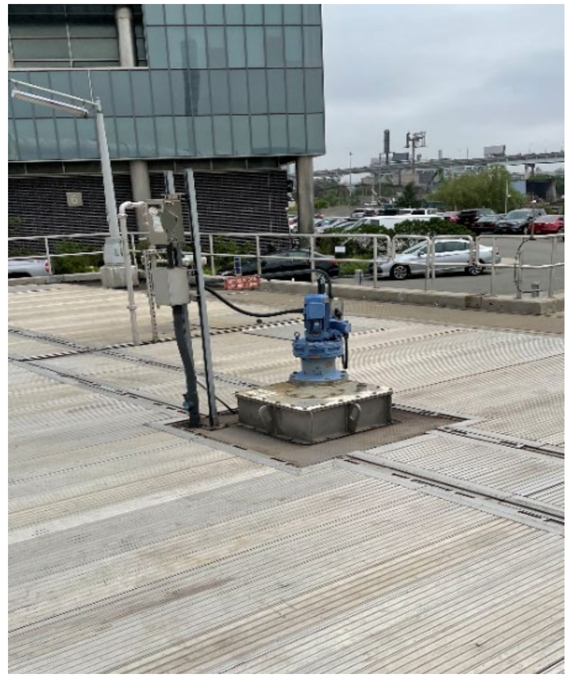

Photo 2- Grit collector mechanisms is largely inaccessible due to aluminium cladding; the drive was visible. The drives are all in good condition.

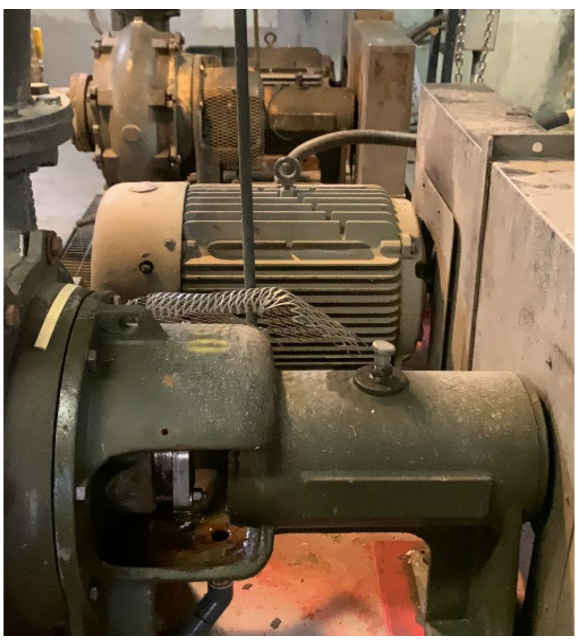

Photo 3 - Several of the grit pumps in the North Battery were leaking during our inspection.

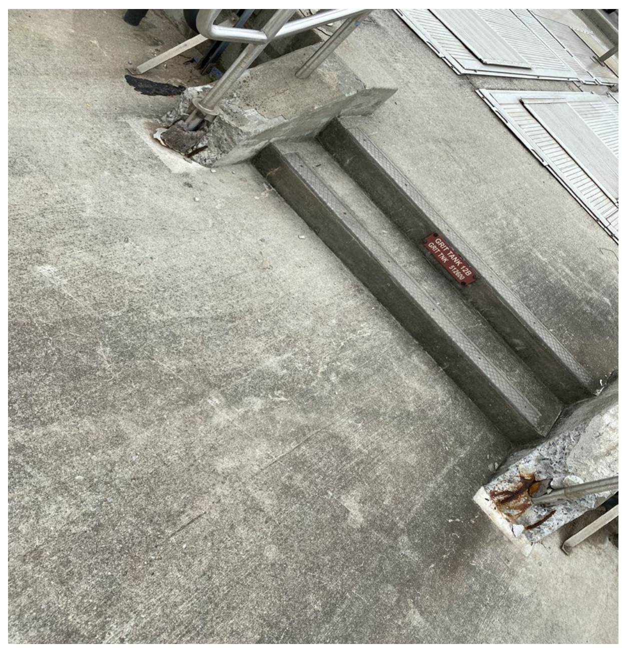

Photo 4 - Spalling Concrete noted on stairs between Grit Tanks and Aeration Tanks. (Adjacent to Grit Tank 12B)

3.3.1.2 Scum (skimming) Removal Systems

Key Process Mechanical Assets – Scum Weir Gates, Scum Pumps

The North, Central and South Batteries each have a separate scum removal system. Each system includes scum gates for scum collection, a scum outlet channel (common to all scum removal gates in a Battery) for conveying scum to the scum wet well, a scum wet well for mixing and containment, and recirculation and transfer pumps for scum pumping. The North Battery Scum Removal System handles scum from Final Settling Tanks Nos. 17 – 24, the Central Battery Scum Removal System handles scum from Final Settling Tanks Nos. 9 – 16, and the South Battery Scum Removal System handles scum from Final Settling Tanks Nos. 1 – 8.

Collected scum flows through the gates into the Battery's scum collection channel where it flows by gravity to a scum wet well in either the North Control Building (North and Central Battery Scum Removal Systems) or the South Control Building (South Battery Scum Removal System). Each scum wet well is equipped with two recirculation pumps for mixing and two transfer pumps for disposal. Vaughn centrifugal chopper pumps are used for all four pumps in each battery. Each pump is supplied with seal water by adjacent Seal Water System pumps.

Figure 3-2: Newtown Creek WRRF – Site Photographs of Scum Removal System and Scum Pumps

Photo 5 - Scum Collection System in good condition and operating as intended.

Photo 6 - Scum Weir Gate failed. Stem of the gate missing. Operations was responding to his issue during our assessment.

Photo 7 - Scum Recirculation Pumps are in good condition and operating as intended.

Photo 8 - Scum Transfer Pumps are in good condition and operating as intended.

3.3.2 Secondary Treatment

3.3.2.1 Process Air

Key Process Mechanical Assets – Blowers, Process Air Piping

The process air blower system provides air to various locations for all three batteries (North, Central and South Batteries) including the aeration tanks, the final settling tanks, the grit tanks' influent channels, the aeration tanks' influent and effluent channels, and the final settling tanks' influent channels. The blowers, located in the Main Building, provide process air through overhead process air piping that crosses the main entrance and runs East-West along the North side of all three batteries.

Blowers:

There are currently nine process air blowers located within the Main Building Blower Room. There is space for a 10th blower and its listed as planned in the NC WRRF O&M Manual. Each blower skid, Turblex Inc Multistage Centrifugal, horizontal split type, includes an inlet/discharge silencer, oil lubrication system, water to oil cooling system, and inlet/discharge valving. Overall, the blowers are in good condition as shown in Figure 3-3. This is consistent with the scores developed in 2020, which has the Blowers at a 2.45 and the supporting systems at a 2.66. The blower building structure is in good condition.

Process Air Piping:

There were no reported issues with the process air piping. While visible, the piping is predominately overhead, standing up to 15 feet above the tank surfaces. In general, the piping appears to be in good condition, but it's not fully accessible. Conversely, our structural team was able to access and assess the structural support structures for the process air and considered it in good condition.

Figure 3-3: Newtown Creek WRRF – Site Photographs of Process Air Blower Skids and Process Air Header

Photo 9 - Process Air Blower in good condition, operating as intended.

Photo 10 - Process Air support systems, cooling water and lube oil, both appear to be in good condition without operating issues.

Photo 11 - Process air header over to South, Central and North Batteries appears in good condition. Structural was able to assess the support structure throughout the batteries and confirmed its in good condition.

3.3.2.2 Aeration Tanks

Key Process Mechanical Assets – Aeration Tanks, Control Buildings, RAS/WAS Pumps, Final Settling Tanks

Aeration Tanks

As discussed in Section 1, secondary treatment at NC WRRF is accomplished with a step-feed activated sludge process within the Aeration Tanks. Each tank is comprised of 4 passes (Pass A, B, C and D), where degritted wastewater can be added at the head of each pass. The tanks are divided into zones, where each zone is equipped with a grid of diffusers that permit process air to aerate the water. There are 12 Aeration tanks at NC WRRF, 4 in each battery.

South Battery	–	Tanks 1 through 4
Central Battery	–	Tanks 5 through 8
North Battery	–	Tanks 9 through 12

Each of the Aeration Tanks are covered, which greatly limited our team's ability to evaluate those assets. Even diffuser performance, where issues with can be seen by bubbling at the surface, could not be assessed during our assessment. Our team did discuss the aeration tank's performance with plant operations staff, and there were no reported issues for performance. Our team was able to evaluate each pass's process air header/valving and mixer motors. The tanks are in good condition, which aligns with the 2020 assessment, where process mechanical equipment within the Aeration Tanks, including mixers and diffusers, were scored a 2.69.

Other mechanical equipment associated with the Aeration Tanks includes spray water, sluice gates, and polymer systems. The influent and effluent sluice gates all appeared in good condition (the portion below the water surface/tank level was inaccessible); however, the plant operations did note issues with Rotork actuators. Spray water and polymer piping seemed in good condition, but our team was unable to view its introduction into the Aeration Tanks. It was considered part of the mechanical equipment assessed in 2020 that was considered in good condition.

Figure 3-4: Newtown Creek WRRF – Site Photographs of Aeration Tanks

Photo 12 - Process Air piping into each tank seemed in good condition, with no reported issues or clear leaks.

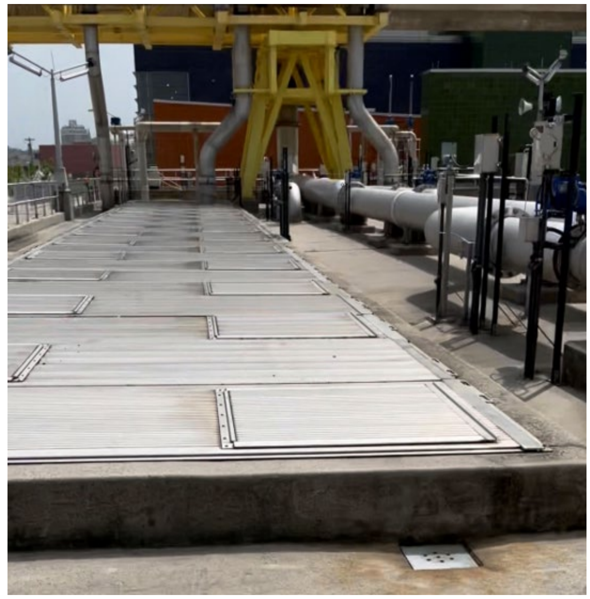

Photo 13 - Aeration Tanks are covered with aluminum cladding.

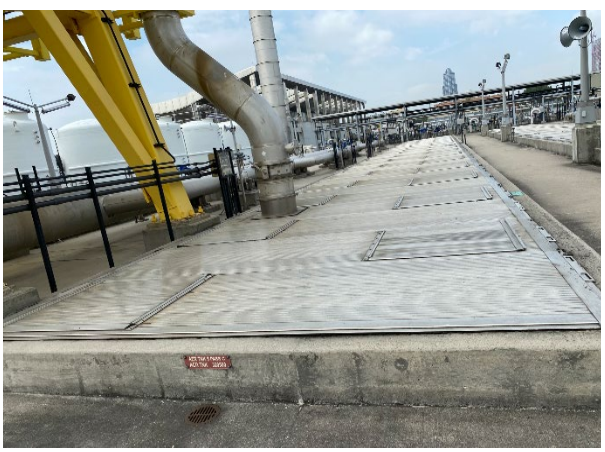

Photo 14 - There were no indications of weakness in the visible areas of the tanks. Some minor settling cracks were recorded.

Photo 15 - Condition across all three batteries is consistent. Tanks are considered in good condition.

Control Buildings – North and South

The North and South Control Buildings were built alongside the batteries they support. The North Control Building, which supports the North and Central Battery, is the older of the two structures. The South Control Building only supports the South Battery. The Control Building houses electrical distribution equipment, HVAC equipment, Polymer Tanks and Pumps, Odor Control

Systems and Ventilation, RAS/WAS pump station, Skimming Pump Station, Seal Water and Effluent water systems, and a temporary scum handling facility in the North Control Building only.

Our structural team assessed both superstructures and considered them in good repair. This is consistent with the 2020 assessment. The tunnel system, which runs East-West beneath the main road, provides access to the lower level of the Control Buildings as well. In those areas, there were a few noticeable cracks that have been fixed on the floor and wall of the tunnel. In the lower level of the Control Buildings, there are detachments of the ceiling's plaster, which has fallen onto process equipment. However, the tunnel system and basement levels are both considered in good condition. The RAS/WAS and Skimmings wet wells were mostly inaccessible; however, no cracks or leaks were recorded on the visible sections.

The odor control fans, located in the lower level, feed airflow into exterior exposed carbon filled vessels. The system is operating as intended and is considered in good condition. All other HVAC equipment for heating and cooling in the Control Buildings, is considered in good condition. This includes hot water pumps, chill water pumps, chillers, and air handling units. Condenser water pumps did show signs of corrosion and wear and would now be considered in fair condition. The polymer storage tanks, and metering pumps are in good condition.

Lastly, there are a few cosmetic imperfections in the exterior of both Control Buildings. It needs minor repair and minor or routine maintenance.

Figure 3-5: Newtown Creek WRRF – Site Photographs of Control Buildings and Tunnel System

Photo 16 - Control Buildings are considered in good condition.

Photo 17 - Lower level/Tunnel level floor cracks that have been fixed.

Photo 18 - Odor Control Fans in good condition. Carbon Tanks at surface level operating as intended.

Photo 19 - Ceiling Plaster has detached.

Photo 20 - Polymer Storage Tanks are in good condition

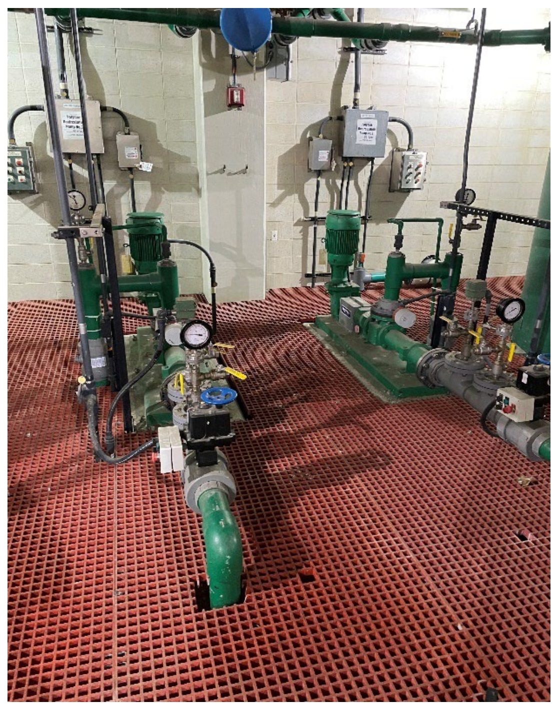

Photo 21 - Polymer metering pumps are in good condition

Return Activated Sludge Pumps and Waste Activated Sludge Pumps

The activated sludge process removes organic mattery using biological oxidation. Microorganisms consume and convert pollutants contained in the wastewater. Sludge within the aeration tanks contains these microorganisms and its critical to recycle a portion of the sludge to maintain strong performance within the Aeration Tanks. Sludge captured in the final settling tanks and recycled using return activated sludge pumps (RAS pumps) to the head of each Aeration Tank. Waste activated sludge pumps (WAS pumps) remove/waste a portion of the sludge to maintain desired MLSS levels and prevent operational headaches.

The facility's RAS (ITT Industries – Model SSE-H, 250 HP) and WAS pumps (ITT Industries, 50 HP) are all located in the North and South Control Buildings. The North Control Building lower level (tunnel level) houses the wet well and pumps for both the North and Central Batteries, while the South Control Building services only the South Battery. There are four RAS and four WAS pumps per battery.

During the 2020 assessment, RAS pumps were considered in good condition across all three batteries, with the South Battery considered to be in the worst condition of the three. During our inspection, there was a single RAS pump located in the south battery that was leaking during operation. RAS Pump #3 has been downgraded to fair condition, while the others are all good condition and operating as intended. With proper maintenance, the leaking can be mitigated. The 250 HP motors all seemed in good condition as well.

WAS pumps were in similar condition to the RAS pumps; however, we did not notice any leaking issues. Their previous ratings were in line with our assessment.

Figure 3-6: Newtown Creek WRRF – Site Photographs of RAS/WAS Pumps

Photo 22 - RAS and WAS Piping are in good condition.

Photo 23 - WAS Pumps are in good condition. Some corrosion was noticed on the system; however, it does not impact operations.

Photo 24 - RAS Pumps are mostly in good condition. RAS pumps #3 had significant leakage during our assessment. Corrosion, likely caused by the leak, was noticed as well.

Photo 25 - RAS Motors are in good condition.

3.3.2.3 Sediment Tanks

Key Process Mechanical Assets – Settling Tanks, Settling Tank Drives and Rakes

Final Settling Tanks

The final settling tanks, also known as Sediment Tanks since there are no primary tanks, are all designed the same. Flow travels east to west in the tanks with rakes extending in both directions from the middle of the tank. The east side of the tank has shallow rakes only, intended solo for capturing settled solids while the west side of the tank has surface level rakes intended for skimmings capture and lower-level rakes intended for solids capture once more. Skimmings capture is controlled with a series of sluice gates, which when open permit flow into the skimmings trough and ultimately into a Skimmings Wet Well. From there, it is pumped to the Central Residuals Building for dewatering and hauling.

Solids capture from the longitudinal rakes brings solids to the center of the tank where a series of cross collector rakes consolidate the solids before a telescoping valve allows the tank the capture the solids and bring the flow down to the RAS wet well.

In general, the process mechanical equipment associated with the final tanks are in good condition. The North and Central batteries did have noticeably more recently installed equipment than the South Battery, where the drives and valves/actuators were older. Plant operations did report issues with the Rotork actuators atop the tanks, where they had significant issues with moisture infiltration and subsequent failure of the actuators. We recorded an instance of this, and it can be seen in Figure 4-7 below.

During our inspection, Final Settling Tank #3 was down for maintenance. Our team was able to get a look at the conditions within the tank including the rakes/chains. Overall, the condition of the process mechanical equipment is considered in good condition. The Rotork actuators which operate the sluice gates throughout the tanks, need to be monitored more closely and could require replacement long term. Our team noted the actuators as fair condition, largely due to water infiltration and reported issues by plant staff, a downgrade from their 2020 score.

During our inspection, we recorded a handful of motors that showed moderate surface corrosion, but the asset still seems to be operating as intended. A few of the drives did seem to have moderate vibration/squeaking issues, but the system was still operating as intended. Figures 4-7, show the condition of the drives and rakes.

Figure 3-7: Newtown Creek WRRF – Site Photographs of Settling Tanks, Drives, and Rakes

Photo 26 - Surface Corrosion on motor noted but unit is still in good condition, operating as intended.

Photo 27 - All cross and Longitudinal collector drives are considered in fair to good condition.

Photo 28 - Skimmings collection atop each tank was operating as intended.

Photo 29 - Rotork actuators are older compared to Central and North Batteries. As noted by DEP, there have been issues with Rotork actuators in the past. These are considered in fair condition, but water infiltration could cause operational issues.

3.3.3 Centrifuge Building

Key Process Mechanical Assets – Secondary Clarifier Distribution Boxes, Secondary Clarifier Tanks

3.3.3.1 Centrifuges

While this assessment focused on the systems associated with the Aeration Tanks, WAS is thickened prior to digestion at NC WRRF. Any changes to the Aeration Tanks, such as implementing BNR, may alter WAS conditions heading to the centrifuges. This assessment evaluated the centrifuges to ensure their condition would not hamper any BNR alternatives considered.

Overall, the centrifuges (BSC3114 Bird – Humboldt Centrifuge) are considered in good condition. While DEP may consider other technologies for better performance, the centrifuges are operating as intended. Their condition should not be a limiting factor when considering BNR alternatives.

Figure 3-8: Newtown Creek WRRF – Site Photographs of Centrifuges

Photo 30 – Centrifuges located in the Thickener Building, are in good condition.

3.4 Condition Assessment of Electrical Assets at NC WRRF

3.4.1 North Control Building

Key Process Electrical Assets – Unit Substation, Electrical Distribution

Unit Substations (USS) located in North Control Building acts as the power distribution consisting of four (4) unit substations, these unit substations feeds/energizes eighteen (18) different Motor Control Centres (MCCs). Each unit substation has two (2) disconnect switch mechanisms and two (2) 13.8KV transformers. The main cable connections to the unit substations, transformer and disconnect switch is protected by a cover door and is not visible to determine connections or voltage leaks. The conduits leaving the top of the unit substation branch to different lower voltage distributions and had no sign of voltage leaks or conduit cracks. Overall, the outside surface of the unit substation was assessed in good condition as shown in Figure 3-9 with no signs of surface corrosion, concrete cracks, water damage, breakers tripped, conduit corrosion/support damage, and non-functional devices. The previous condition assessment had the same rating.

Figure 3-9: Newtown Creek WRRF – Site Photographs of Unit Substation Electrical Room in North Battery Building

Photo 31 – Unit Substation Disconnect Mechanism have cover doors and limited view of the inside connections.

Photo 32 – Unit Substation Transformer have cover doors and limited view of the inside connections.

Photo 33 – Unit Substation overall rating is in good condition.

Motor Control Centers:

There are currently eight (8) MCCs located within the North Control Building used to energize service water pumps, sodium hypochlorite metering pumps, pressure wash pumps, chiller, service air compressors, condenser water pump, WAS pumps, RAS pumps, odor control fans, exhaust fans, and various electrical outlets. There were no reported issues with the MCC units; our team noticed some MCC bucket/cubicles are tagged out of service for repurposing. Overall, the units were assessed in good condition with no signs of surface corrosion, concrete cracks, water damage, open bucket doors, conduit corrosion/support damage, although with some non-functional devices and tripped breakers. The previous condition assessment had the same rating. It is important to note that MCC-18-04-03 appears to be in good condition, which was previously scored in fair condition in 2020. The condition improvement is likely due to facility maintenance. Overall, the MCC units appeared in good condition presently as shown in Figures 4-10.

Figure 3-10: Newtown Creek WRRF – Site Photographs of Motor Control Centers in Electrical Room in North Battery Building

Photo 34 – MCC 18-04-03 unit appears in good condition operating as intended.

Photo 35 – Devices are functional, one MCC cubicle lockout of service.

ATS:

There are currently five (5) Automatic Transfers Switches (ATS) located within the North Control Building. During our assessment, we noticed that ATS switches are missing labels, but it was observed that all ATS' are in good condition as shown in the following figures shown below. Overall, ATS' are scored in good condition, and they maintain their condition from the previous assessment.

Figure 3-11: Newtown Creek WRRF – Site Photographs of ATS in Electrical Room in North Battery Building

Photo 36 – ATS is in good condition, and is operating as intended

Photo 37 – ATS switch is in good condition, no label or tag to identify the system.

Transformers:

There are currently sixteen (16) Transformers (XFM) located within the North Control Building which includes eight transformers that belong to USS 1-4 (four for A sides and four for B sides), seven lighting transformers and one fire alarm transformer. Transformers had no signs of holes/voltage leak, surface, and concrete cracks. Overall, the transformers are scored in good condition, and they maintain their condition from the previous assessment.

Figure 3-12: Newtown Creek WRRF – Site Photographs of Transformers in Electrical Room in North Battery Building

Photo 38 – Transformer is in good condition with no holes or dielectric leak.

Photo 39 – Transformer is in good condition with no holes or dielectric leak.

Photo 40 – Transformer is in good condition with no holes or dielectric leak.

Photo 41 – Fire Alarm Transformer is in good condition with no holes or dielectric leak.

UPS:

There are currently two Uninterrupted Power Supplies (UPS) located within the North Control Building. During our assessment, visually, the system doesn't exhibit any cracks, corrosion, connection leaks, holes, or failures. The electronics inside the UPS show signs of deterioration. Overall, the team scored the UPS in fair condition, and they maintain their condition from the previous assessment.

Figure 3-13: Newtown Creek WRRF – Site Photographs of UPS in Electrical Room in North Battery Building

Photo 42 – UPS system visually appears to be in good condition.

Photo 43 – The UPS internal components show signs of deterioration.

3.4.2 South Control Building

Key Process Mechanical Assets – Switchgear, MCC, VFD, ATS, Transformers, UPS

Switchgear:

Switchgear (SWGR) located in South Control Building acts as the power distribution consisting of two (2) switchgears. These switchgears feed/energize six different MCCs that are in the South Control Building, VFDs, and other MCC's that are located outside the building. The main cable connections to the switchgears are protected by a cover door and is not visible to determine connections or voltage leaks. The conduits leaving the top of the switchgear branches to different lower voltage systems. The conduit is predominately overhead, standing up to 10 feet above the switchgear. In general, the visible overhead conduit was assessed in good condition with no sign of voltage leaks or conduit cracks. Overall, the outside surface of the switchgear was assessed in good condition as shown in the figures below. The system showed no signs of surface corrosion, concrete cracks, water damage, breakers tripped, conduit corrosion/support damage, and non-functional devices. The previous condition assessment had the same rating.

Figure 3-14: Newtown Creek WRRF – Site Photographs of Unit Substation Electrical Room in South Battery Building

Photo 44 – Switchgear 19-01-01 is

Photo 45 – Switchgear 19-01-02 is in good condition operating as intended.

Motor Control Centers:

There are currently six (6) MCC units located within the South Control Building used to energize service hot water pumps, waste activated sludge pumps, polymer room sump pumps, overhead doors, polymer blending units, ATS, HV units, Air Filter Units, Monorails, CRAC units, odor control fans, exhaust fans, and various electrical outlets. There were no reported issues with the MCC units but noticed some MCC bucket/cubicles are tagged out of service for repurposing. The units were assessed in good condition with no signs of surface corrosion, concrete cracks, water damage, open bucket doors, conduit corrosion/support damage, some non-functional devices, and tripped breakers. The previous condition assessment had the same rating. Overall, the MCC units appeared in good condition as shown in figures on the next page.

Figure 3-15: Newtown Creek WRRF – Site Photographs of MCCs Electrical Room in South Battery Building

Photo 46 – MCC 19-04-01 unit is in good condition operating as intended.

Photo 47 – MCCs is in good condition.

ATS:

There are currently four (4) ATS located within the South Control Building. During our assessment, it was observed that all ATS' are in good conditions as shown in the following figures. Overall, the ATS' are scored in good condition, and they maintain their condition from the previous assessment.

Figure 3-16: Newtown Creek WRRF – Site Photographs of ATS in Electrical Room in South Battery Building

Photo 48 – ATS is in good condition and operating as intended.

Photo 49 – ATS is in good condition and operating as intended.

Transformers:

There are currently twelve (12) Transformers (XFM) located within the South Control Building. During our assessment, the transformers were assessed in good condition with no signs of surface corrosion, concrete cracks, water damage, and conduit corrosion/support damage. Therefore, as they were scored in good condition previously in 2020, our assessment concludes they are still in the same condition. The following figures demonstrate a few of them.

Figure 3-17: Newtown Creek WRRF – Site Photographs of Transformers in Electrical Room in South Battery Building

Photo 50 – Transformer is in good condition and operating as intended.

Photo 51 – Transformer is in good condition and operating as intended.

Photo 52 – Transformer is in good condition and operating as intended.

Photo 53 – Transformer is in good condition and operating as intended.

Variable Frequency Drive:

There are currently four (4) Variable Frequency Drives (VFD) located within the South Control Building. During our assessment, the VFD units were assessed in good condition with no signs of surface corrosion, concrete cracks, water damage, and conduit corrosion/support damage. It is important to note that VFD #2, VFD #3, and VFD #4 appear in the good condition which were previously scored in poor condition in 2020. Overall, the VFD units appeared in good condition as shown in figures below.

Figure 3-18: Newtown Creek WRRF – Site Photographs of VFDs in Electrical Room in South Battery Building

Photo 54 – VFD #1, VFD #2, VFD #3, and VFD #4 are in good condition operating as intended.

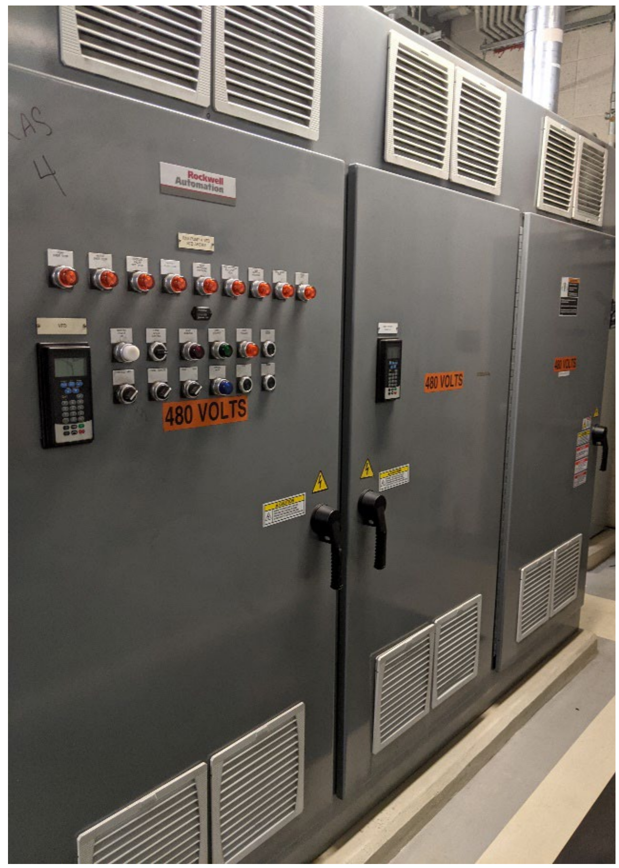

Photo 55 – VFD #4 is in good condition operating as intended.

3.4.3 Centrifuge Building

Key Process Mechanical Assets – MCC,

Motor Control Centers:

There are currently five (5) MCC units assessed located within the Centrifuge Building. There were no reported issues with the MCC units but noticed the roof leaking near MCC 9. This will impact and reduce the unit's condition. Overall, the MCCs were assessed in good condition with no signs of surface corrosion, concrete cracks, open bucket doors, and conduit corrosion/support damage. The previous condition assessment had the same rating. Overall, the MCC units appeared in good condition as shown in the figures below.

Figure 3-19: Newtown Creek WRRF – Site Photographs of MCCs in the Centrifuge Building

Photo 56 – MCC is in good condition operating as intended.

Photo 57 – MCCs devices are functional and MCC is in good condition.

3.5 Summary of the Results

The physical condition ratings assigned to all assets within the Aeration Tanks and associated systems are summarized in this section. Table 3-2 to 3-5 below averages the scores for all similar assets to provide a benchmark understanding of their condition.

Table 3-2: Newtown Creek WRRF 2020/2021 Condition Assessment Data – North Battery

Location	System	Discipline	Primary Asset	2020 Rating	2021 Rating
North Battery	Grit Removal	Process Mechanical	Pumps	Good	Fair[1]
North Battery	Grit Removal	Process Structural	Tanks	Good	Good
North Battery	Aeration	Process Structural	Tanks	Good	Good
North Battery	Aeration	Process Mechanical	Process Air	Good	Fair to Good [2]
North Battery	RAS/WAS	Process Mechanical	RAS Pumps	Good	Good
North Battery	RAS/WAS	Process Mechanical	WAS Pumps	Good	Good
North Battery	Skimmings Removal	Process Mechanical	Scum Collection	Good	Good
North Battery	Sediment Tanks	Process Mechanical	Collectors and Drives	Good	Fair to Good [2]
North Battery	Sediment Tanks	Process Structural	Tanks	Good	Good
North Battery	North Control Building	Structural	Building	Good	Good

Table 3-3: Newtown Creek WRRF 2020 Condition Assessment Data – Central Battery

Location	System	Discipline	Asset	2020 Rating	2021 Rating
Central Battery	Grit Removal	Process Mechanical	Pumps	Good	Good
Central Battery	Grit Removal	Process Structural	Tanks	Good	Good
Central Battery	Aeration	Process Structural	Tanks	Good	Good
Central Battery	Aeration	Process Mechanical	Process Air	Good	Fair to Good 2
Central Battery	RAS/WAS	Process Mechanical	RAS Pumps	Good	Good
Central Battery	RAS/WAS	Process Mechanical	WAS Pumps	Good	Good
Central Battery	Skimmings Removal	Process Mechanical	Scum Collection	Good	Good
Central Battery	Sediment Tanks	Process Mechanical	Collectors and Drives	Good	Fair to Good 2
Central Battery	Sediment Tanks	Process Structural	Tanks	Good	Good

Table 3-4: Newtown Creek WRRF 2020 Condition Assessment Data – South Battery

Location	System	Discipline	Asset	2020 Rating	2021 Rating
South Battery	Grit Removal	Process Mechanical	Pumps	Good	Good
South Battery	Grit Removal	Process Structural	Tanks	Good	Good
South Battery	Aeration	Process Structural	Tanks	Good	Good
South Battery	Aeration	Process Mechanical	Process Air	Good	Fair to Good 2

Location	System	Discipline	Asset	2020 Rating	2021 Rating
South Battery	RAS/WAS	Process Mechanical	RAS Pumps	Good	Fair to Good [3]
South Battery	RAS/WAS	Process Mechanical	WAS Pumps	Good	Good
South Battery	Skimmings Removal	Process Mechanical	Scum Collection	Good	Good
South Battery	Sediment Tanks	Process Mechanical	Collectors and Drives	Good	Fair to Good [2]
South Battery	Sediment Tanks	Process Structural	Tanks	Good	Good
South Battery	South Control Building	Structural	Building	Good	Good

Table 3-5: Newtown Creek WRRF 2020 Condition Assessment Data – Facility Wide Systems

Location	System	Discipline	Asset	2020 Rating	2021 Rating
Main Building	Process Air	Process Mechanical	Blowers	Good	Good
Main Building	Process Air	Electrical	Blower Motors	Good	Good
Main Building	Process Air	Process Mechanical	Blower Supporting Systems (cooling water, Lube oil)	Good	Good
Main Building	Process Air	Structural	Building	Good	Good
Polymer	Polymer System	Process Mechanical	Pumps and Piping	Good	Good

Location	System	Discipline	Asset	2020 Rating	2021 Rating
Sludge Thickening	Sludge Thickening	Process Mechanical	Centrifuges	Good	Good
Sludge Thickening	Sludge Thickening	Structural	Building	Good	Good
Sludge Thickening	Electrical Distribution	Electrical	MCCs	Good	Good
North Control Building	Odor Control	HVAC	Odor Control System	Good	Good
South Control Building	Odor Control	HVAC	Odor Control System	Good	Good
North Control Building	Electrical Distribution	Electrical	MCCs	Fair to Good	Good [4]
North Control Building	Electrical Distribution	Electrical	ATS	Fair to Good	Good [5]
North Control Building	Electrical Distribution	Electrical	Transformer	Good	Good
North Control Building	Electrical Distribution	Electrical	SWGR	Good	Good [6]
South Control Building	Electrical Distribution	Electrical	MCCs	Good	Good
South Control Building	Electrical Distribution	Electrical	ATS	Good	Good
South Control Building	Electrical Distribution	Electrical	Transformer	Good	Good

Location	System	Discipline	Asset	2020 Rating	2021 Rating
South Control Building	Electrical Distribution	Electrical	SWGR	Good	Good

1. North Battery Grit Pumps were considered in good condition in 2020. During the 2021 assessment, our team downgraded the North Battery grit pumps to fair condition due to observed leakage and continued deterioration.
2. The actuators on the sluice gates associated with the Aeration and Settling Tanks are presenting significant issues for plant operations. The Rotork actuators seem to be having issues with water infiltration, which is causing failures within the unit. We noted several failed actuators with several others displaying clear signs of water infiltration inside.
3. RAS Pump #3 has significant leakage during our assessment. That individual pump has been downgraded to fair condition.
4. Motor Control Center MCC-18-01-03 was considered in fair condition. During our 2021 inspection, we upgraded the score of this asset to good condition due to proper maintenance.
5. Automatic Transfer Switch ATS-18-02 was considered in fair condition. During our 2021 inspection, we upgraded the score of this asset to good condition due to proper maintenance.
6. UPS in North Control Building were scored in fair condition in 2020 and 2021.

4. CONCLUSIONS

The primary objective of this condition assessment was to establish the assets and systems whose condition requires them to be considered in the near future capital improvement plans. Any BNR alternative that is making substantial changes to the Aeration Tanks would be a logical time to upgrade conditions of systems whose remaining useful life is expiring. A system such as the grit pumps, whose condition was noticeable more worn in 2021 than 2020, will be replaced under all of the BNR alternatives evaluated moving forward. Systems that will be replaced due to capacity limitations, such as process air or electrical distribution, will be discussed separately during the BNR alternatives analysis.

Overall, the assets associated with liquid stream treatment are in good condition. Below is a discussion on each discipline:

Structural:

- Each Grit Tank, Aeration Tank and Sediment Tank was evaluated. While conditions within the tank were unable to be inspected, our assessment and discussions with plant staff confirmed the results of the 2020 inspection. The tanks are considered in good condition.
    - Capital improvements to the Grit, Aeration and/or Settling tanks are not necessary to facilitate BNR unless additional capacity is required. This will be determined during the BNR alternatives analysis.
- The North and South Control Buildings were evaluated, and both considered to be in good condition. Capital improvements to improve their condition are not needed at this time.
- The tunnel system and lower level of each Control Building was evaluated. While some settling cracks were noted, they've been repaired already, and the tunnel/lower level is considered in good condition. No capital improvement projects are recommended at this time.

Figure 4-1: Newtown Creek WRRF – Structural Summary Photographs

Photo 58- Aeration Tanks, shown above, were covered in aluminium cladding. The visible portion of the tanks and cladding are considered in good condition.

Photo 59- Settling Cracks in the tunnel system were noted during our assessment. The facility has already taken the proper measures to secure these cracks.

Electrical:

- The electrical distribution system for the Aeration Tanks is primarily housed within the North and South Control Building Electrical Rooms. Assets in both areas are in good condition per the 2020 and 2021 assessments, with a handful of assets being upgraded in conditions scores due to improvements made in the last 18 months.
    - Capital improvements to the electrical distribution system are not necessary to facilitate BNR unless additional capacity is required. This will be determined during the BNR alternatives analysis.
- UPS within the North Control Building was scored in fair condition. The internal components show signs of age.
    - DEP could consider a capital improvement to replace the two North Battery UPS's

Figure 4-2: Newtown Creek WRRF – Electrical Summary Photographs

Photo 60 – Motor Control Centers in both the North and South Control Building Electrical Rooms are in good condition.

Photo 61 – VFD #1, VFD #2, VFD #3, and VFD #4 appear in good condition operating as intended.

Process Mechanical/HVAC:

- Grit pumps are beginning to show signs of deterioration in the North Battery. The Central Battery has a handful of pumps where leakage was noted during our assessment. It's possible both systems will need capital improvements within the next 5-10 years.
    - It is recommended that the North Battery grit pumps be considered under the Capital Improvement Plan for NC WRRF.
- Grit Collector mechanisms are drives were mostly inaccessible. No issues were reported by plant staff during either the 2020 or 2021 assessment. The assets are considered in good condition.
    - Capital improvements to improve condition of the collector mechanisms and drives are not required.
- The process mechanical equipment associated with the aeration tanks were mostly inaccessible. Mixers, diffusers, and the spray water system were all mostly inaccessible. Our team relied on the 2020 scores for those assets. Process air piping and butterfly

valves located above the tank, where evaluated and confirmed the assets are in good condition.

  - At this time, no capital improvement projects to improve condition within the aeration tanks to process mechanical equipment is required. Some BNR alternatives may require additional capacity, such as the process air system, which will be evaluated under the BNR alternatives analysis.
  - Rotork actuators associated with the tanks were noted by the plant to be a “headache”. It is recommended that the Rotork actuators be considered under the Capital Improvement Plan for NC WRRF.
- RAS/WAS Pumps and associated valves/piping were considered in good condition. It is worth noting that the pumps did show some signs of deterioration not previously noted during the 2020 assessment. Our team recorded a significant leak in RAS pump #3, which can lead to corrosion issues.
  - At this time, no capital improvement projects to improve condition of the RAS/WAS pumps is required. Some BNR alternatives may require changes to the RAS/WAS system, which will be explored during the BNR alternatives analysis.
- Collector mechanisms and drives are in good condition. No issues were reported by plant staff during either the 2020 or 2021 assessment.
  - Capital improvements to improve condition of the collector mechanisms and drives are not required.
- Other systems including seal water, polymer, and spray water systems were all scored in good condition. No capital improvements on these systems are needed at this time.
- Our team evaluated the centrifuges since adjustments to the aeration tanks could have impacts on WAS conditions and flows. The centrifuges are considered in good condition.
  - Capital improvements to the sludge dewatering system are not required due to condition. The facility may want to consider other alternatives, such as gravity belt thickeners, but that’s not required due to their condition. Each BNR alternative considered will consider impacts to the sludge handling systems and consider DEPs programmatic drives.
- HVAC and odor control systems were all considered in good condition.

Figure 4-3: Newtown Creek WRRF – Process Mechanical Summary Photographs

Photo 62 – Rotork actuators were reported to have had significant issues with waterproofing. Actuators will be recommended for replacement for each BNR alternative assesses.

Photo 63 - Process Air Blowers and supporting systems (i.e., lube oil, cooling water, etc) are considered in good condition.

Photo 64 - Several grit pumps in the North Battery were visibly leaking during our inspection. The condition of the pump support pads was noticeably corroded, likely due to pump leakage. These pumps are considered in fair condition currently, but likely will deteriorate quickly.

Photo 65 - Skimming Transfer and Recirculation chopper pumps are in good condition.

Photo 66 - Process air header over to South, Central and North Batteries are in good condition. Both process mechanical and structural team members assessed the system and confirmed it is in good condition.

Appendix C

Technical Memorandum 3 – Flow and Loading Projections

THE CITY OF NEW YORK

NYC DEPARTMENT OF ENVIRONMENTAL PROTECTION

1429-ENGSVC-S-NC-008

BNR Feasibility Study for the Newtown Creek WRRF TM 3 – Flow and Loading Projections

March 31, 2022

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Acronyms and Abbreviations

AA	average annual
AEMLSS	aerator effluent mixed liquor suspended solids
$cBOD_5$	5-day carbonaceous biochemical oxygen demand
cfm	cubic feet per minute
gpm	gallons per minute
HRT	hydraulic retention time
lbd	pounds per day
MD	maximum daily
MGD	millions of gallons per day
mg/L	milligrams per liter
MM	maximum monthly
MW	maximum weekly
NH_3-N	ammonia
NO_2-N	nitrite
NO_3-N	nitrate
NYCDEP	New York City Department of Environmental Protection
NYMTC	New York Metropolitan Transportation Council
O&M	Operations and Maintenance
RAS	return activated sludge
SLR	solids loading rate
SOR	surface overflow rate
SRT	solids retention time
TKN	Total Kjeldahl Nitrogen
TN	total nitrogen
TSS	total suspended solids
VSR	volatile solids reduction
WAS	waste activated sludge
WRRF	wastewater resource recovery facility

Executive Summary

This technical memorandum (TM) focuses on the evaluation of the following feasibility study components and conclusions:

Influent Flow and Loading Projections

The establishment of future influent flow and mass loadings was based on observed historical operations and performance data and population growth projections from the New York Metropolitan Transportation Council (NYMTC) based on 2010 US Census Data, provided to Arcadis by NYCDEP for 2030, 2040 and 2050 conditions at the WRRF. The growth projections were developed in 2019 and the basis for the projections is historical average influent flows and concentrations for the 2015 to 2019 operating period. The proposed flow in MGD, peaking factors (PF), and mass loadings (in pounds per day, lbd) for the 2030, 2040, and 2050 conditions are summarized in Table ES-1 through Table ES-3.

Table ES- 1. Future Influent Flow and Mass Loadings – 2030 Condition

Parameter	AA	MM	MW	MD
Flow, MGD	230	262	320	563
Flow PF	---	1.14	1.40	2.45
Load PF	---	1.15	1.35	2.00
COD, lbd	701,676	806,928	947,263	1,403,353
$cBOD_5$, lbd	317,659	365,308	428,840	635,318
$cBOD_5$ (uninhibited), lbd	334,378	384,535	451,410	668,756
TSS, lbd	310,228	356,762	418,807	620,455
VSS, lbd	277,359	318,963	374,435	554,718
TKN, lbd	59,130	67,999	79,825	118,260
NH_3-N, lbd	38,358	44,111	51,783	76,715
TP, lbd	7,764	8,929	10,482	15,529
PO_4-P, lbd	4,705	5,410	6,351	9,409

Notes:
AA – average annual, MM – maximum monthly, MW – maximum weekly, MD – maximum daily.

Table ES- 2. Future Influent Flows and Mass Loadings – 2040 Condition

Parameter	AA	MM	MW	MD
Flow, MGD	238	272	332	583
Flow PF	---	1.14	1.40	2.45
Load PF	---	1.15	1.35	2.00
COD, lbd	727,664	836,814	982,347	1,455,329
$cBOD_5$, lbd	329,424	378,838	444,723	658,849
$cBOD_5$ (uninhibited), lbd	346,762	398,777	468,129	693,525
TSS, lbd	321,717	369,975	434,319	643,435
VSS, lbd	287,632	330,776	388,303	575,263

Parameter	AA	MM	MW	MD
TKN, lbd	61,320	70,518	82,782	122,640
NH_3-N, lbd	39,778	45,745	53,701	79,557
TP, lbd	8,052	9,260	10,870	16,104
PO_4-P, lbd	4,879	5,611	6,587	9,758

Table ES- 3. Future Influent Flows and Mass Loadings – 2050 Condition

Parameter	AA	MM	MW	MD
Flow, MGD	242	277	338	594
Flow PF	---	1.14	1.40	2.45
Load PF	---	1.15	1.35	2.00
COD, lbd	740,658	851,757	999,889	1,481,317
$cBOD_5$, lbd	335,307	385,603	452,664	670,614
$cBOD_5$ (uninhibited), lbd	352,955	405,898	476,489	705,909
TSS, lbd	327,462	376,582	442,074	654,925
VSS, lbd	292,768	336,683	395,237	585,536
TKN, lbd	62,415	71,777	84,260	124,830
NH_3-N, lbd	40,489	46,562	54,660	80,977
TP, lbd	8,196	9,425	11,064	16,392
PO_4-P, lbd	4,966	5,711	6,704	9,932

Comparison of Historical Operations and Performance with Ten State Standards and WRRF Basis of Design

Historical operation of the NC WRRF was compared to typical design standards and recommendations outlined in Ten State Recommended Standards for Wastewater Facilities (10SS) and the original design basis and intent of the WRRF. The majority of critical operating and loading criteria from 10 SS for a conventional activated sludge WWRF (i.e., grit removal retention time, chlorine contact detention times) were met when compared to historical operations, and those that were beyond what is typically recommended by 10SS was well within the threshold established in the WRRF basis of design, outlined in Enhanced Track 3 Basis of Design for the WRRF. Parameters that have met industry standards for historical operating conditions include grit removal detention time, aeration tank MLSS, sedimentation tank surface overflow rate (SOR), sedimentation tank solids loading rate (SLR), sedimentation tank weir loading rate (WLR), chlorine disinfection tank hydraulic retention time (HRT), anaerobic digester cell residence time, and anaerobic digester volatile loading rates. Parameters that have historically been outside the recommendations of 10 SS but within the threshold established in the WRRF basis of design as outlined in Enhanced Track 3 Basis of Design include: aeration tank BOD loading rate, and aeration tank F:M ratio.

WRRF Hydraulic Capacity Evaluation

A hydraulic evaluation was performed to confirm the hydraulic capacity of the existing liquid treatment train to ensure that treatment at the 2030, 2040, and 2050 influent conditions are not limited on a hydraulic basis. The physical configurations of each treatment unit (unit process) were modeled using basic hydraulic principles such as the orifice equation, Manning's open channel/closed conduit equation, weir equation, and mass balance to perform the maximum capacity calculation, leaving a certain freeboard as applicable. Water depth in the unit was used to derive the velocity and flow rates through the treatment unit.

Based upon this evaluation the WRRF should have no issue passing 700 MGD (i.e., peak sustained flow requirement per SPDES permit) of raw influent flow through the liquid treatment train with up to one unit out of service in all unit processes.

1 Introduction and Purpose

The purpose of this technical memorandum is to:

1. Establish future flow and mass loadings by using 2015 NYMTC growth projections as developed in 2019 by the NYCDEP for 2030, 2040, and 2050 for use in the BNR evaluation.
2. Summarize existing infrastructure capacity for each unit process in comparison with Ten States Standards guidelines.
3. Summarize the hydraulic modeling evaluation.

2 Influent Flow and Loading Projections

As part of the BNR feasibility study for the NC WRRF, Arcadis has developed a series of influent flow and mass loading projections for the use in evaluation of BNR treatment alternatives. The future flow/mass loading projections are based upon population growth estimates for the WRRF collection area provided by NYCDEP and historical influent flow/mass loadings which were validated as part of the full-plant process model development and calibration (see TM 4 *Process Model Development and Calibration*).

It is important to note that based on discussions between DEP and Arcadis it has been decided to eliminate plant operations and performance data between 2020 and 2021 from consideration in the development of current and future influent flows and mass loadings. A significant drop in the influent loading was observed during calendar year 2020 and 2021 and is attributed to the COVID-19 Pandemic and reduction of office workers, particularly in lower Manhattan.

2.1 Current Influent Flows and Mass Loadings

The process model calibration effort validated historical influent flows and mass loadings (see TM 1 *Historical Operations and Performance Summary* and TM 4 *Process Model Development and Calibration*), providing a close match to all key operating parameters and secondary effluent quality. **Table 1** summarizes pre-COVID-19 Pandemic raw influent strength between 2015 and 2019, along with model predicted values between 2015 and 2017. Also shown are the proposed annual average influent concentrations to be utilized in the development of flows and mass loadings as part of this evaluation.

Table 1. Proposed True Raw Influent Concentrations - Annual Average Conditions

Parameter	Plant Data (2015 - 2019)	Model (2015 - 2017)	Proposed AA
Flow, MGD	213	212	213
COD, mg/L	326	367	367
$cBOD_5$, mg/L	166	166	166

Parameter	Plant Data (2015 - 2019)	Model (2015 - 2017)	Proposed AA
$cBOD_5$ (uninhibited), mg/L	175	174	175
TSS, mg/L	162	157	162
VSS, mg/L	145	138	145
TKN, mg/L	31	30	31
NH_3-N, mg/L	20	21	20
TP, mg/L	4.1	4.7	4.1
PO_4-P, mg/L	2.5	2.3	2.5

Table 2 summarizes historical influent flow rates for the WRRF, with yearly average values and peaking factors for annual average (AA), maximum month (MM), maximum week (MW), and maximum day (MD). Also highlighted are the proposed yearly average influent flow rate for **Current Conditions**, as well as the proposed influent flow peaking factors to be utilized as part of the development of future flow and mass loading projections.

The proposed baseline influent flow rate for Current Conditions is 213 MGD, which represents the average influent flow value between 2015 and 2019 before the onset of the COVID-19 pandemic. Flow peaking factors for MM through MD conditions were chosen to be slightly higher than the average peaking factors across that time period for conservatism.

Table 2. Historical Plant Influent Flow and Peaking Factors – 2015 to 2021

Year	Influent Flow, MGD				Peaking Factors		
	AA	MM	MW	MD	MM	MW	MD
2015	213	232	280	528	1.09	1.31	2.48
2016	211	229	258	444	1.08	1.22	2.10
2017	211	231	287	518	1.09	1.36	2.45
2018	220	249	301	480	1.13	1.37	2.18
2019	207	236	288	475	1.14	1.40	2.30
2020	190	222	243	452	1.17	1.28	2.38
2021 (Partial)	193	206	222	339	1.07	1.15	1.76
Avg (2015-2019)	**213**	**235**	**283**	**489**	**1.11**	**1.33**	**2.30**
Avg (2020-2021)	**191**	**214**	**233**	**396**	**1.12**	**1.22**	**2.07**
Proposed Current Average Value	**213**				**1.14**	**1.40**	**2.45**

Table 3 summarizes historical influent loading peaking factors for influent $cBOD_5$, TSS, and NH_3-N, as included in TM 1 documenting historical plant operations and performance. Also shown are proposed influent loading peaking factors for MM, MW, and MD conditions to be utilized as part of the development of future flow and mass loading projects.

As shown and agreed upon with DEP, one set of loading peaking factors were chosen for MM through MD conditions. MM and MW peaking factors of 1.15 and 1.35 was chosen based on historical $cBOD_5$ and TSS loadings, which are reasonable for a treatment facility of this size. A MD peaking factor of 2.0 was chosen based the available data for $cBOD_5$ and NH_3.

Table 3. Historical Plant Influent Load Peaking Factors – $cBOD_5$, TSS, and NH_3-N - 2015 to 2021

Year	$cBOD_5$ PF			TSS PF			NH_3 PF		
	MM	MW	MD	MM	MW	MD	MM	MW	MD
2015	1.15	1.36	1.98	1.12	1.36	2.75	1.54	1.66	1.79
2016	1.11	1.20	1.58	1.15	1.29	2.79	1.30	1.34	1.62
2017	1.19	1.39	1.74	1.12	1.35	2.47	1.19	1.31	2.48
2018	1.14	1.29	2.30	1.17	1.34	2.51	1.12	1.22	1.96
2019	1.11	1.40	2.76	1.15	1.48	3.44	1.17	1.24	1.87
2020	1.28	1.41	2.01	1.37	1.66	3.10	1.26	1.37	1.60
2021 (Partial)	1.06	1.14	1.72	1.12	1.19	2.41	1.03	1.11	1.64
Avg (2015-2019)	**1.14**	**1.33**	**2.07**	**1.14**	**1.36**	**2.79**	**1.27**	**1.36**	**1.94**
Avg (2020-2021)	**1.17**	**1.27**	**1.86**	**1.25**	**1.42**	**2.76**	**1.15**	**1.24**	**1.62**
Proposed Values	**1.15**	**1.35**	**2.00**						

Based upon the proposed average annual influent concentrations, the proposed historical average influent flow rate, and the proposed set of flow and loading peaking factors, **Table 4** summarizes the flows and mass loadings representing **Current Conditions** at the WRRF.

Table 4. Raw Influent Flows and Mass Loadings - Current Conditions

Parameter	AA	MM	MW	MD
Flow, MGD	213	243	297	521
Flow PF	---	1.14	1.40	2.45
Load PF	---	1.15	1.35	2.00
COD, mg/L	367	369	355	299
COD, lbd	649,700	747,155	877,096	1,299,401
$cBOD_5$, mg/L	166	167	160	135
$cBOD_5$, lbd	294,129	338,248	397,074	588,258
$cBOD_5$ (uninhibited), mg/L	175	176	169	142
$cBOD_5$ (uninhibited), lbd	309,359	355,763	417,635	618,718
TSS, mg/L	162	163	157	132
TSS, lbd	287,248	330,335	387,785	574,496
VSS, mg/L	145	146	140	118
VSS, lbd	256,814	295,336	346,699	513,628
TKN, mg/L	31	31	30	25
TKN, lbd	54,750	62,963	73,913	109,500
NH_3-N, mg/L	20	20	19	16
NH_3-N, lbd	35,516	40,843	47,947	71,032
TP, mg/L	4.1	4.1	3.9	3.3
TP, lbd	7,189	8,267	9,705	14,378
PO_4-P, mg/L	2.5	2.5	2.4	2.0
PO_4-P, lbd	4,356	5,009	5,881	8,712

2.2 Future Influent Flows and Mass Loadings

Population growth projections for the WRRF collection area based upon 2015 NYMTC projections were provided to Arcadis by the DEP. **Table 5** summarizes the increase in population as a percentage compared to Current Conditions for 2030, 2040, and 2050, with values of 8%, 12%, and 14%, respectively.

Table 5. Population Growth Factors for Newtown Creek WRRF - 2030, 2040, and 2050

Year	Growth from Current Conditions %
2030	8%
2040	12%
2050	14%

To determine future influent flow rates to the WRRF, the yearly average flow of 213 MGD at Current Conditions was scaled up to the 2030, 2040, and 2050 conditions using the growth factors described above in **Table 5**. For each of these future scenarios the MM, MW, and MD influent flows were calculated using the proposed flow peaking factors summarized previously in **Table 2**. **Table 6** summaries all influent flows to the WRRF at Current Conditions, 2030, 2040, and 2050. It was assumed for the purposes of this study that influent flow to the WRRF would increase proportionally with estimate population growth and mass loadings.

Table 6. Current and Future Raw Influent Flows – 2030, 2040, and 2050

Year	Influent Flow, MGD				Peaking Factors		
	AA	MM	MW	MD	MM	MW	MD
Current Conditions	213	243	297	521	1.14	1.40	2.45
2030	230	262	320	563			
2040	238	272	332	583			
2050	242	277	338	594			

Future flows and mass loadings for 2030, 2040 and 2050 are summarized in **Table 7** through **Table 9**. As noted earlier, future average annual influent mass loadings were developed assuming proportional growth between influent flow and loading rates utilizing the growth rates shown in **Table 5**, meaning that historical average influent concentrations remain the same between Current Conditions and the 2050 condition. Future MM, MW, and MD loadings were then calculated based on the proposed load peaking factors discussed previously.

Table 7. Future Influent Flow and Mass Loadings – 2030 Condition

Parameter	AA	MM	MW	MD
Flow	230	262	320	563
Flow PF	---	1.14	1.40	2.45
Load PF	---	1.15	1.35	2.00
COD, mg/L	367	369	355	299
COD, lbd	701,676	806,928	947,263	1,403,353
$cBOD_5$, mg/L	166	167	160	135
$cBOD_5$, lbd	317,659	365,308	428,840	635,318
$cBOD_5$ (uninhibited), mg/L	175	176	169	143
$cBOD_5$ (uninhibited), lbd	334,378	384,535	451,410	668,756
TSS, mg/L	162	163	157	132
TSS, lbd	310,228	356,762	418,807	620,455
VSS, mg/L	145	146	140	118
VSS, lbd	277,359	318,963	374,435	554,718
TKN, mg/L	31	31	30	25
TKN, lbd	59,130	67,999	79,825	118,260
NH_3-N, mg/L	20	20	19	16
NH_3-N, lbd	38,358	44,111	51,783	76,715

Parameter	AA	MM	MW	MD
TP, mg/L	4.1	4.1	3.9	3.3
TP, lbd	7,764	8,929	10,482	15,529
PO_4-P, mg/L	2.5	2.5	2.4	2.0
PO_4-P, lbd	4,705	5,410	6,351	9,409

Table 8. Future Influent Flows and Mass Loadings – 2040 Condition

Parameter	AA	MM	MW	MD
Flow	238	272	332	583
Flow PF	---	1.14	1.40	2.45
Load PF	---	1.15	1.35	2.00
COD, mg/L	367	369	355	299
COD, lbd	727,664	836,814	982,347	1,455,329
$cBOD_5$, mg/L	166	167	160	135
$cBOD_5$, lbd	329,424	378,838	444,723	658,849
$cBOD_5$ (uninhibited), mg/L	175	176	169	143
$cBOD_5$ (uninhibited), lbd	346,762	398,777	468,129	693,525
TSS, mg/L	162	163	157	132
TSS, lbd	321,717	369,975	434,319	643,435
VSS, mg/L	145	146	140	118
VSS, lbd	287,632	330,776	388,303	575,263
TKN, mg/L	31	31	30	25
TKN, lbd	61,320	70,518	82,782	122,640
NH_3-N, mg/L	20	20	19	16
NH_3-N, lbd	39,778	45,745	53,701	79,557
TP, mg/L	4.1	4.1	3.9	3.3
TP, lbd	8,052	9,260	10,870	16,104
PO_4-P, mg/L	2.5	2.5	2.4	2.0
PO_4-P, lbd	4,879	5,611	6,587	9,758

Table 9. Future Influent Flows and Mass Loadings – 2050 Condition

Parameter	AA	MM	MW	MD
Flow	242	277	338	594
Flow PF	---	1.14	1.40	2.45
Load PF	---	1.15	1.35	2.00
COD, mg/L	367	369	355	299
COD, lbd	740,658	851,757	999,889	1,481,317
$cBOD_5$, mg/L	166	167	160	135
$cBOD_5$, lbd	335,307	385,603	452,664	670,614
$cBOD_5$ (uninhibited), mg/L	175	176	169	143
$cBOD_5$ (uninhibited), lbd	352,955	405,898	476,489	705,909
TSS, mg/L	162	163	157	132
TSS, lbd	327,462	376,582	442,074	654,925
VSS, mg/L	145	146	140	118
VSS, lbd	292,768	336,683	395,237	585,536
TKN, mg/L	31	31	30	25
TKN, lbd	62,415	71,777	84,260	124,830
NH_3-N, mg/L	20	20	19	16
NH_3-N, lbd	40,489	46,562	54,660	80,977
TP, mg/L	4.1	4.1	3.9	3.3
TP, lbd	8,196	9,425	11,064	16,392
PO_4-P, mg/L	2.5	2.5	2.4	2.0
PO_4-P, lbd	4,966	5,711	6,704	9,932

3 Existing Infrastructure Treatment Capacity

Arcadis evaluated existing treatment infrastructure capacity based on industry recommendations from 10 SS and historical operations and performance data between 2015 and 2019 (see TM 1 *Historical Operations and Performance Summary*). For this evaluation, the flows and mass loadings representing Current Conditions were utilized, as shown in **Table 10**.

Flow and mass loadings representing the WRRF design condition were based on the *Enhanced Track 3 Basis of Design,* shown in **Table 11**. The following sections summarize relevant design parameters for the grit tanks, aeration tanks, sedimentation tanks, chlorine contact tanks, and anaerobic digesters.

Table 10. Raw Influent Flows and Mass Loadings - Current Conditions

Parameter	AA	MM	Pk Hr
Flow, MGD	213	243	700
Flow PF	---	1.14	3.29
Load PF	---	1.15	---
COD, mg/L	367	369	---
COD, lbd	649,700	747,155	---
$cBOD_5$, mg/L	166	167	---
$cBOD_5$, lbd	294,129	338,248	---
$cBOD_5$ (uninhibited), mg/L	175	176	---
$cBOD_5$ (uninhibited), lbd	309,359	355,763	---
TSS, mg/L	162	163	---
TSS, lbd	287,248	330,335	---
VSS, mg/L	145	146	---
VSS, lbd	256,814	295,336	---

Table 11. Raw Influent Flows and Mass Loadings – Enhanced Track 3 Basis of Design

Parameter	AA	MM	Pk Hr
Flow, MGD	310	350	700
Flow PF	---	1.1	2.3
BOD_5, mg/L	132	138	107
BOD_5, lbd	341,200	402,800	625,000
TSS, mg/L	150	159	124
TSS, lbd	387,800	464,100	725,000

3.1 Grit Removal Tanks

The NC WRRF has 24 grit tanks, each with a volume of 12,180 ft^3. 10 SS recommends a minimum hydraulic retention time (HRT) of three minutes at design peak hourly flows. Based on the peak hour flow of 700 MGD the installed aerated grit tanks meet the 10 SS recommendation for all flow conditions shown in **Table 12**.

Table 12. Ten States Standards Comparison - Grit Tanks

Parameter	Current		Design (Enhanced Track 3)	
	AA	Pk Hr	AA	Pk Hr
Influent Flow, MGD	213	700	310	700
# Units	24			
Volume, ft^3/unit	12,180			
10 SS HRT, minutes	3 - 5			
HRT, minutes	15	4.5	10	4.5

3.2 Biological Treatment

3.2.1 Activated Sludge Aeration Tanks

There are twelve aeration tanks between the three batteries, each with a volume of 2.2 million gallons (MG). The aeration tanks received degritted raw influent and plant recycle flows, as well as return activated sludge. Each tank is a four-pass step-feed aeration tank, with RAS being fed to Pass A, and raw influent being fed to the remaining passes. The aeration tanks were evaluated based on aerator effluent MLSS (AEMLSS), BOD_5 loading rates, the F:M (food to mass) ratio, and HRT. Results of this evaluation are shown in **Table 13** for both Current Conditions and the plant Design Condition as outlined in the *Enhanced Track 3 Basis of Design*.

Historical aerator effluent mixed liquor concentrations fall within the 10 SS recommendation of 1,000 – 3,000 mg/L for average conditions. The current AA BOD_5 loading rate is approximately 89 lbd BOD per 1,000 ft^3 of aeration tank. While this is greater than the 10 SS recommendation of 40 lbd BOD per 1,000 ft^3, it falls within the Design Condition BOD_5 loading rate of 100 lbd BOD_5 per 1,000 ft^3 as outlined in *Enhanced Track 3 Basis of Design*. The historical average F:M ratio is approximately 1.2 lbd BOD_5 per lb MLVSS and design value is about 0.8 lbd BOD_5 per lb MLVSS. While the current F:M exceeds the maximum 10 SS recommendation of 0.5 it is also within the range given in the *Enhanced Track 3 Basis of Design*. Finally, NC WRRF is operating with an aeration tank HRT of 3.0 hours, which is greater than the *Enhanced Track 3 Basis of Design* AA HRT of 2.0 hours. As 10 SS does not provide a recommendation for HRT in an activated sludge system, the *Enhanced Track 3 Basis of Design* HRT was used as the guideline for this parameter.

Table 13. Ten States Standards - Activated Sludge Aeration Tanks

Parameter	Current		Design (Enhanced Track 3)	
	AA	**Pk Hr**	**AA**	**Pk Hr**
Influent Flow, MGD	213	700	310	700
RAS Flow, MGD	90	90	155	154
Recycle, MGD	8.0	13.2	11.7	13.2
Recycle BOD Concentration, mg/L	313	-	313	-
Aeration Influent BOD, lbd	315,040	-	372,900	-
AEMLVSS, mg/L	1,210	-	2,003	-
# Units	12			
Volume, MG/unit	2.2			
10 SS MLSS, mg/L	*1,000 - 3,000*			
AEMLSS, mg/L	1,450	-	2,400	-
10 SS BOD Loading, lbd BOD/1,000 ft³	*40*			
BOD Loading, lbd BOD/1,000 ft³	89	-	106	-
10 SS F:M, lbd BOD/lb MLVSS	*0.2 - 0.5*			
F:M, lbd BOD/lb MLVSS	1.2	-	0.8	-
HRT, hours	3.0	0.9	2.0	0.9

3.2.2 Sedimentation Tanks

There are 24 sedimentation tanks in operation at the WRRF, with eight tanks in each battery. 10 SS provides recommendations for surface overflow rate (SOR), solids loading rate (SLR), and weir loading rate (WLR) at peak hour conditions. **Table 14** summarizes SOR, SLR, and WLR for both Current Conditions and Design Conditions.

As the treatment facility was designed for an average annual (AA) flow of 310 MGD and is currently operating at 213 MGD on an AA basis, the sedimentation tanks are still below the loading recommendations for SLR at all conditions and SOR through the current and design MM flow condition. While the SOR exceeds the 10 SS recommendation at the peak hourly flow conditions it matches the peak SOR as outlined in the *Enhanced Track 3 Basis of Design.*

Each sedimentation tank has six effluent troughs with v-notch weir plates on each side, resulting in approximately 1,188 linear feet of weir length per sedimentation tank. The recommendation for a maximum WLR is 30,000 gpd per linear ft., which is achieved for all flow conditions through peak hourly.

Table 14. Ten States Standards - Sedimentation Tanks

Parameter	Current		Design (Enhanced Track 3)	
	AA	**Pk Hr**	**AA**	**Pk Hr**
Influent Flow, MGD	213	700	310	700
RAS Flow, MGD	90	90	155	154
AEMLSS, mg/L	1,450		2,400	
# Units	24			
Weir Length, LF/unit	1,188			
Length, ft/unit	396.2			
Width, ft/unit	56.0			
Volume, MG/unit	2.0			
10 SS SOR, gpd/ft²	*1,200*			
Surface Overflow Rate, gpd/ft²	399	1,314	582	1,314
10 SS SLR, lbd/ft²	*40*			
Solids Loading Rates, lbd/ft²	6.9	18	17	32
10 SS WLR, gpd/LF	*30,000*			
Weir Loading Rates, gpd/ft	7,455	24,551	10,873	24,551

3.3 Effluent Disinfection - Chlorine Contact Tanks

Chlorine disinfection is typically designed based on hydraulic retention time. The WRRF utilizes three chlorine contact tanks operating in parallel, each with a capacity of 2.6 MG. 10 SS recommends a minimum HRT of 15 minutes at the peak hourly flow. As shown in **Table 15** the plant is operating with a 54-minute HRT at the AA flow and a 16-minute HRT at the peak hourly flow, meeting this recommendation for all flow conditions.

Table 15. Ten States Standards - Chlorine Disinfection Tanks

Parameter	Current		Design (Enhanced Track 3)	
	AA	Pk Hr	AA	Pk Hr
Influent Flow, MGD	213	700	310	700
# Units	3			
Volume, MG/unit	2.6			
10 SS HRT, minutes	*15*			
HRT, minutes	54	16	37	16

3.4 Anaerobic Digestion

The current anaerobic digester HRT and volatile loading rates are shown in **Table 16** below. NC WRRF has eight anaerobic digesters installed, each with a 3 MG volumetric capacity and seven units are typically in operation. The 10 SS recommendation for volatile loading rate is 80 lbd VS per 1,000 ft^3 of digester volume. The facility is current operating in this range, with a volatile loading rate of 71 lbd VS per 1,000 ft^3 at the AA condition and 82 lbd VS per 1,000 ft^3 at the MM condition. The digesters also meet the MOP 8 volatile loading recommendation of 0.12 to 0.20 lbd VS per ft^3 as shown in **Table 16**. The digesters were designed to meet the process to significantly reduce pathogens (PSRP) regulation for a minimum cell residence time for mesophilic digestion of 15 days (*40 CFR Part 503*) when operating with two digesters out of service. As shown, the MM residence time is 28 days with all units in service and 25 days with one unit out of service which comfortably meets the PSRP regulation at current conditions.

Table 16. Ten States Standards - Anaerobic Digesters

Parameter		Current AA	Current MM
Digester Feed Sludge, lbd VS		228,631	262,926
Digested Sludge, gpd		638,166	856,841
# Units		8	
Volume, MG/unit		3.0	
Cell Residence Time, days	All Units	38	28
	1 OOS	33	25
10 SS Vol. Loading, lbd of VS/1,000 ft^3		*80*	
Volatile Loading, lbd of VS/1,000 ft^3	All Units	71	82
	1 OOS	81	94
MOP 8 Vol. Loading, lbd of VS/ft^3		*0.12*	*0.20*
Volatile Loading, lbd of VS/ft^3	All Units	0.07	0.08
	1 OOS	0.08	0.09

4 Hydraulic Modeling

This section describes the analyses performed to assess the hydraulic losses through each of the treatment processes within NC WRRF. The goal is two-fold: first is to assess the hydraulic conditions in various treatment units for the rated wet weather capacity of 700 MGD and the second is to assess the maximum throughput for each of the treatment processes and determine the maximum flow that can potentially be handled by the plant hydraulically.

4.1 Flow Path

The screened flow from Manhattan Pump Station and Brooklyn/Queens Pump Station is pumped into the influent splitter box at the NC WRRF, as shown in **Figure 1**. Flow from the influent splitter box is distributed to North, Central, and South battery grit tanks, through twelve 60-inch influent conduits, to an uptake shaft flow by gravity into a grit influent channel. Each grit influent channel discharges wastewater into two grit tanks. A total of 24 grit tanks (two (2) per aeration tank and eight (8) grit tanks per battery) are available in the North, Central and South Batteries. De-gritted effluent from each grit tank is discharged over a fixed weir into the aeration tank influent channel which feeds into the aeration basin.

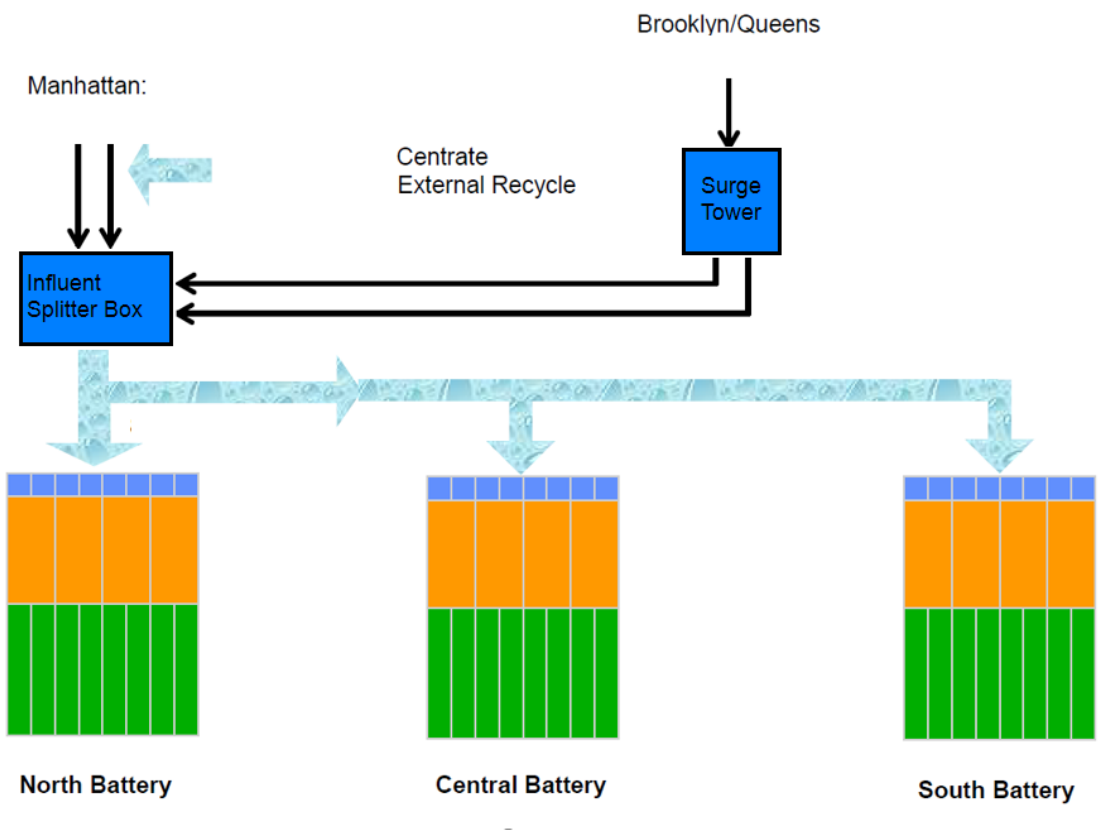

Figure 1. Conveyance Details from Influent Splitter Box to the Batteries
(Source: O&M manual, Chapter 11 - Influent Distribution, May 2013)

One aeration influent channel and one effluent channel are present in each battery. There are four aeration basins per battery and each aeration tank has four passes (A, B, C, and D), and the de-gritted wastewater may be added at the headend of each pass. The aeration influent sluice gates control the flow distribution to the headend of each pass, through a step-feed distribution process. There are a total of 48 influent sluice gates (four sluice gates per aeration tank) which control flow into the aeration basins. Aeration tank effluent enters the final settling/sedimentation tanks through aeration effluent sluice gates in Pass D into a common final/sedimentation influent channel. There are 36 (3 per tank) total aeration effluent sluice gates that guide the flows into the sedimentation tank influent channel.

The flow from the sedimentation influent channel flows through 72 (3 per tank) sedimentation influent sluice gates into the sedimentation tanks. There are eight final settling tanks available in each of the North, Central and South Batteries for a total of 24 final settling tanks.

The settled solids in the sedimentation tank are either returned to the aeration tanks as RAS using RAS pumps or sent to the solids handling facilities as WAS using WAS pumps. The clarified final settling tank effluent flows over effluent weirs into a common final effluent channel. Each Battery's final settling tank effluent channel is equipped with two drop shafts that convey the effluent to the chlorine contact tanks for disinfection prior to discharge through the plant outfall, as shown in **Figure 2**.

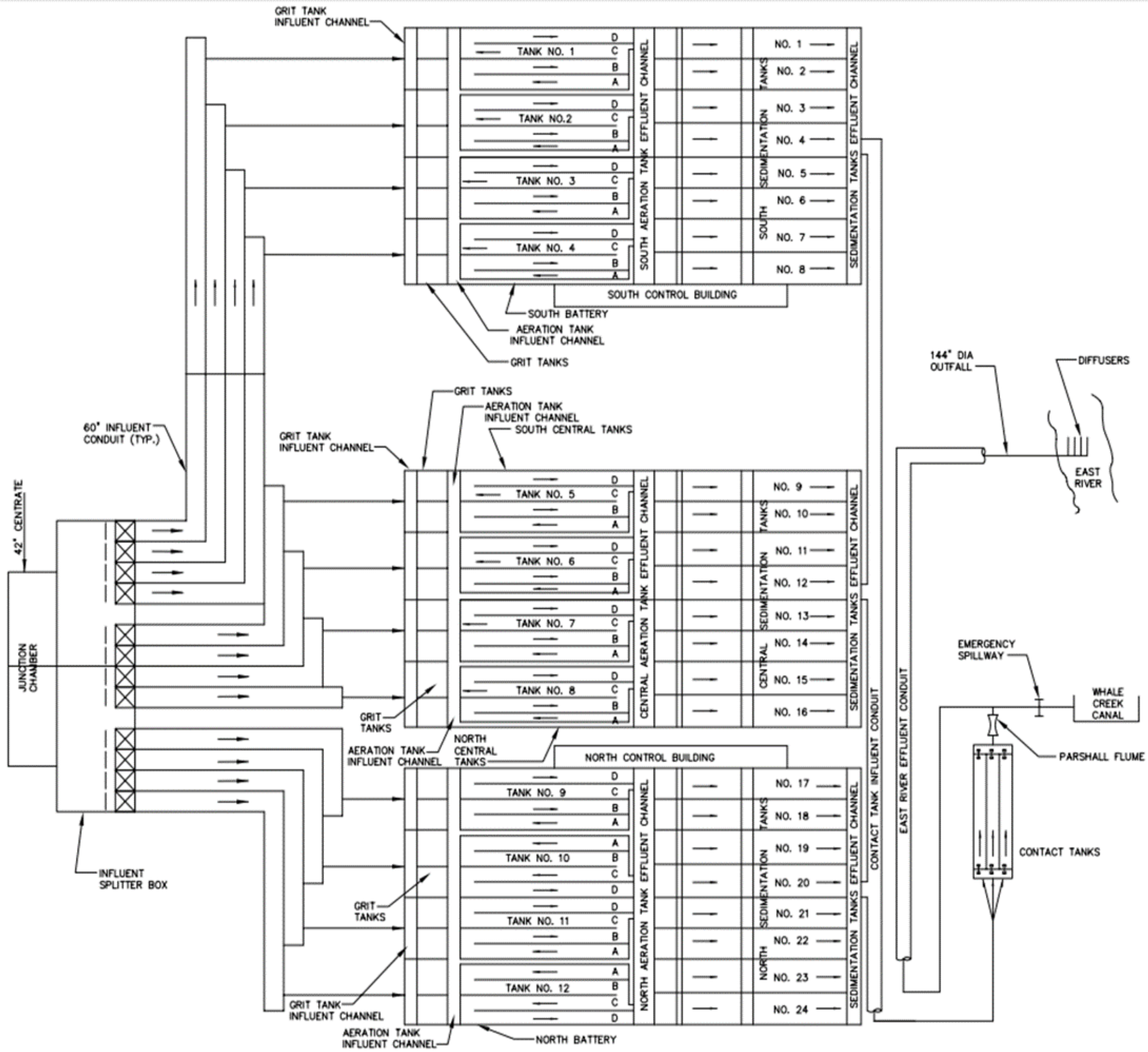

Figure 2. Newtown Creek WRRF – Process Flow Diagram
(Source: O&M manual, Chapter 13 – Aeration System, May 2013)

Flow from the chlorine contact tank influent channel is sent to the three (3) chlorine contact tanks through three sluice gates (one per tank), as shown in **Figure 3.**. Sodium hypochlorite is added for disinfection followed by sodium bisulfite for dechlorination through the chlorine contact tanks prior to discharge.

Under normal flow and tide conditions, the entire plant effluent flows into East River India Street Outfall. During high plant flow and high tide conditions, some portion of the plant effluent is split between the East River and Whale Creek Outfalls in accordance with a wet weather operating plan. **Table 17** shows this operating plan in terms of the flow split between East River outfall and the Whale Creek outfall based on influent flow and tidal conditions.

Table 17. Flow Split between East River Outfall and Whale Creek Outfall

Tidal Condition	Plant Flow, MGD				Outfall Location
	180	**310**	**465**	**700**	
Mean Low	180	310	465	611	East River
Elevation -4.86	0	0	0	89	Whale Creek
Mean Average	180	310	465	550	East River
Elevation -2.73	0	0	0	150	Whale Creek
Mean High	180	310	465	485	East River
Elevation -0.68	0	0	0	215	Whale Creek
25 Year Flood	172	196	222	265	East River
Elevation +4.6	8	114	243	435	Whale Creek

(Source: O&M Manual, Chapter 18, Page 2 of 35 Disinfection System May 2013 PDF)
Note: Elevations are based on Borough of Brooklyn Highway Datum, which is 2.56 feet above mean sea level at Sandy Hook, New Jersey

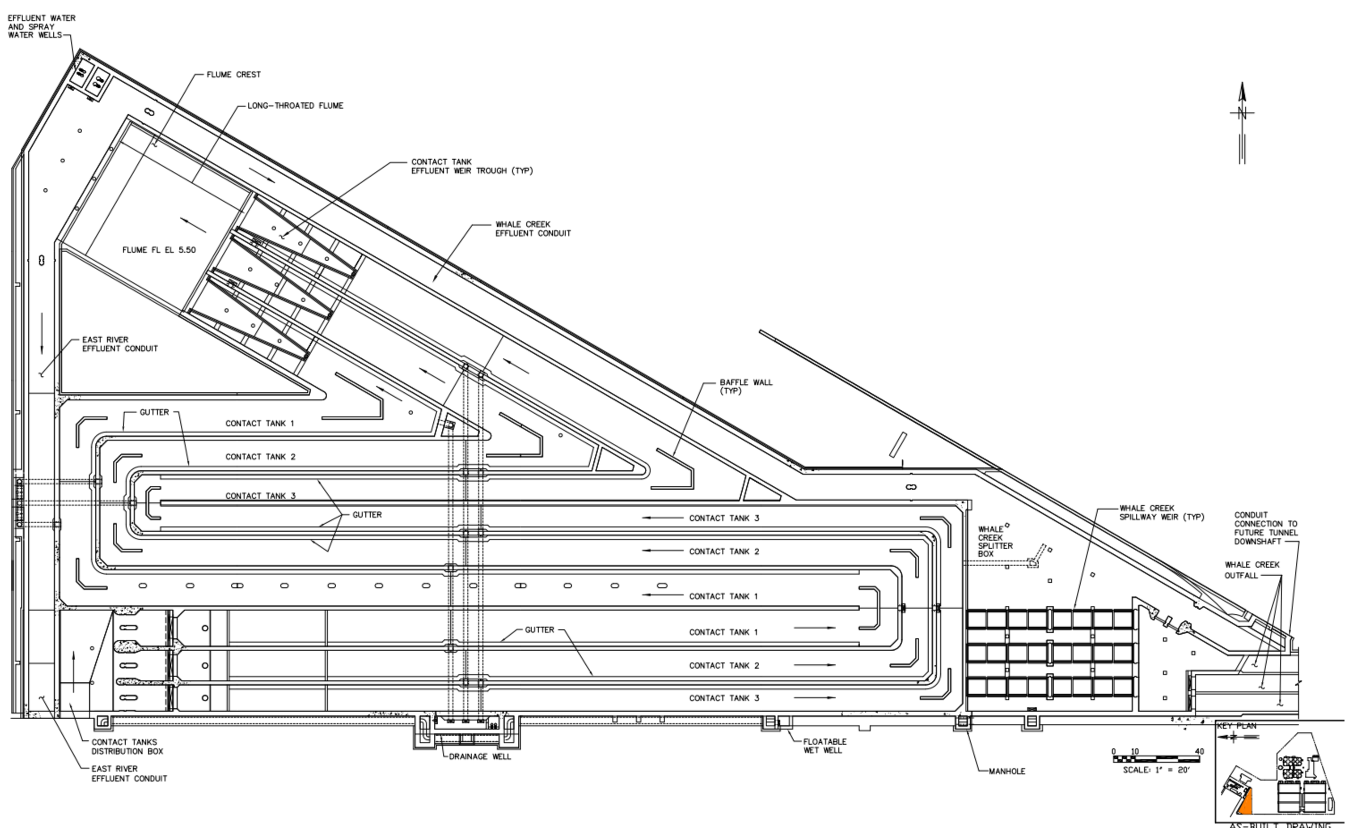

Figure 3. Flow through Chlorine Contact Tanks
(Source: Contract NC-32G, AB-NC-32G-06M-02)

4.2 Hydraulic Model Development

A desktop model has been developed in Microsoft Excel platform for the hydraulic evaluation of wastewater treatment processes and to determine the existing hydraulic capacities of process units at the NC WRRF. The design details from the design/as-built drawings from contracts NC-35, NC-35G, and NC-32G and the plant Operational and Maintenance (O&M) manual were used to guide the development of the model. The head losses through the main hydraulic structures from the Grit Influent Channel to the Chlorine Contact Tanks were calculated to determine the maximum tank elevation and tank capacity for each process unit. **Figure 4** shows the general process flow diagram and the specific hydraulic structures for which the head losses were considered for computing the maximum tank elevations.

The following section focuses on each treatment process system and the assumptions made to estimate the losses through each treatment process.

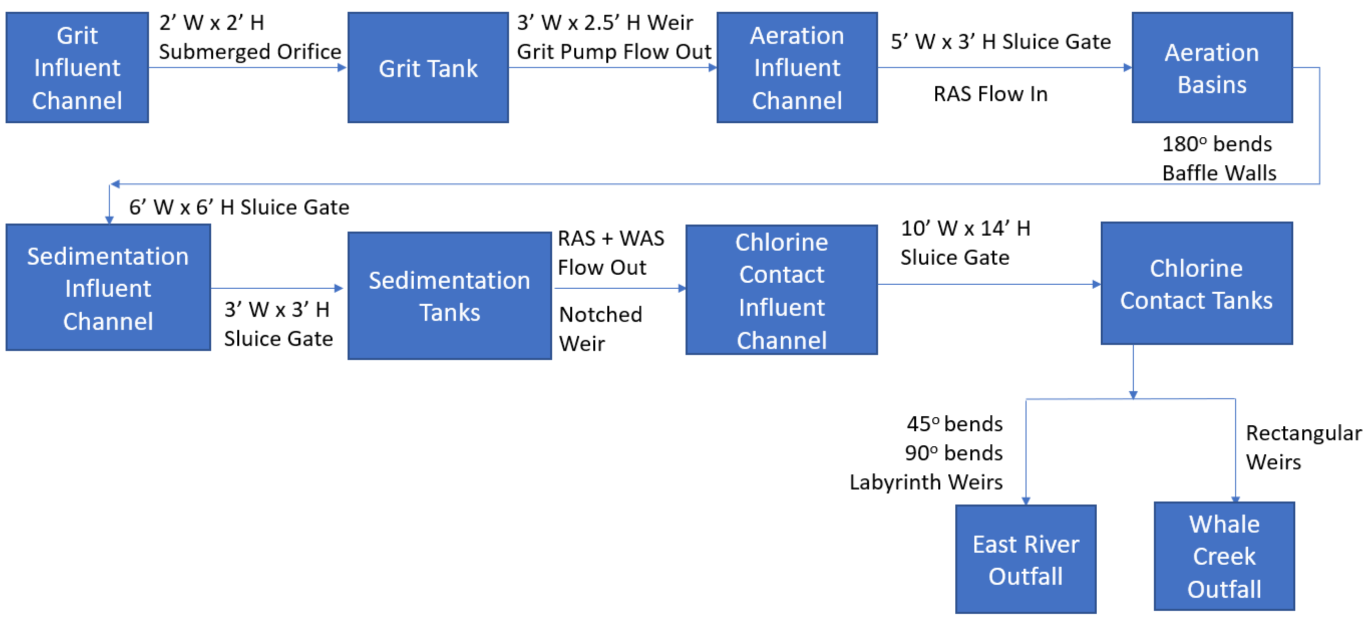

Figure 4. NC WRRF General Process Flow Diagram

4.2.1 General Assumptions

The hydraulic evaluation was performed for an existing daily average flow of 213 MGD, an average design flow of 310 MGD and the peak wet weather flow of 700 MGD. The tank bottom elevations, weir invert elevations, and tank dimensions are consistent for the North, Central, and South batteries of the WRRF, based on the referenced as-built drawings. A conservative 2-feet of freeboard from the top of the concrete elevation of the tank was assumed to determine the maximum allowable tank elevation. The grit pump operating conditions and the RAS/WAS flows were assumed based on the maximum pump capacity and the number of pumps operating at each unit process per the O&M Manual. **Table 18** summarizes the key hydraulic equations used for this hydraulic analysis.

Table 18. Key Hydraulic Equations

Manning's Equation	$V = \frac{1.49}{n} * R_H^{\frac{2}{3}} * S^{\frac{1}{2}}$	V= Velocity n= Manning's Roughness Coefficient R_H = Hydraulic Radius S= Slope
Rectangular Weirs	$Q = CLH^{3/2}$	Q = Flow Discharge C= Discharge Coefficient L= Length of the Weir H = Head (depth of discharge over the weir)
V-Notch Weirs	$Q = CH^{5/2}$	Q = Flow Discharge C= Discharge Coefficient H = Head (depth of discharge over the weir)
Labyrinth Weirs	$Q = \frac{2}{3}CLH^{1.5}\sqrt{2g}$	Q = Flow Discharge C= Discharge Coefficient L= Length of the Weir H = Head (depth of discharge over the weir)
Minor Head Losses	$h_L = K\frac{V^2}{2g}$	h_L = Headloss K = Loss Coefficient for the type of fitting V= Mean Velocity

4.2.2 Grit System

The wastewater from the grit influent channel flows through the six submerged orifices (2' W x 2' H) per tank into the grit tank and flows over a fixed weir (3' W x 2.5' H) into the aeration basin. Grit collected in the grit hoppers are transferred by grit pumps to the Central Residuals Building. The flow from the grit influent channel and the flow leaving via grit pumps were considered for the head loss calculations.

The 3' W x 2.5' H fixed weir from the grit tank which flows into the aeration system was the initial hydraulic structure used to calculate the grit tank elevations and other upstream elevations. A rectangular suppressed weir was assumed to calculate the required head over the weir for the wastewater to flow into the aeration basins.

The grit tank was considered as an open channel and Manning's equation was used to calculate the losses within the tank. A Manning's roughness coefficient of 0.015 was used for the concrete tank, assuming a moderately rough concrete surface. The grit pump capacity of 195 gallons per minute (gpm) per pump (24 pumps in total) was used to calculate the flow out of the grit tanks. The pump capacity and the number of pumps operating was considered as constant for all the evaluated flow conditions.

The downstream elevation of the grit tank and the losses through the submerged orifices were used to calculate the tank level in the influent grit channel.

4.2.3 Aeration System

The flow from the aeration tank influent channel flows into step-feed aeration configuration through a predetermined flow-split through 5' W x 3' H sluice gates. The sluice gate was modeled as a rectangular orifice with submerged port in the wall to determine the loss coefficient for head loss calculations. Both the aeration influent channel and the aeration basins were modeled as open channels and the Manning's equation was used to calculate the head loss within each process unit. A Manning's roughness coefficient of 0.015 was used for the aeration influent channel. Minor losses for the 90-degree bends were also accounted for while computing the losses in the aeration influent channel.

For aeration basins, in order to account for the losses in each of the four passes, minor head losses from the 180-degree bends for each pass were considered along with a Manning's roughness coefficient of 0.015 for concrete to calculate the head loss in the aeration basins and the water level in the basins. In this analysis, the losses added from the baffle walls were also considered to calculate the water levels in the aeration basins.

RAS flow into the aeration system (RAS pump capacity of 18,055gpm, when two pumps operating per battery) was considered along with the wastewater flow from the grit tanks to determine the hydraulic capacity of the aeration basins. The effluent from the aeration basins goes through 6' W x 6' H aeration effluent sluice gates into the sedimentation influent channel. The effluent sluice gates are also treated as rectangular orifices with submerged port in the wall for the analysis.

4.2.4 Final Settling System/Sedimentation System

The flow from the aeration basins goes through 6' W x 6' H sluice gates into the sedimentation influent channel and then through 72 (3 per sedimentation tank) 3' W x 3' H sluice gates into the sedimentation tanks. The effluent from the sedimentation tank flows through an effluent weir trough into the final effluent channel.

The sluice gates were modeled as rectangular orifices with submerged ports in the wall to determine the loss coefficient for head loss calculations. Sedimentation tank influent channel and the sedimentation basins were modeled as open channels and the Manning's equation with a Manning's roughness coefficient of 0.015 for concrete was used to compute the water levels in the influent channel and the sedimentation tanks.

There are three segments per sedimentation tanks and three notched weirs per segment. The V-notch weir's discharge coefficient was used to calculate the required head over the weir for the sedimentation effluent to flow to the effluent channel. The calculated sedimentation tank elevation is used to calculate the elevations in the tanks upstream (sedimentation influent channel, aeration basins, and aeration basin influent channel) using the Manning's and minor head loss equations.

RAS flow from the sedimentation tanks is recycled into the aeration basin and WAS flow is removed from the system. Two RAS pumps per battery at a pump capacity of 18,055 gpm are used to pump the flow out of the sedimentation tank and into the aeration basin. Two WAS pumps per battery with a pump capacity of 1,736 gpm are used to pump the flow out of the sedimentation tanks. The flow leaving the sedimentation system was also considered to calculate the water levels in the sedimentation basins.

4.2.5 Chlorine Contact Tank

Flow from the sedimentation tank effluent channel flows through two drop shafts into an effluent conduit to the chlorine contact influent channel. The dimensions of the effluent conduit and the chlorine contact influent channel were approximated using the as-built drawings and google maps.

The flow from the chlorine contact influent channel goes through three 10' W x 14' H sluice gates into three chlorine contact tanks. The sluice gate is assumed to be a rectangular orifice with submerged port in the wall. The chlorine contact tank is modeled as an open channel with bend losses. The bend losses throughout the chlorine contact tanks were accounted for. The hypochlorite flow and the sodium bisulfite flow into the chlorine contact tanks are minor and were not considered in this hydraulic evaluation.

Chlorine contact tanks were modeled as open channels with 90-degree bends and 45-degree bends in the channel. During normal conditions, the effluent flow from chlorine contact tanks flows through the effluent weir to discharge to East River Outfall. At peak wet weather flow conditions around 700 MGD, the flow is split between East River outfall and the Whale Creek outfall based on the tidal conditions.

The effluent weirs to East River outfall were modeled as labyrinth weirs with a discharge coefficient of 0.6 to calculate the head needed for the effluent to flow to the outfall. The effluent weirs to the Whale Creek outfall were modeled as rectangular suppressed weirs with a discharge coefficient of 3.3.

4.3 Results and Discussion

The results from the hydraulic evaluation through the existing NC WRRF show that all the process treatment units can hydraulically handle the rated wet weather capacity of 700 MGD. The elevations predicted by the Desktop model were compared with available information from the reference drawings for the HGLs corresponding to 700 MGD influent flow and these elevations correlated well. This Desktop model was considered validated based on this comparison and the model was subsequently used to perform the throughput analysis and determine the maximum flows that could be sent through each treatment unit hydraulically.

Table 19, **Table 20** and **Table 21** show the flows, and tank water levels in each process unit during existing daily average, design average, and peak wet weather flow conditions, respectively. The maximum allowable elevations were calculated by assuming a 2-feet freeboard from the top of the concrete elevation for each unit. The influent flows into each process unit and the flows leaving the process unit were also considered in this analysis. **Figure 5** depicts the tank water levels in each process unit through the treatment system.

Table 19. Water Levels and Total Flows in each Process System during Daily Average Flow Conditions

Inputs	Existing Daily Average Flow Conditions				
Current Daily Average (MGD)	213				
Treatment Process System	**Max Allowable Elevation (ft)**	**Water Level EL (ft)**	**Flow In (MGD)**	**Flow Out (MGD)**	**Total Flow (MGD)**
Grit Influent Channel	16.0	15.0	213	0	213
Grit Tank (Influent flow in - 7 MGD Grit pump flow out)	16.0	15.0	213	7	206
Aeration Influent Channel	16.0	13.1	206	0	206
Aeration Tank (Grit Tank Effluent Flow In + 90 MGD RAS Flow In)	14.7	13.1	296	0	296
Sedimentation Influent Channel	15.0	13.1	296	0	296
Sedimentation Tanks (Aeration Tank Effluent Flow In - 90 MGD RAS Flow Out - 15 MGD WAS Flow Out)	13.5	13.1	296	105	296
Chlorine Contact Influent Channel (Sedimentation Effluent Flow In)	12.0	10.1	191	0	191
Chlorine Contact Tank (Sedimentation Effluent Flow In	12.0	10.1	191	0	191

Table 20. Water Levels and Total Flows in each Process System during Design Dry Weather Flow Conditions

Inputs			Design Average Flow Conditions		
Design Annual Average (MGD)			310		
Treatment Process System	**Max Allowable Elevation (ft)**	**Water Level EL (ft)**	**Flow In (MGD)**	**Flow Out (MGD)**	**Total Flow (MGD)**
Grit Influent Channel	16.0	15.1	310	0	310
Grit Tank (Influent flow in - 7 MGD Grit pump flow out)	16.0	15.1	310	7	303
Aeration Influent Channel	16.0	13.2	303	0	303
Aeration Tank (Grit Tank Effluent Flow In + 155 MGD RAS Flow In)	14.7	13.2	458	0	458
Sedimentation Influent Channel	15.0	13.1	458	0	458
Sedimentation Tanks (Aeration Tank Effluent Flow In = 155 MGD RAS Flow Out - 15 MGD WAS Flow Out)	13.5	13.1	458	170	288
Chlorine Contact Influent Channel (Sedimentation Effluent Flow In)	12.0	10.2	288	0	288
Chlorine Contact Tank (Sedimentation Effluent Flow In	12.0	10.2	288	0	288

Table 21. Water Levels and Total Flows in each Process System during Peak Wet Weather Flow Conditions

Inputs			Peak Wet Weather Flow Conditions		
Design Maximum Instantaneous Wet Weather Flow (MGD)			700		
Flow through Whale Creek Outfall (MGD), Mean High Tide			215		
Treatment Process System	**Max Allowable Elevation (ft)**	**Water Level EL (ft)**	**Flow In (MGD)**	**Flow Out (MGD)**	**Total Flow (MGD)**
Grit Influent Channel	16.0	15.7	700	0	700
Grit Tank (Influent flow in - 7 MGD Grit pump flow out)	16.0	15.6	700	7	693
Aeration Influent Channel	16.0	13.4	693	0	693
Aeration Tank (Grit Tank Effluent Flow In + 155 MGD RAS Flow In)	14.7	13.4	848	0	848
Sedimentation Influent Channel	15.0	13.4	848	0	848
Sedimentation Tanks (Aeration Tank Effluent Flow In - 155 MGD RAS Flow Out - 15 MGD WAS Flow Out)	13.5	13.2	848	170	678
Chlorine Contact Influent Channel (Sedimentation Effluent Flow In)	12.0	10.5	678	0	678
Chlorine Contact Tank (Sedimentation Effluent Flow In)	12.0	10.2	678	0	678

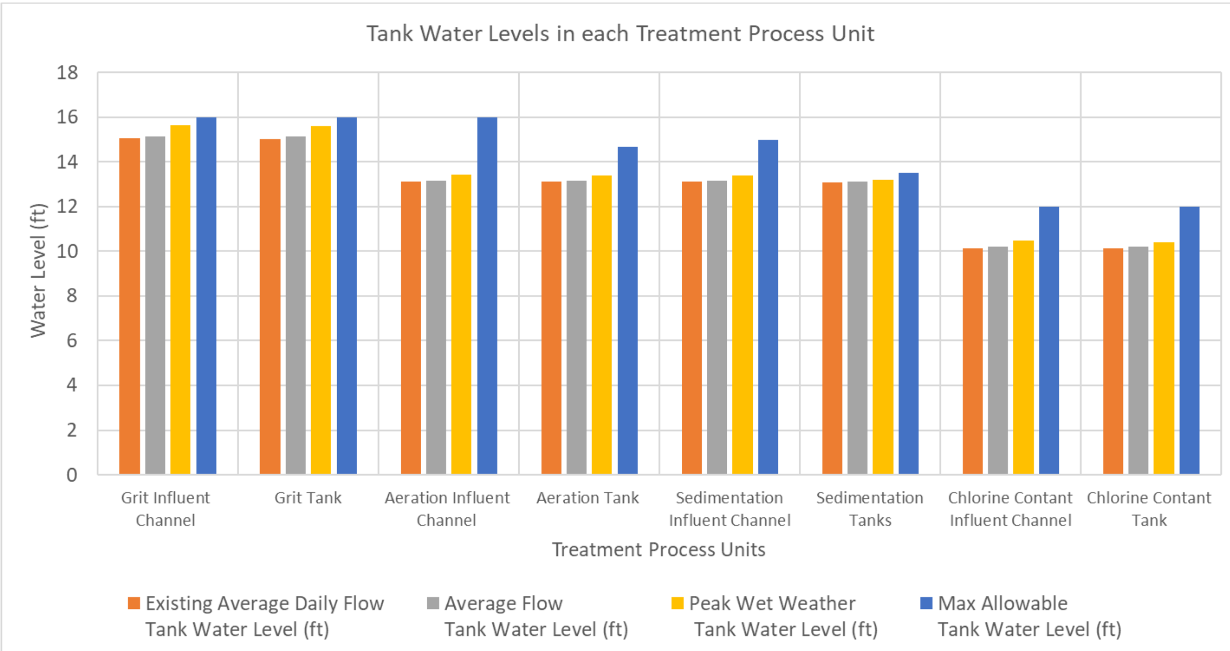

Figure 5. Water Levels in each Treatment Process Unit for Various Flow Conditions

The maximum throughput for each of the treatment process unit when all the units are in operation is presented in **Table 22**. The results from this analysis conclude that the treatment system can handle up to a 1,000 MGD of influent flow before the grit influent channels reach the maximum allowable elevation in the channel. Open channels generally show high capacities due to low velocities and the associated low head losses, however, the tanks show limitations due to maximum allowable velocities necessary for efficient treatment processes. Aeration influent channels can sustain up to 2,950 MGD, however the upstream grit tanks will be fully submerged and aeration basins, sedimentation basins, chlorine contact tanks will exceed the maximum allowable elevations. **Figure 6** presents the flows in each treatment unit for various flow conditions. In addition, the main force mains coming into the plant cannot accommodate a flow above 500 MGD.

Table 22. Maximum Hydraulic Capacities in each Treatment Process System

Treatment Process System	Max Throughput Flow (MGD)
Grit Influent Channels	1,000
Grit Tanks	1,100
Aeration Influent Channels	2,950
Aeration Tanks	2,450
Sedimentation Influent Channels	2,700
Sedimentation Tanks	2,300
Chlorine Contact Influent Channel	1,900
Chlorine Contact Tanks (215 MGD to Whale Creek Outfall + Remaining to East River Outfall)	2,900

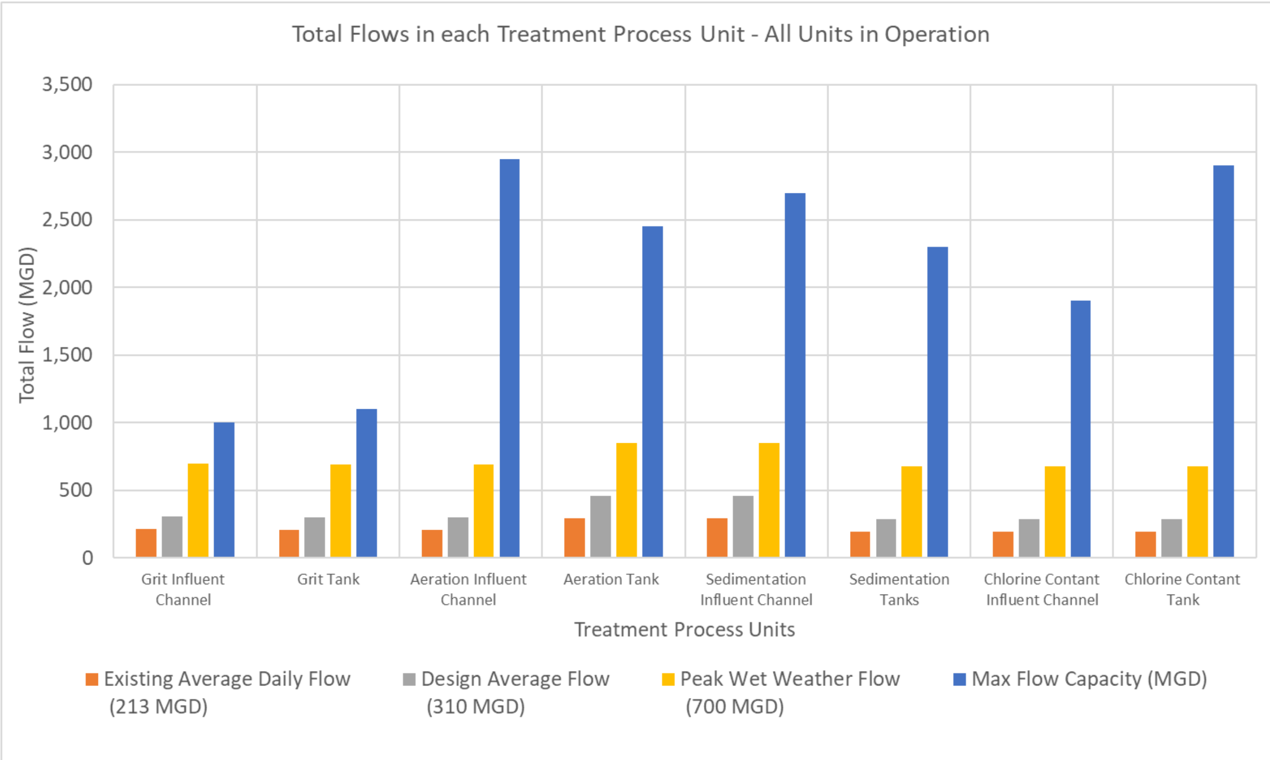

Figure 6. Flows in each Treatment Process Unit for Various Flow Conditions

Based on the hydraulic analysis performed herein, there appears to be no limitation at the NC WRRF unit processes hydraulically when all units are in operation and to accept a total flow of 800 MGD when the Manhattan Pump Station and Brooklyn-Queens Pump Station each bring in 400 MGD during emergency operations to the plant. The maximum SPDES rated capacity of 700 MGD can be hydraulically available for sustained operation, depending on the rainfall intensity and duration that contribute to wet weather inflows to the WRRF.

Table 23 and **Figure 7** present the maximum throughput for each process unit when one unit in each battery is down (two grit tanks, one aeration basin, and two sedimentation basins in each battery are not in operation). In this scenario, only two chlorine contact tanks are in operation. This is assumed to represent a scenario when some units undergo operation and maintenance, while the others are functional.

Table 23. Maximum Hydraulic Capacities in each Treatment Process System (one unit in each battery down)

Treatment Process System	Max Throughput Flow (MGD)
Grit Influent Channels	750
Grit Tanks	850
Aeration Influent Channels	2,500
Aeration Tanks	2,150
Sedimentation Influent Channels	2,400
Sedimentation Tanks	1,800
Chlorine Contact Influent Channel	1,300
Chlorine Contact Tanks	2,000

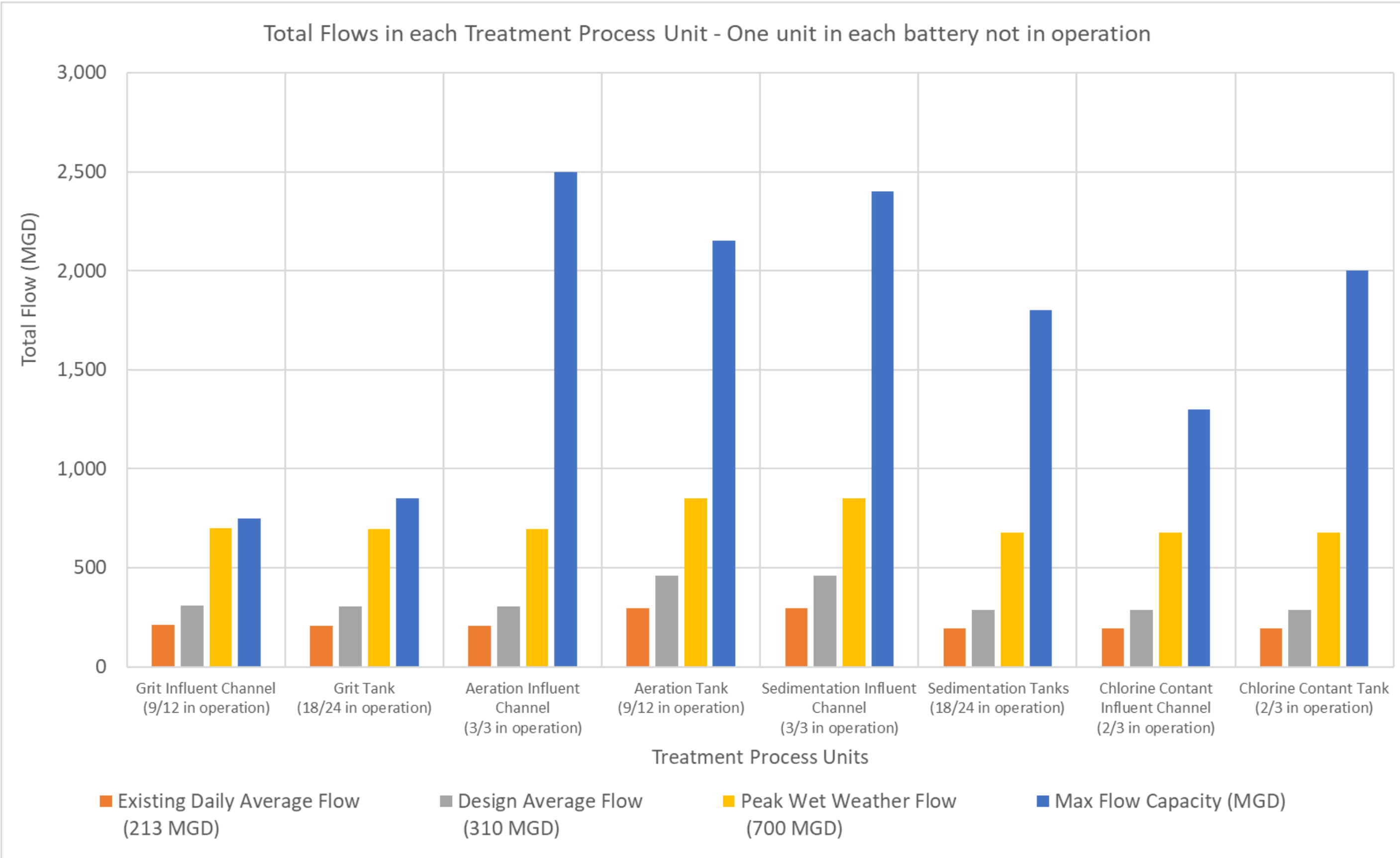

Figure 7. Flows in each Treatment Process Unit with One Unit in each Battery Down

Under this analysis, when one unit not in operation per battery, the maximum throughput flow into the treatment system is 750 MGD for which the maximum allowable elevation does not exceed in upstream/downstream process systems.

5 Conclusions

During the development of this technical memorandum, the future projected influent flow rates and mass loadings were calculated for 2030, 2040, and 2050 using NC Sewershed Population Growth (2010 Census Data) and respective scaling factors for each of the 10-year increment (8%, 12%, and 14%). In addition, the current conditions were used to develop projected flows and mass loadings that will be used as the design condition when evaluating BNR treatment alternatives as a part of this project.

Historical operation of the WRRF was compared to typical design standards and recommendations outlined in Ten States Recommended Standards for Wastewater Facilities (10SS) and the original design basis and intent of the WRRF. The majority of critical operating and loading criteria for a conventional activated sludge WWRF were met when compared to the historical operations, and those that were beyond what is typically recommended by 10SS were well within the threshold established in the WRRF basis of design, as outlined in Enhanced Track 3 Basis of Design for the WRRF.

A hydraulic evaluation was performed to determine the treatment capacity of the existing liquid treatment train to ensure that treatment at the 2030, 2040, and 2050 influent conditions are not limited on a hydraulic basis. Based upon this evaluation the WRRF should have no issue passing 700 MGD (i.e., peak sustained flow requirement per SPDES permit) worth of raw influent flow through the liquid treatment train with up to one unit out of service in all unit processes.

Appendix D

Technical Memorandum 4 – Full-Plant Process Model Development and Calibration

THE CITY OF NEW YORK

NYC DEPARTMENT OF ENVIRONMENTAL PROTECTION

1429-ENGSVC-S-NC-008

BNR Feasibility Study for the Newtown Creek WRRF

TM 4 – Full-Plant Process Model Development and Calibration

March 31, 2022

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Acronyms and Abbreviations

AA	average annual
$cBOD_5$	5-day carbonaceous biochemical oxygen demand
cfm	cubic feet per minute
gpd	gallons per day
lbd	pounds per day
MGD	millions of gallons per day
mg/L	milligrams per liter
AEMLSS	aerator effluent mixed liquor suspended solids
NH_3-N	ammonia
NO_2-N	nitrite
NO_3-N	nitrate
NYC DEP	New York City Department of Environmental Protection
RAS	return activated sludge
SRT	solids retention time
TKN	Total Kjeldahl Nitrogen
TN	total nitrogen
TSS	total suspended solids
VSR	volatile solids reduction
WAS	waste activated sludge
WRRF	wastewater resource recovery facility

Executive Summary

The purpose of this technical memorandum ™ is to summarize the calibration of a full-plant process model to historical operations and performance data. Arcadis obtained NC WRRF performance data from January 2015 to Mach 2021 from the DEP for use in this calibration. The performance data between January 2015 and December 2019 was the most consistent from this data set and not impacted by the COVID-19 pandemic (refer to NC-008 TM #1 *Historical Operations and Performance Data Evaluation*) and the first three years were utilized in the model calibration effort.

The full plant model calibration provided the following conclusions:

- **Raw Influent Strength:**

There was a close match between the observed historical raw influent concentrations and model predictions for all influent parameters, along with good to excellent matches on all key operating parameters and performance indicators (see **Table ES- 1)**. Therefore, it is proposed to utilize the historical annual average influent concentrations (pre-COVID 19 Pandemic) verified during the calibration effort when developing current and future flow and loadings projections for use in the BNR alternatives evaluation for the NC WRRF.

Table ES- 1 – Historical Average and Proposed Raw Influent Concentrations - Annual Average Conditions

Parameter	Plant Data (2015 - 2019)	Model (2015 - 2017)	Proposed AA Concentrations
Flow, MGD	213	212	213
COD, mg/L	326	367	367
$cBOD_5$, mg/L	166	166	166
$cBOD_5$ (uninhibited), mg/L	175	174	175
TSS, mg/L	162	157	162
VSS, mg/L	145	138	145
TKN, mg/L	31	30	31
NH_3-N, mg/L	20	21	20
TP, mg/L	4.1	4.7	4.1
PO_4-P, mg/L	2.5	2.3	2.5

- **Biological Treatment:**

Model predictions for average mixed liquor suspended solids (MLSS), aerator effluent MLSS (AEMLSS), waste activated sludge (WAS) loadings, and return activated sludge (RAS) TSS concentrations were within 2% of the historical plant data, with model predicted solids retention times (SRT) within 0.1 days of reported SRTs. These parameters show the process model accurately reflects typical plant operations at NC WRRF.

- **Effluent Quality:**

Effluent quality matched well for $cBOD_5$, TSS, TP, PO_4-P, NH_3-N, NO_3-N, NO_2-N, and TN. The model predicted effluent nitrogen speciation were all within 5% of the plant data, which provides confidence in the full-plant process model as an accurate tool for modeling BNR alternatives as part of this feasibility study.

- **Solids Handling:**

Solids handling data for thickened and digested sludge loading was tracked during the model calibration. The model predictions for thickened and digested sludge are within approximately 10% of plant data, which is a good match to observed data is acceptable for the purposes of this evaluation.

It is important to note that a sensitivity analysis on anaerobic digester performance was not performed as part of this effort since anaerobic digestion does not impact the liquid treatment stream. All thickened sludge sent to the anaerobic digesters discharge to sludge holding tanks and are shipped to one of the DEP's sludge dewatering facilities.

1 Introduction and Purpose

The NC WRRF is a high rate activated sludge treatment plant. The WRRF is rated to treat 310 MGD on a 12-month rolling average basis and is required to treat a minimum of 700 MGD during wet weather operations. A process flow diagram showing the liquid and solids treatment trains is in **Figure 1**.

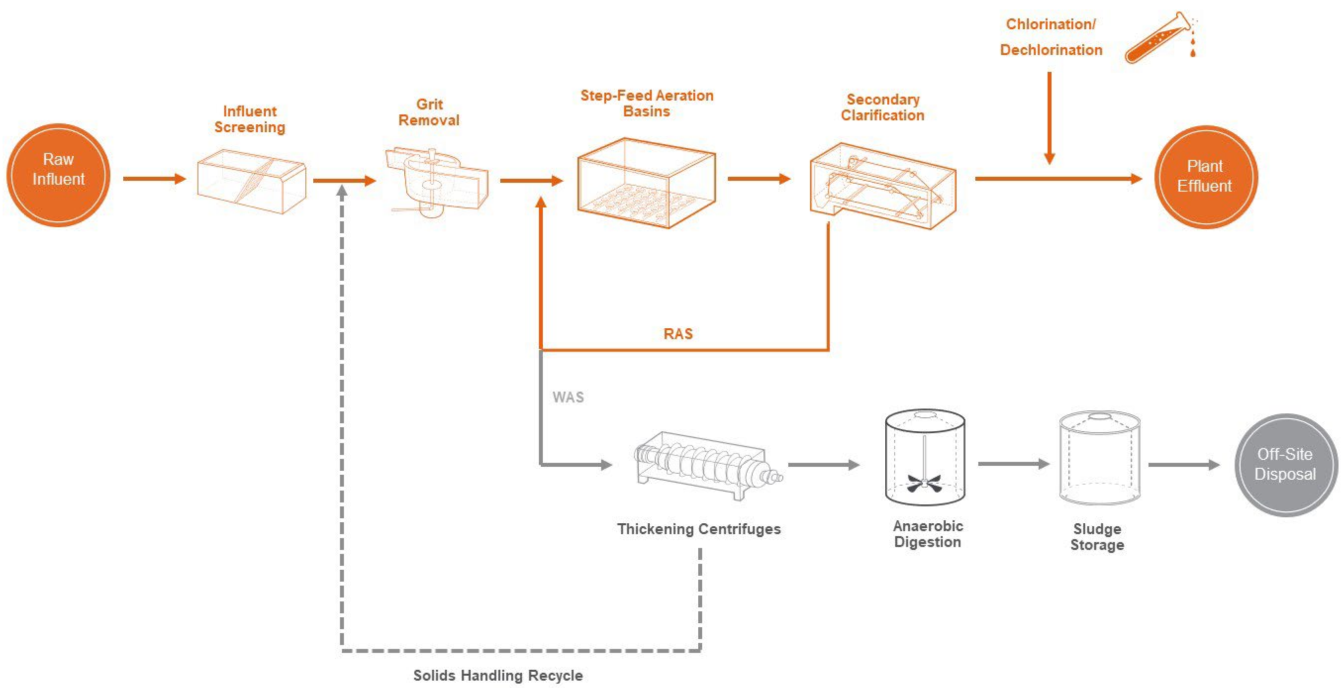


Figure 1. Process Flow Diagram – Newtown Creek WRRF

Arcadis has developed a full-plant process model utilizing BioWin 6.2 by EnviroSim to assess the feasibility of future biological nutrient removal operation at the facility to reduce effluent nitrogen discharges. The purpose of this technical memorandum is to summarize the calibration of the process model to historical operations and performance data.

A schematic of the full-plant process model is shown in **Figure 2**, which includes raw influent, a consolidated activated sludge process with all aeration tanks modeled as one large unit, and secondary clarification in the liquid treatment train, as well as sludge thickening and anaerobic digesiton in the solids handling treatment train.

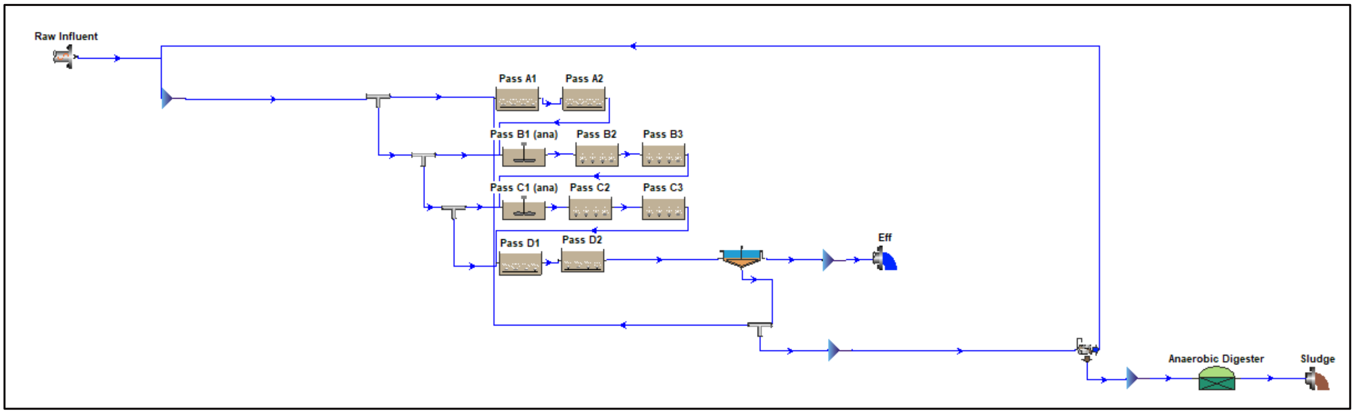


Figure 2. Full Plant BioWin Process Model - Newtown Creek WRRF

2 Process Model Calibration

Arcadis received historical operations and performance data for the period between January 2015 to March 2021. The data set showed consistent influent loadings, effluent quality, and plant operations, excluding operations between early 2020 and 2021 period. During this two-year period influent flow and loadings decreased, likely due to the COVID-19 pandemic and changes to workforce commuting into New York City.

Based on the consistency of the dataset through the first three years of available data, the process model was calibrated utilizing a daily-dynamic simulation covering historic operations between January 2015 and December 2017.

2.1 Influent Characteristics and Fractionation

The development of the model raw influent stream was based on historically observed influent concentrations for 5-day carbonaceous biochemical oxygen demand ($cBOD_5$), inert suspended solids (ISS), total Kjeldahl itrogen (TKN) and ammonia (NH_3-N), with outliers removed where necessary.

It is important to note that the analysis of $cBOD_5$ includes the use of a nitrification inhibitor. To ensure that the inhibitor has not impacted the measurement of $cBOD_5$, observed values were increased by approximately 5% to allow for a better match between observed and predicted values for activated sludge operation, solids handling, and effluent quality.

Table 1 shows the wastewater fractions utilized in this model calibration, with changes from model default values highlighted in red. The wastewater fractions were the same as those used in the 2016 BioWin Calibration completed by the Design Joint Venture (Greeley and Hansen, Hazen and Sawyer, Malcolm Pirnie) and summarized in the Technical Memorandum *Newtown Creek Wastewater Treatment Plant Process Model Calibration and Process Optimization Analysis.* The Fna fraction was changed from a value of 0.57 g N-NH_3/g TKN in the previous calibration to 0.70 g N-NH_3/g TKN to better match plant data for influent NH_3 between 2015 and 2017 as explained in **Section 2.3.1**.

Table 1. Process Model Influent Wastewater Fractionation

Name	Default	Value
Fbs - Readily biodegradable (including Acetate)	0.16	**0.135**
Fac - Acetate	0.15	**0**
Fxsp - Non-colloidal slowly biodegradable	0.75	**0.74**
Fus - Unbiodegradable soluble	0.05	**0.088**
Fup - Unbiodegradable particulate	0.13	**0.11**
Fcel - Cellulose fraction of unbiodegradable particulate	0.5	**0**
Fna - Ammonia	0.66	**0.70**
Fnox - Particulate organic nitrogen	0.5	0.5
Fnus - Soluble unbiodegradable TKN	0.02	0.02
FupN - N:COD ratio for unbiodegradable part. COD	0.035	0.035
Fpo4 - Phosphate	0.5	**0.488**
FupP - P:COD ratio for unbiodegradable part. COD	0.011	0.011
Fsr - Reduced sulfur [H2S]	0.15	**0**
FZbh - Ordinary heterotrophic COD fraction	0.02	0.02
FZbm - Methylotrophic COD fraction	1.00E-04	1.00E-04
FZao - Ammonia oxidizing COD fraction	1.00E-04	1.00E-04
FZno - Nitrite oxidizing COD fraction	1.00E-04	1.00E-04
FZaao - Anaerobic ammonia oxidizing COD fraction	1.00E-04	1.00E-04
FZppa - Phosphorus accumulating COD fraction	1.00E-04	1.00E-04
FZpa - Propionic acetogenic COD fraction	1.00E-04	1.00E-04
FZam - Acetoclastic methanogenic COD fraction	1.00E-04	1.00E-04
FZhm - Hydrogenotrophic methanogenic COD fraction	1.00E-04	1.00E-04
FZso - Sulfur oxidizing COD fraction	1.00E-04	1.00E-04
FZsrpa - Sulfur reducing propionic acetogenic COD fraction	1.00E-04	1.00E-04
FZsra - Sulfur reducing acetotrophic COD fraction	1.00E-04	1.00E-04
FZsrh - Sulfur reducing hydrogenotrophic COD fraction	1.00E-04	1.00E-04
FZe - Endogenous products COD fraction	0	0

2.2 Kinetic, Stoichiometric and Physical/Chemical Parameters

Model default values were utilized for kinetic, stoichiometric, and physical/chemical parameters within the model, save for the following adjustments made to better match nitrification performance (based on information provided in Technical Memorandum *Newtown Creek Wastewater Treatment Plant Process Model Calibration and Process Optimization Analysis*):

- **Kinetic – Anaerobic hydrolysis factor (AD)**

This parameter was increased from the default value of 0.5 to 0.7.

- **Kinetic – Autotrophic low pH limit**

This parameter was increased from the default value of 5.5 to 6.1.

- **Kinetic – Autotrophic high pH limit**

This parameter was decreased from the default value of 9.5 to 8.9.

- **Kinetic – AOB Max Specific Growth Rate, 1/d**

This parameter was decreased from the default value of 0.9 to 0.8 to better match nitrification performance in the model with the observed historical performance.

- **Kinetic – NOB Max Specific Growth Rate, 1/d**

This parameter was increased from the default value of 0.7 to 0.75 to better match effluent speciation during cold weather and low aerobic SRT operation seen in observed historical performance.

2.3 Process Model Validation and Results

2.3.1 Raw Influent Flow, Concentrations, and Loadings

Observed raw influent flow and model predicted flow rates from the dynamic calibration simulation are shown in **Figure 3** below. Across the modeling period (2015 through 2017) the average annual (AA) raw influent flow was 212 MGD with peak day flow rates up to 528 MGD.

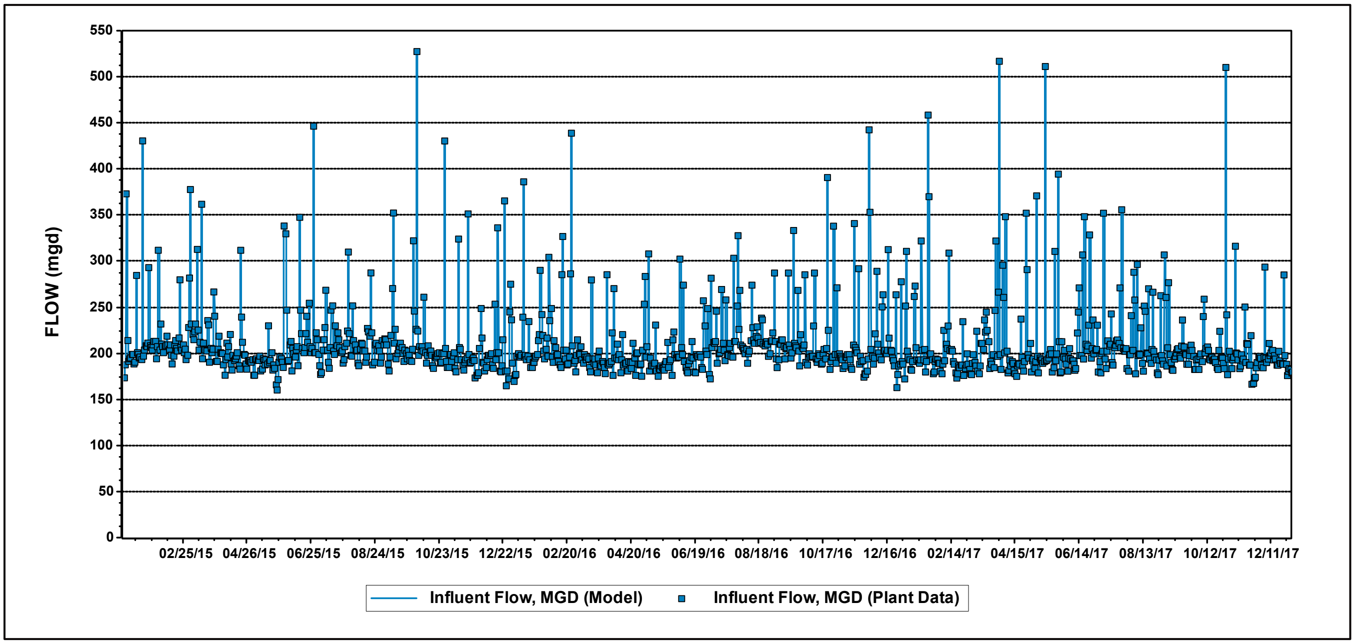


Figure 3. Raw Influent Flow - January 2015 to December 2017

Raw influent $cBOD_5$ concentrations and loading rates are shown in **Figure 4**. Predicted values for $cBOD_5$ concentrations and loadings are within 4% of observed values. Concentrations and loadings for $cBOD_5$ from the plant data and model predictions are summarized in **Table 2**. It is important to point out that all the comparisons of model predictions are done to observed plant data without outlier removal.

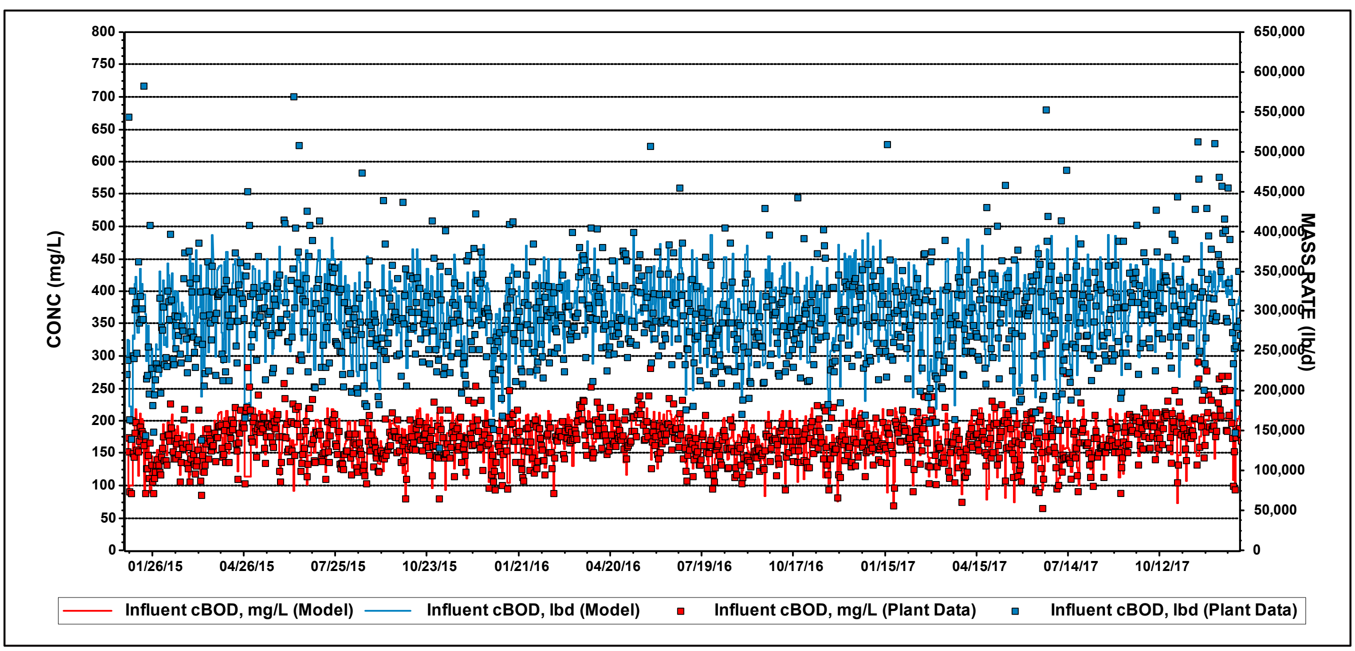


Figure 4. Raw Influent $cBOD_5$ Concentrations and Loadings - January 2015 to December 2017

Table 2. Raw Influent cBOD5 Concentrations and Loadings - January 2015 to December 2017

Year	Influent $cBOD_5$ Concentration, mg/L			Influent $cBOD_5$ Loading, lbd		
	Observed Plant Data*	Model	% Difference	Observed Plant Data*	Model	% Difference
2015	164	171	4%	288,457	298,915	4%
2016	166	176	6%	288,608	304,054	5%
2017	172	177	3%	296,771	303,894	2%
Average	167	175	4%	291,279	302,288	4%

* *Note: All comparisons of model predictions are done to observed plant data without outlier removal.*

Raw influent TSS and VSS concentrations and loading rates are shown in **Figure 5** and **Figure 6**. Predicted values for TSS concentrations are within 2% of observed values while predicted values for VSS concentrations are within 6% of observed values. Concentrations and loadings for TSS and VSS from the plant data and model predictions are summarized in **Table 3** and **Table 4**. It was concluded that this greater difference for VSS compared to TSS is due to the lack of historical daily VSS data, as the volatile percentage on days when TSS and VSS data are both available is approximately the same for model predictions and historical data (see **Table 5**).

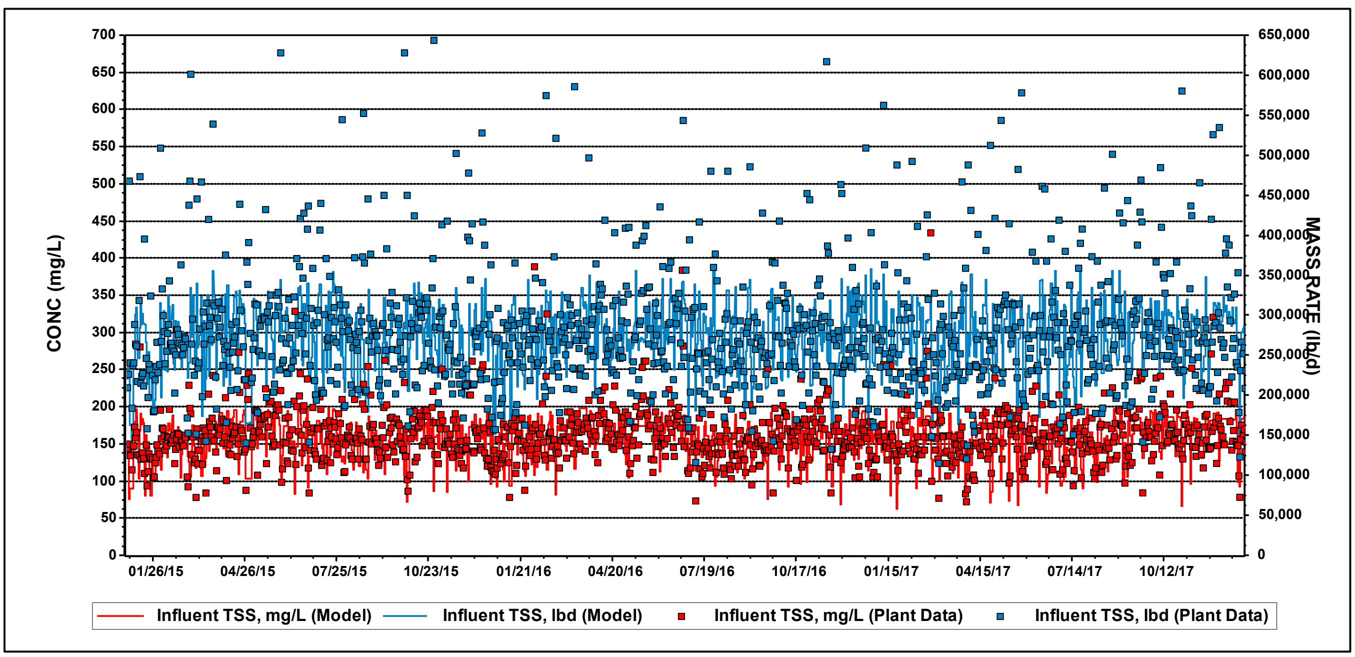


Figure 5. Raw Influent TSS Concentrations and Loadings - January 2015 to December 2017

Table 3. Raw Influent TSS Concentrations and Loadings - January 2015 to December 2017

Year	Influent TSS Concentration, mg/L			Influent TSS Loading, lbd		
	Observed Plant Data*	Model	% Difference	Observed Plant Data*	Model	% Difference
2015	161	154	-4%	287,850	269,317	-6%
2016	161	158	-2%	285,297	273,947	-4%
2017	161	159	-1%	283,178	273,804	-3%
Average	161	157	-2%	285,442	272,356	-5%

* Note: All comparisons of model predictions are done to observed plant data without outlier removal.

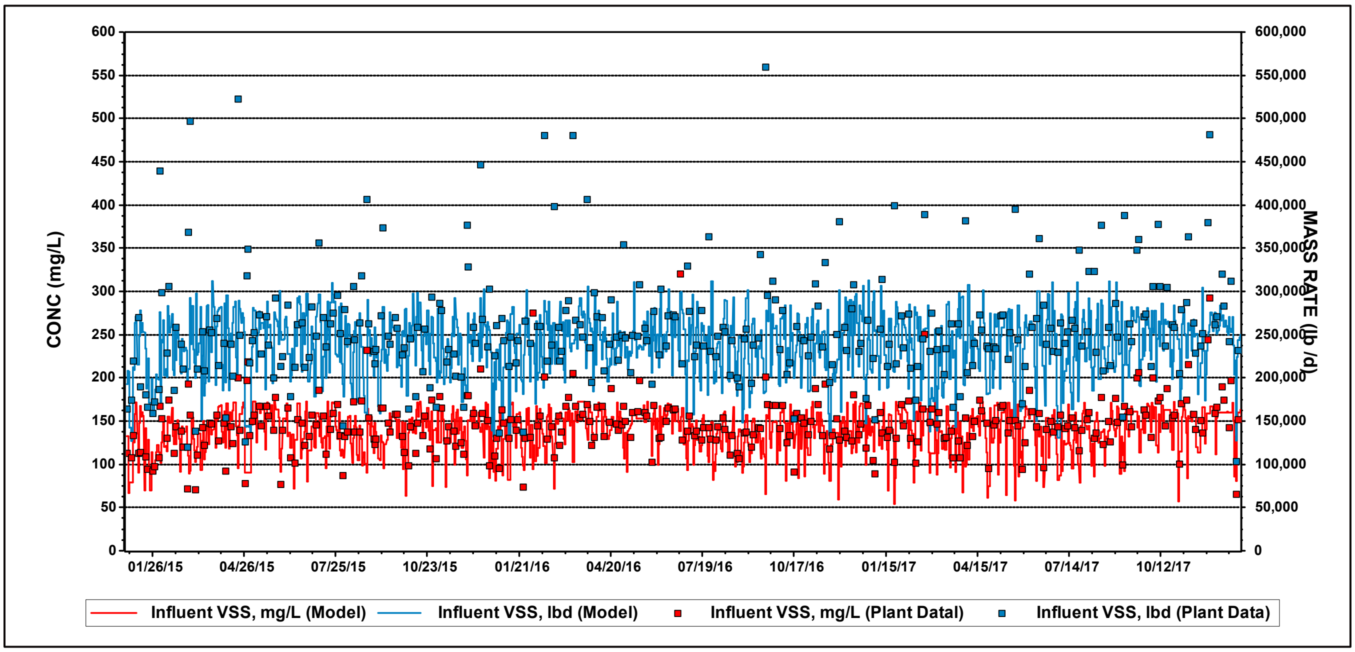


Figure 6. Raw Influent VSS Concentrations and Loadings - January 2015 to December 2017

Table 4. Raw Influent VSS Concentrations and Loadings - January 2015 to December 2017

Year	Influent VSS Concentration, mg/L			Influent VSS Loading, lbd		
	Observed Plant Data*	Model	% Difference	Observed Plant Data*	Model	% Difference
2015	141	135	4%	251,276	236,265	6%
2016	150	139	7%	269,795	240,327	11%
2017	152	140	8%	265,663	240,201	10%
Average	147	138	6%	262,245	238,931	9%

** Note: All comparisons of model predictions are done to observed plant data without outlier removal.*

Table 5. Raw Influent %Volatile Suspended Solids - January 2015 to December 2017

Year	Observed Plant Data	Model
2015	86%	88%
2016	87%	88%
2017	88%	88%
Average	**87%**	**88%**

Raw influent TKN and NH_3-N concentrations and loading rates are shown in **Figure 7** and **Figure 8**. Concentrations and loadings for TKN and NH_3-N from the plant data and model predictions are summarized in **Table 6** and **Table 7**. The influent TKN concentrations are a direct input to the model and are a complete match to the plant data for this reason. The model predicted influent NH_3-N loadings are about 15% greater than the plant data in 2015 which is due to a lower NH_3/TKN ratio (i.e., Fna fraction) during 2015 compared to the remainder of the model period. As there is a 1% match for NH_3-N concentrations and loadings between the model predicted and plant data for typical operations during 2016 and 2017, the variability seen in 2015 can be excused for the purpose of this effort.

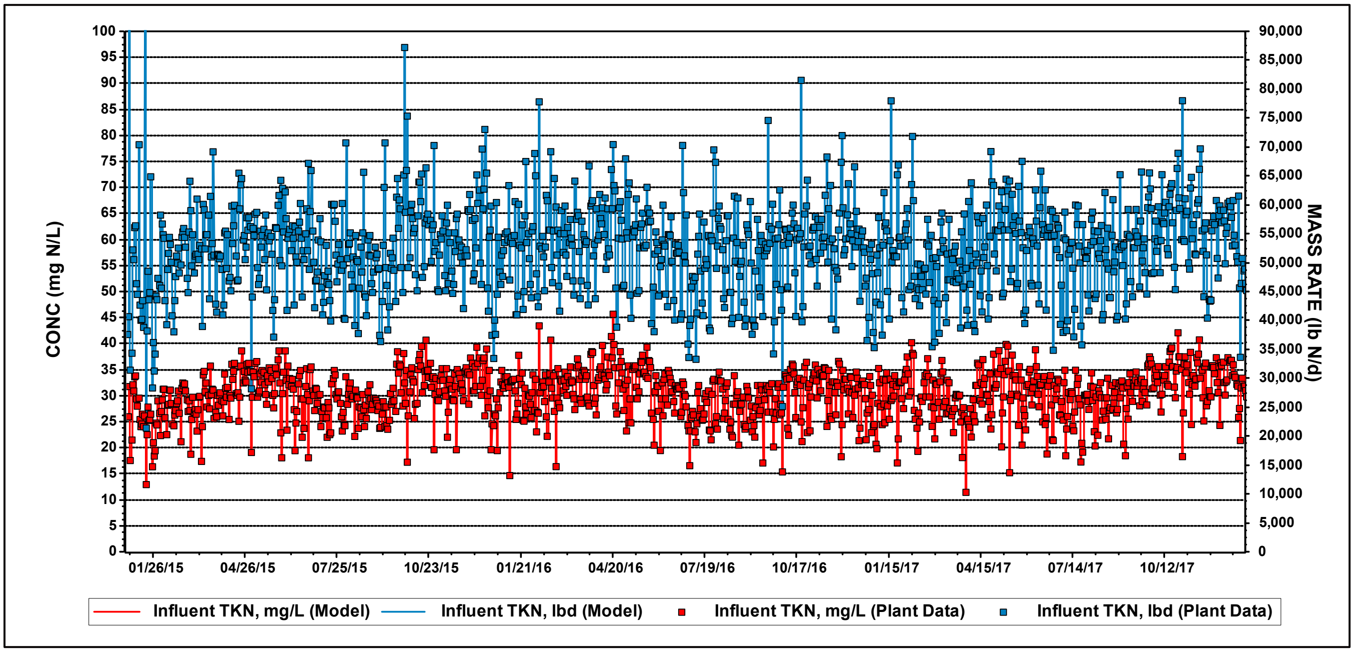


Figure 7. Raw Influent TKN Concentrations and Loadings - January 2015 to December 2017

Table 6. Raw Influent TKN Concentrations and Loadings - January 2015 to December 2017

Year	Influent TKN Concentration, mg/L			Influent TKN Loading, lbd		
	Observed Plant Data*	Model	% Difference	Observed Plant Data*	Model	% Difference
2015	30	30	-1%	51,958	51,992	0%
2016	30	30	1%	52,446	52,477	0%
2017	31	30	-2%	52,389	52,444	0%
Average	30	30	-1%	52,264	52,304	0%

** Note: All comparisons of model predictions are done to observed plant data without outlier removal.*

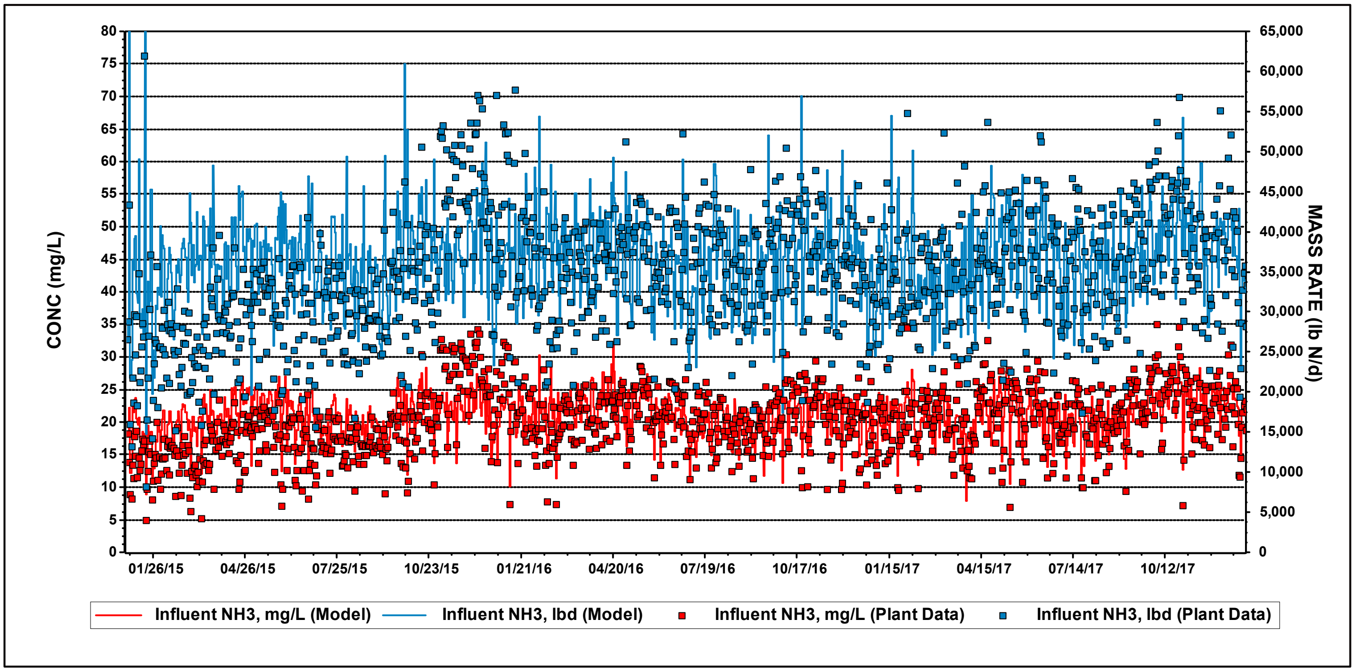


Figure 8. Raw Influent NH_3-N Concentrations and Loadings - January 2015 to December 2017

Table 7. Raw Influent NH_3-N Concentrations and Loadings - January 2015 to December 2017

Year	Influent NH_3-N Concentration, mg/L			Influent NH_3-N Loading, lbd		
	Observed Plant Data*	Model	% Difference	Observed Plant Data*	Model	% Difference
2015	17.4	20.7	19%	31,653	36,394	15%
2016	20.8	21.2	2%	35,907	36,734	2%
2017	21.1	21.3	1%	36,588	36,711	0%
Average	20	21	7%	34,716	36,613	6%

** Note: All comparisons of model predictions are done to observed plant data without outlier removal.*

2.3.2 Activated Sludge

Aerator effluent mixed liquor suspended solids (AEMLSS) concentrations are shown in **Figure 9** and summarized in **Table 8**. For both the plant data and model predicted values, the presented concentrations are the average of the effluent from the North, Central, and South batteries. Model predicted values for AEMLSS are within 2% of observed plant data.

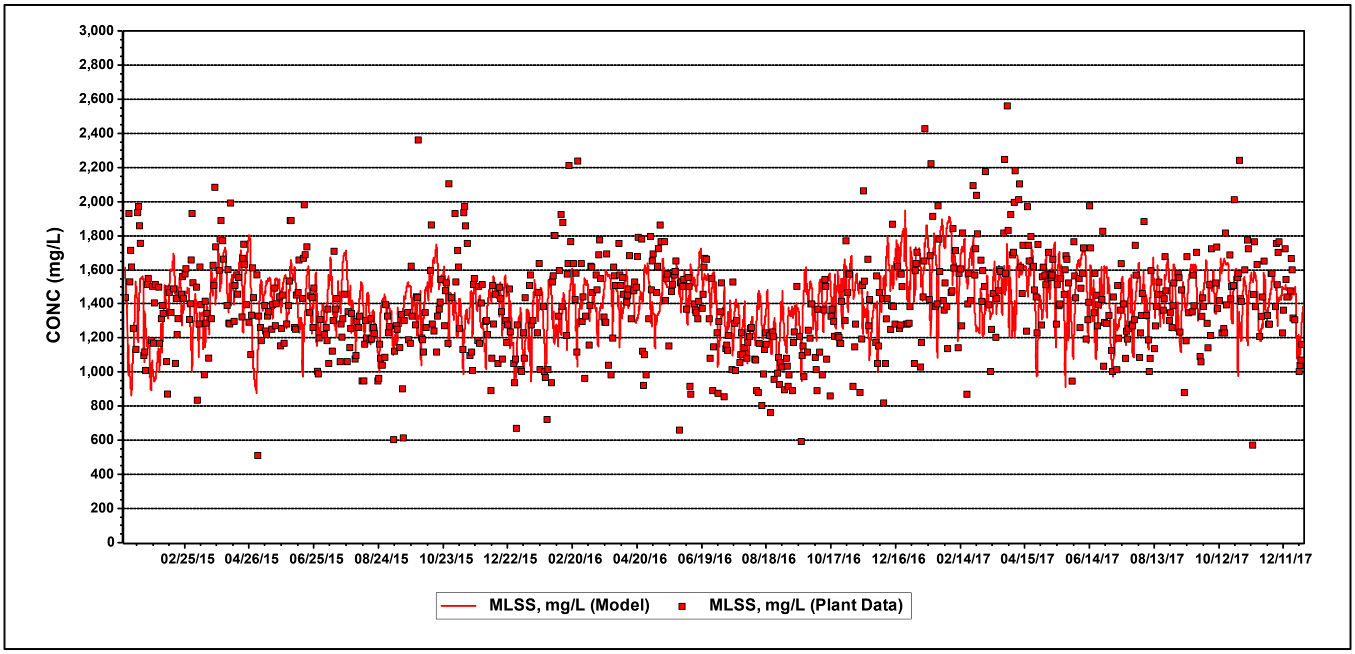


Figure 9. AEMLSS Concentrations - January 2015 to December 2017

Table 8. AEMLSS Concentrations - January 2015 to December 2017

Year	Observed Plant Data	Model	% Difference
2015	1,381	1,384	0%
2016	1,344	1,411	5%
2017	1,509	1,488	1%
Average	**1,411**	**1,428**	**2%**

Return activated sludge (RAS) TSS concentrations and waste activated sludge (WAS) Loadings are shown in **Figure 10** and **Figure 11** and summarized in **Table 9** and **Table 10** below. Model predicted values for RAS TSS are within 2% of observed plant data and model predicted values for WAS loadings are within 1% of observed plant data.

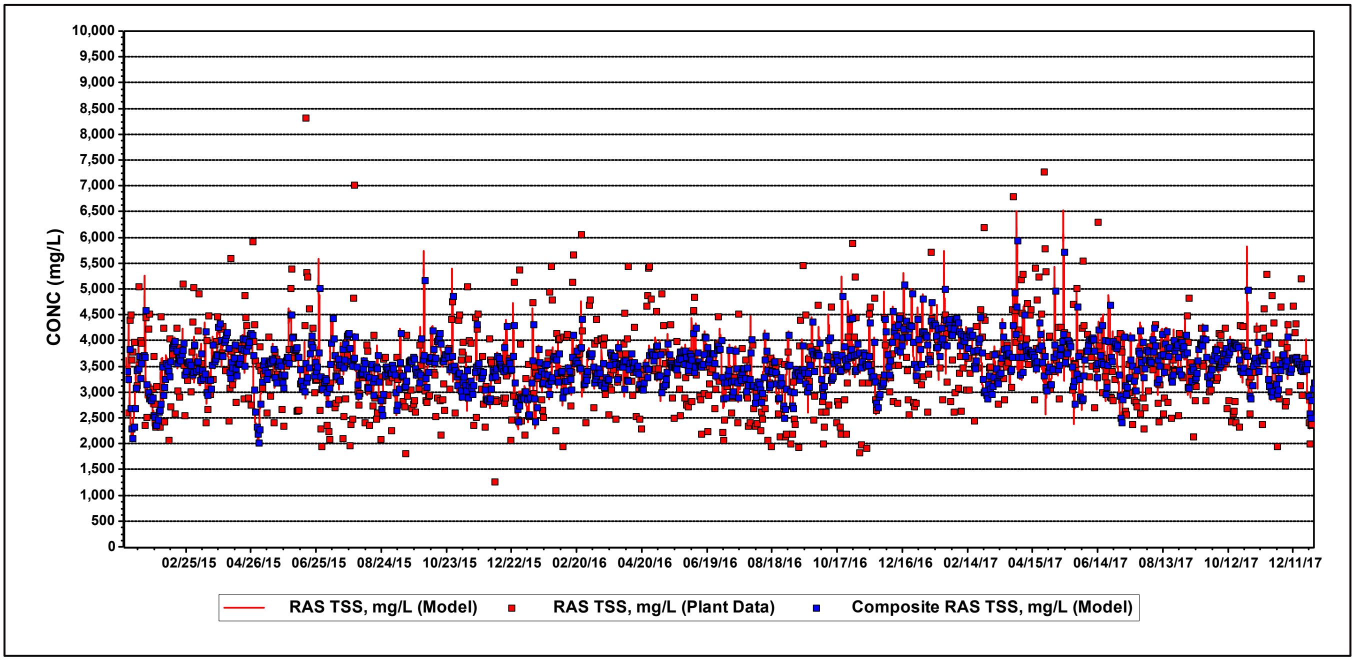


Figure 10. RAS TSS Concentrations - January 2015 to December 2017

Table 9. RAS TSS Concentrations - January 2015 to December 2017

Year	Observed Plant Data	Model	% Difference
2015	3,415	3,448	1%
2016	3,384	3,499	3%
2017	3,646	3,684	1%
Average	**3,482**	**3,543**	**2%**

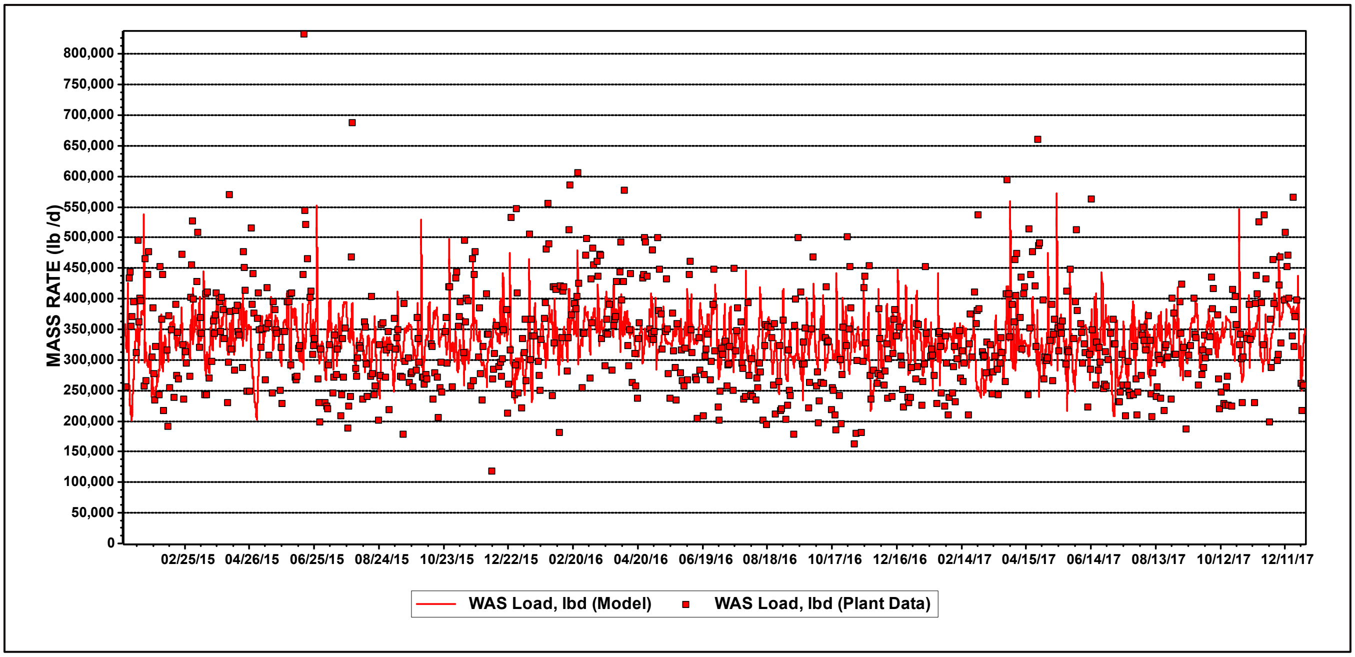


Figure 11. WAS Loads - January 2015 to December 2017

Table 10. WAS Loads - January 2015 to December 2017

Year	Observed Plant Data	Model	% Difference
2015	336,064	332,248	1%
2016	331,736	336,064	1%
2017	331,766	331,642	0%
Average	**333,189**	**333,318**	**1%**

For both the plant data and model predicted values the total solids retention time (SRT) was calculated based on the WAS and secondary effluent TSS loads. As shown in **Table 11** and **Figure 12** there was a difference of only about 0.1 days between total SRT values calculated in the plant data compared with the model predicted data.

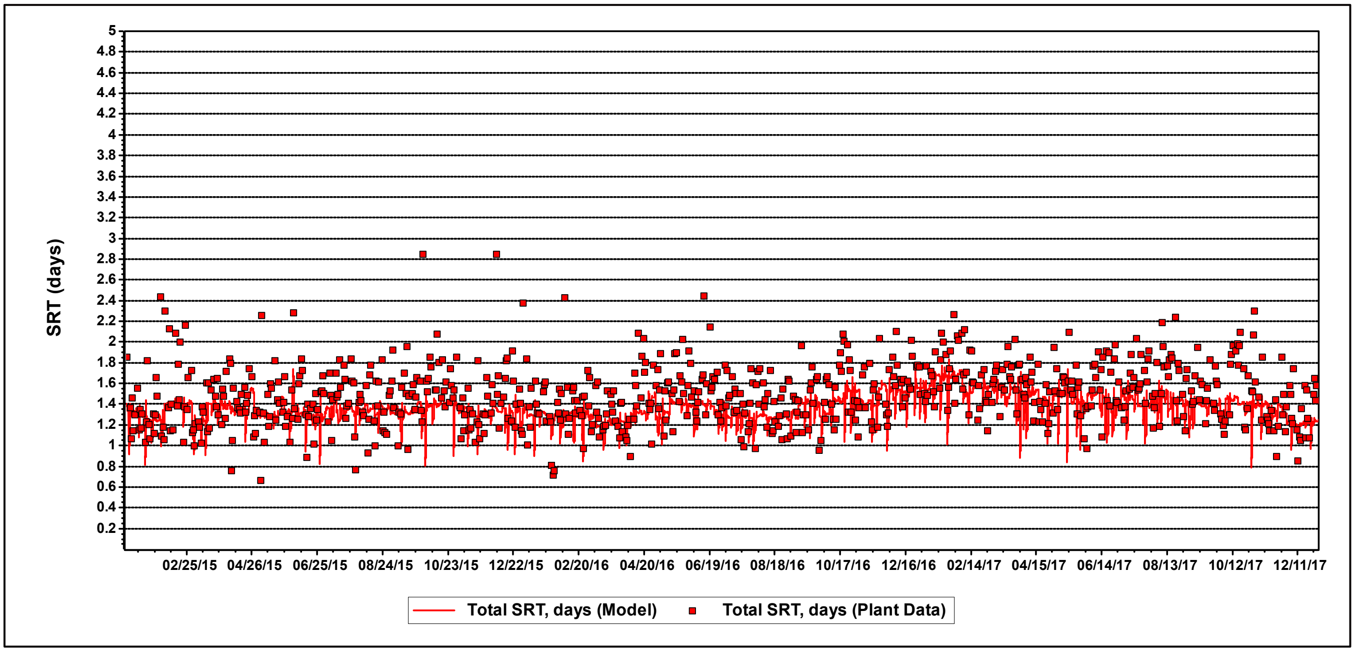


Figure 12. Total Solids Retention Time - January 2015 to December 2017

Table 11. Total Solids Retention Time - January 2015 to December 2017

Year	Observed Plant Data	Model	% Difference
2015	1.5	1.3	9%
2016	1.5	1.3	10%
2017	1.6	1.4	10%
Average	**1.5**	**1.4**	**10%**

2.3.3 Secondary Effluent Quality

Effluent $cBOD_5$ and TSS concentrations are shown in **Figure 13** and **Figure 14** and values are summarized in **Table 12** and **Table 13**. Model predicted values for effluent $cBOD_5$ are within 4% of observed plant data and model predicted effluent TSS was overestimated in the model by 19% over the 3-year time frame. However, the 19% translates to 2.6 mg/L difference which is sufficient for the purpose of this study.

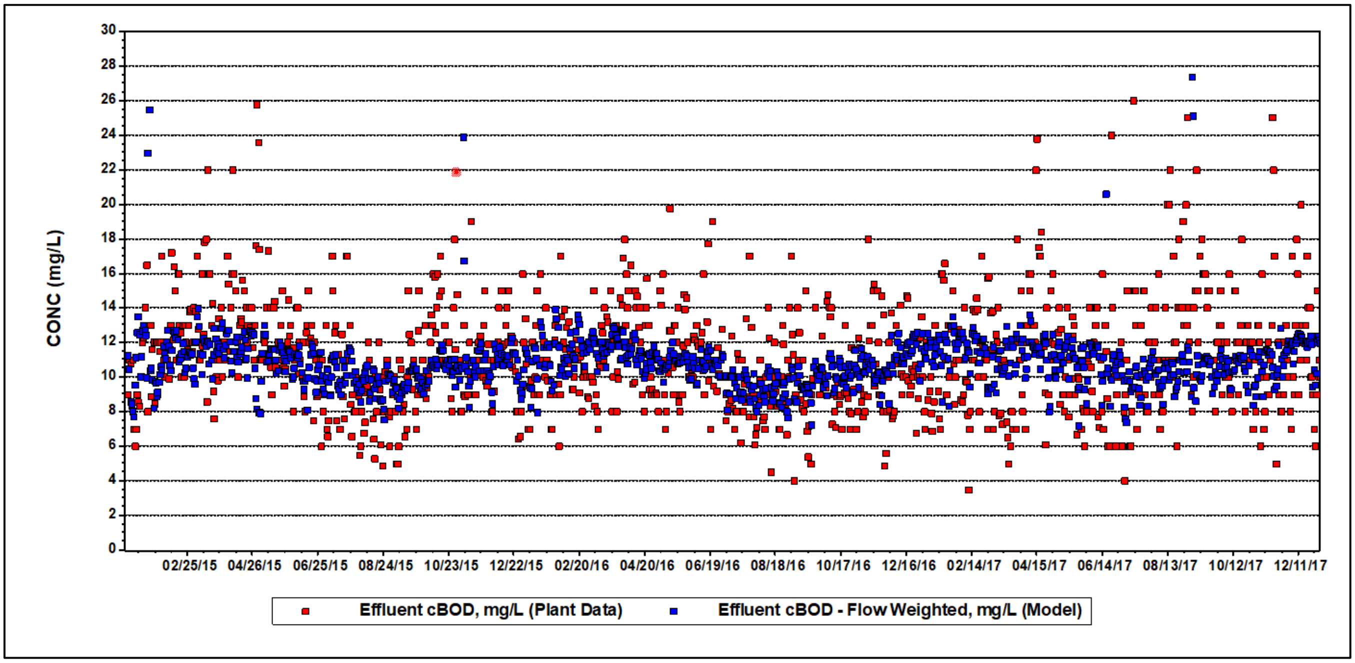


Figure 13. Effluent cBOD$_5$ Concentrations – January 2015 to December 2017

Table 12. Effluent cBOD$_5$ Concentrations – January 2015 to December 2017

Year	Observed Plant Data	Model	% Difference
2015	11.4	10.8	5%
2016	10.7	10.6	0%
2017	11.6	11.1	5%
Average	**11.2**	**10.8**	**4%**

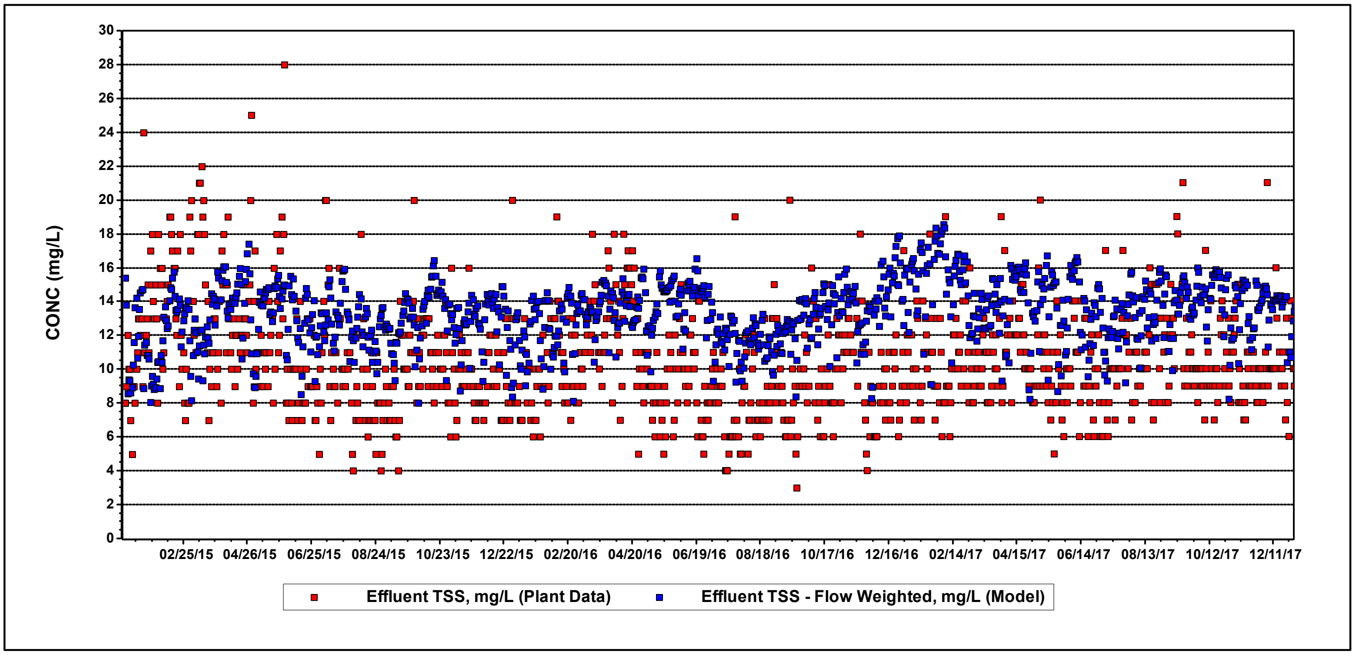


Figure 14. Effluent TSS Concentrations – January 2015 to December 2017

Table 13. Effluent TSS Concentrations – January 2015 to December 2017

Year	Observed Plant Data	Model	% Difference
2015	11.2	12.8	12%
2016	10.0	13.0	23%
2017	10.7	13.8	23%
Average	**10.6**	**13.2**	**19%**

Effluent NH_3-N, NO_3-N, NO_2-N, and TN concentrations are summarized in **Table 14** to **Table 16** and shown in **Figure 15** to **Figure 18** below. Effluent NH_3-N matches by 6% across the modeling period and predicted seasonal variation in nitrification, with effluent NH_3-N concentrations of about 10 mg/L in the warmer months and 20 mg/L during colder temperatures. Effluent NO_3-N and NO_2-N both showed an average concentration of approximately 0.5 mg/L in the plant data. The model predicted values less than 1 mg/L across the time frame for both parameters, showing a good match overall. Lastly, model predicted values for effluent TN are within 5% of observed plant data with 18 mg/L in the plant data and 17 mg/L in the model predictions.

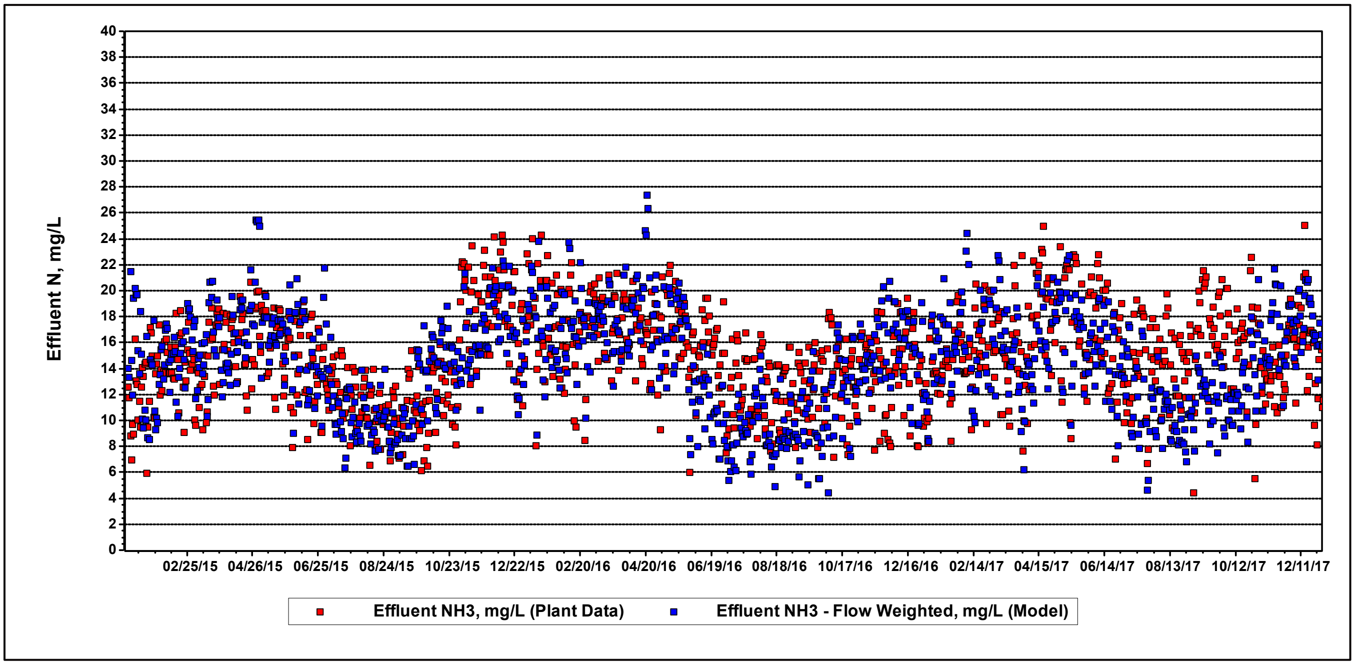


Figure 15. Effluent NH_3-N Concentrations – January 2015 to December 2017

Table 14. Effluent NH_3-N Concentrations – January 2015 to December 2017

Year	Observed Plant Data	Model	% Difference
2015	13.9	14.5	4%
2016	15.0	14.1	6%
2017	15.7	14.6	7%
Average	**15.0**	**14.4**	**6%**

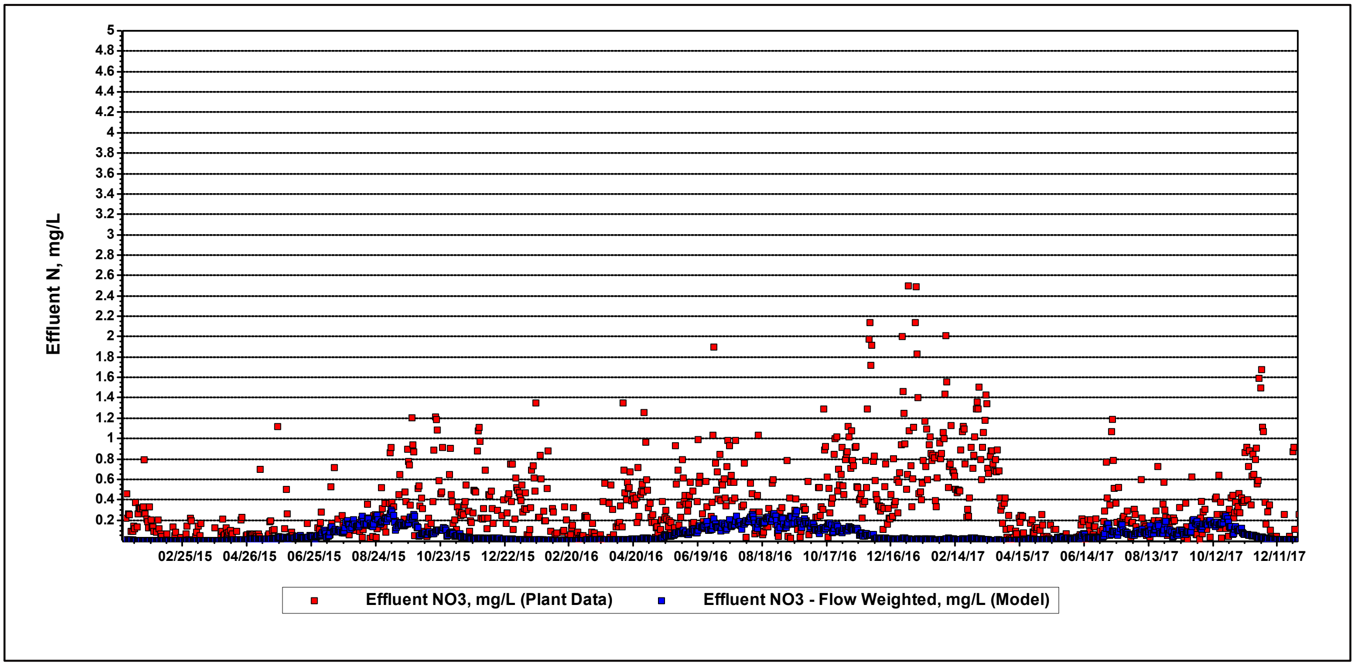


Figure 16. Effluent NO_3-N Concentrations - January 2015 to December 2017

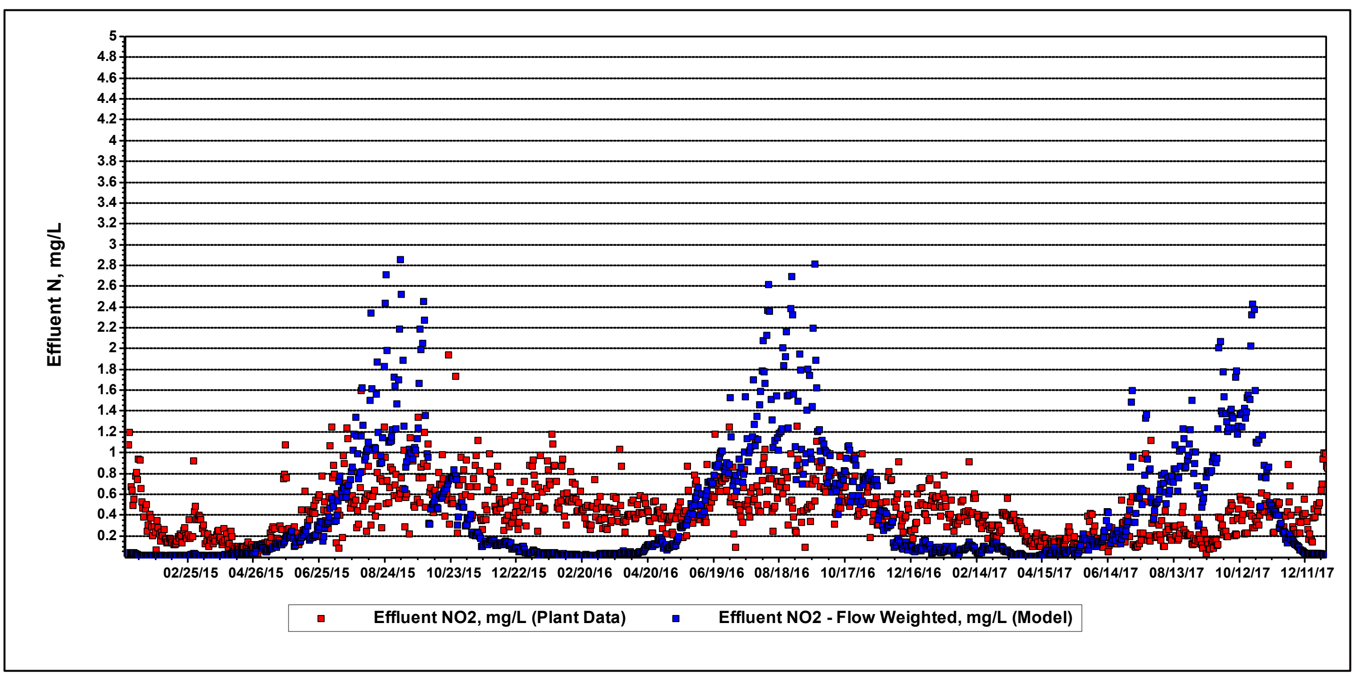


Figure 17. Effluent NO_2-N Concentrations - January 2015 to December 2017

Table 15. Effluent NO_3-N and NO_2-N Concentrations - January 2015 to December 2017

Year	Effluent NO_3-N, mg/L		Effluent NO_2-N, mg/L	
	Observed Plant Data	Model	Observed Plant Data	Model
2015	0.18	< 1	0.47	< 1
2016	0.38	< 1	0.55	< 1
2017	0.51	< 1	0.31	< 1
Average	**0.36**	**< 1**	**0.44**	**< 1**

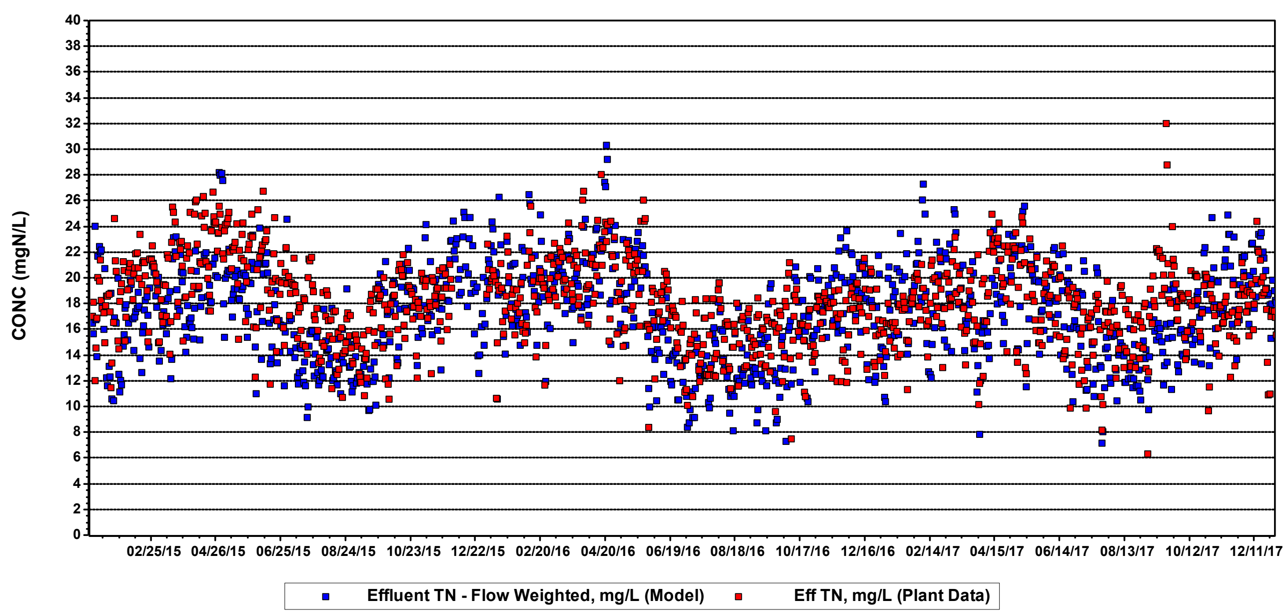


Figure 18. Effluent TN Concentrations - January 2015 to December 2017

Table 16. Effluent TN Concentrations - January 2015 to December 2017

Year	Observed Plant Data	Model	% Difference
2015	18.9	17.3	-8%
2016	17.6	17.1	-3%
2017	18.0	17.5	-3%
Average	**18.1**	**17.3**	**-5%**

2.3.4 Solids Handling

Total and volatile thickened sludge are shown in **Figure 19** and **Figure 20** below, and summarized in **Table 17**. Model predicted values for total thickened sludge are within 11% of observed plant data while model predicted values for volatile thickened sludge are within 6% of observed plant data.

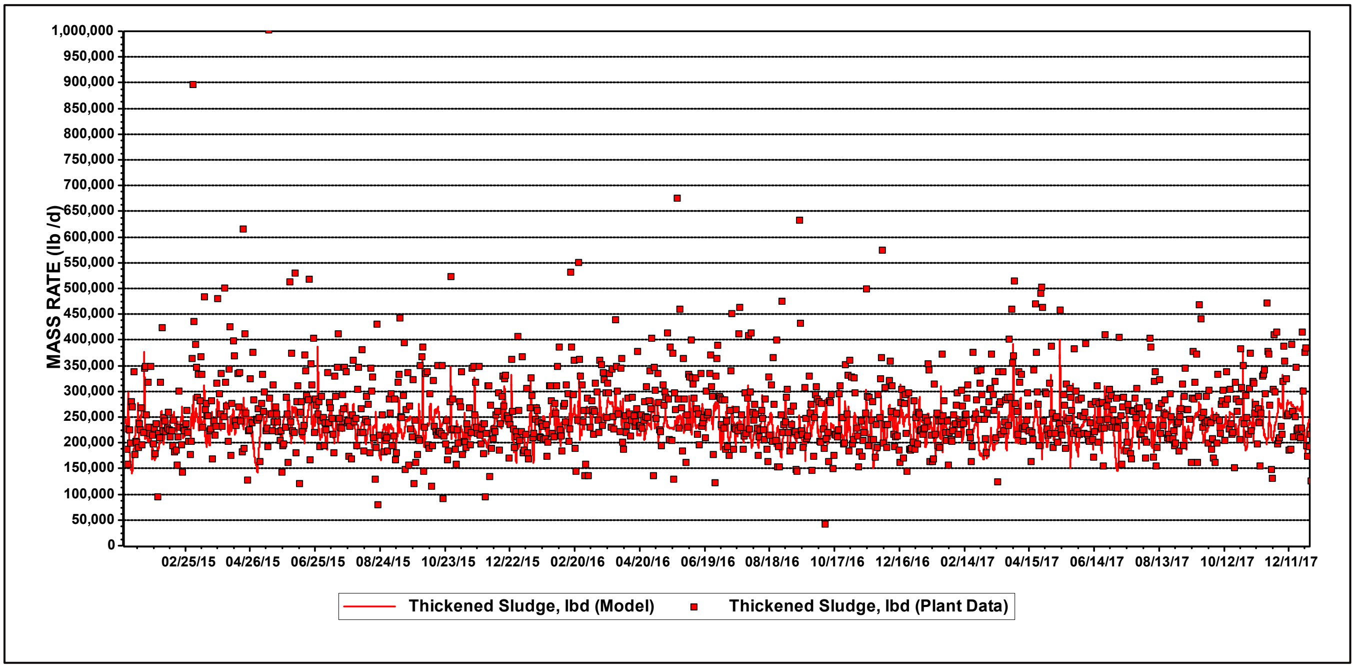


Figure 19. Thickened Sludge Loadings - January 2015 to December 2017

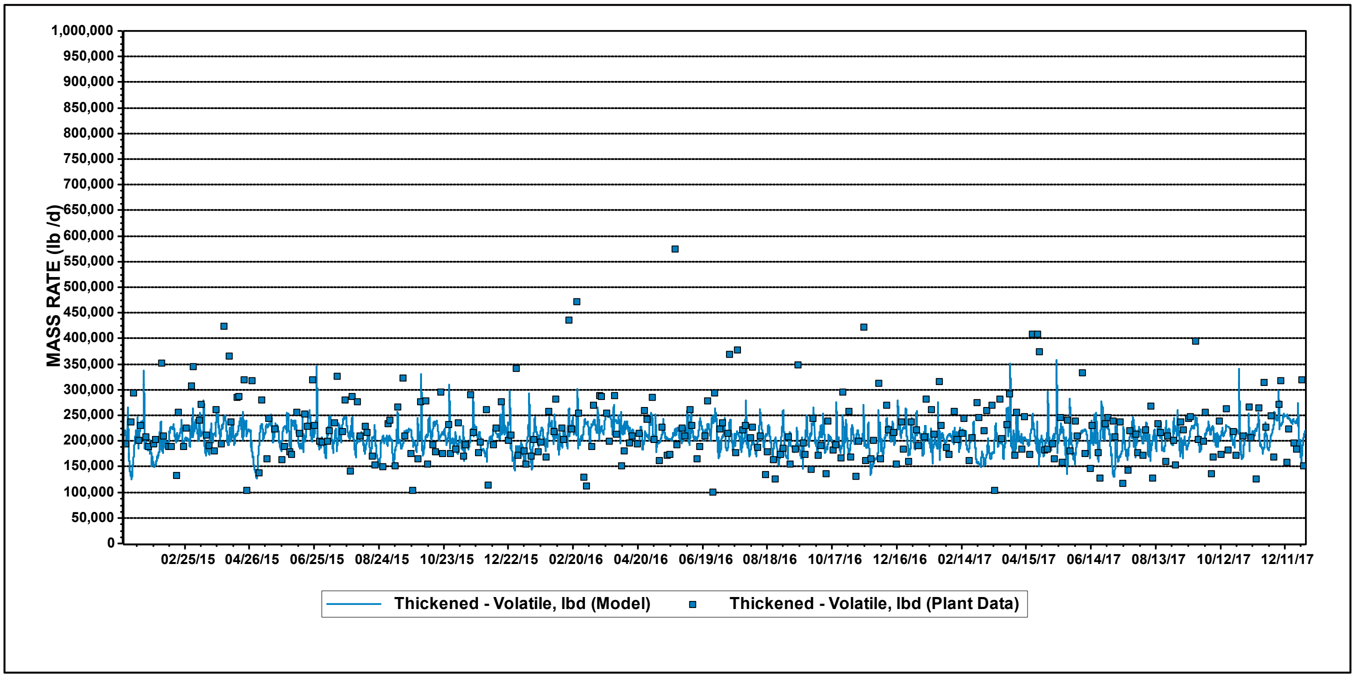


Figure 20. Volatile Thickened Sludge Loadings - January 2015 to December 2017

Table 17. Total and Volatile Thickened Sludge Loadings - January 2015 to December 2017

Year	Thickened Sludge, lbd			Volatile Thickened Sludge, lbd		
	Plant Data	Model	% Difference	Plant Data	Model	% Difference
2015	262,006	232,572	11%	225,477	207,670	8%
2016	263,779	235,245	11%	219,991	209,948	5%
2017	265,049	232,149	12%	222,109	207,058	7%
Average	**263,612**	**233,322**	**11%**	**222,526**	**208,225**	**6%**

Total and volatile digested sludge are shown in **Figure 21** and **Figure 22** below, and summarized in **Table 18**. Model predicted values for total digested sludge are within 11% of observed plant data while model predicted values for volatile digested sludge are within 16% of observed plant data. The model over-predicted digested sludge masses the most significantly in 2015 and matched much more closely in both 2016 and 2017. The 20% to 30% in 2015 is acceptable as the purpose of this study is to evaluate nutrient removal alternatives and not digestor operations.

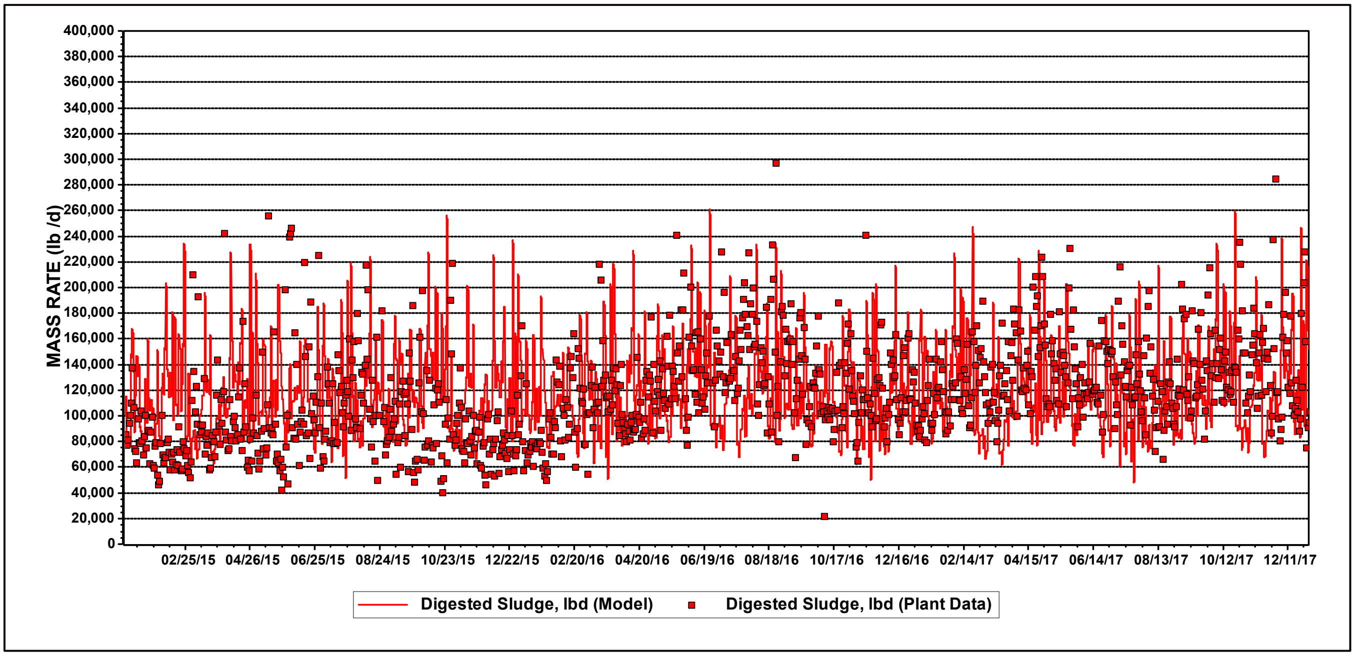


Figure 21. Digested Sludge Loadings - January 2015 to December 2017

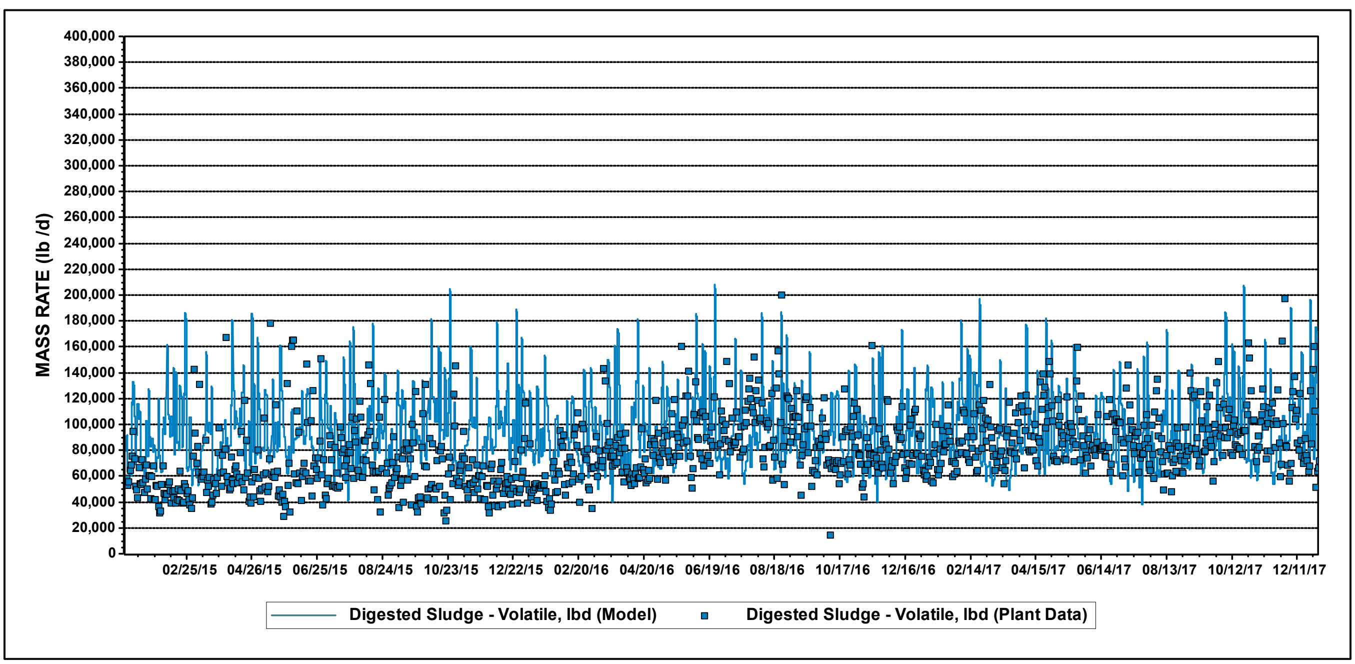


Figure 22. Volatile Digested Sludge Loadings - January 2015 to December 2017

Table 18. Total and Volatile Digested Sludge Loadings - January 2015 to December 2017

Year	Digested Sludge, lbd			Volatile Digested Sludge, lbd		
	Plant Data	Model	% Difference	Plant Data	Model	% Difference
2015	96,300	119,123	19%	65,282	94,834	31%
2016	123,645	119,165	4%	83,248	94,909	12%
2017	132,629	120,429	9%	91,199	96,028	5%
Average	**117,525**	**119,573**	**11%**	**79,910**	**95,257**	**16%**

Volatile solids reduction (VSR) and digester gas production are summarized in **Table 19** and **Table 20** respectively. Model predicted values for VSR are within 18% of observed plant data while model predicted values for digester gas production are within 17% of observed plant data. It is important to note that a sensitivity analysis on anaerobic digester performance was not performed as part of this effort since sludge dewatering is not currently practiced at the facility – therefore no nitrogen rich recycle streams occur. A sensitivity analysis can be performed around the anaerobic digestion process to better match the model to observed performance should dewatering of digested sludge be included as part of the future BNR alternatives being evaluated as part of this effort. In addition, the food waste program which brings outside material to the anaerobic digestion process is not modeled in the calibration simulation due to a lack of information on the strength of that material (i.e., COD, $cBOD_5$, etc.). Based on the available data this program started in late July 2016 and directs approximately 19,500 gpd of food waste to the anaerobic digesters.

Table 19. Volatile Solids Reduction (VSR), %

Year	Plant Data	Model	% Difference
2015	69%	54%	22%
2016	72%	54%	24%
2017	58%	53%	8%
Average	**60%**	**54%**	**18%**

Table 20. Digester Gas Production, cfm

Year	Plant Data	Model	% Difference
2015	968	1,015	5%
2016	1,216	1,018	16%
2017	1,437	995	31%
Average	**1,207**	**1,009**	**17%**

3 Conclusions

The full-plant process model calibrated well to observed plant operations and performance across the 2015 to 2017 operating period, providing good to excellent matches on all key operational and performance parameters within the liquid and solids treatment trains. Effluent nitrogen speciation matched particularly well (within 5% of observed effluent TN concentrations) dynamically across several warm and cold weather operation periods at approximately 42% removal of TN, which demonstrates that the process model is a reliable tool for use in the BNR evaluation at the WRRF.

Most importantly, the process model provided an excellent match to and validate the observed influent strength through the data set. **Table 21** summarizes average influent concentrations from the available plant data between 2015 and 2019 and the model predicted values from the calibration simulation. Due to the excellent match between the model results and plant data, Arcadis proposes using the annual average concentrations shown in **Table 21** in developing future plant loadings for 2030, 2040, and 2050 for use with the BNR evaluation.

Table 21 - Historical Average and Proposed Raw Influent Concentrations for Annual Average Conditions

Parameter	Plant Data (2015 - 2019)	Process Model (2015 - 2017)	Proposed AA Concentrations
COD, mg/L	326	367	367
$cBOD_5$, mg/L	166	166	166
$cBOD_5$ (uninhibited), mg/L	175	174	175
TSS, mg/L	162	157	162
VSS, mg/L	145	138	145
TKN, mg/L	31	30	31
NH_3-N, mg/L	20	21	20
TP, mg/L	4.1	4.7	4.1
PO_4-P, mg/L	2.5	2.3	2.5

Appendix E

Opinion of Probable Construction Cost

C O N S T R U C T I O N   S E R V I C E S   I N C.

SUBJECT:	**GENERAL NOTES & QUALIFICATIONS**	**EST. NO:**	21-0354
PROJECT:	NEWTOWN CREEK BNR OPTIONS	**EST. BY:**	JF
LOCATION:	BROOKLYN, NEW YORK	**CHKD. BY:**	EH
TYPE EST.:	CONCEPTUAL	**DATE:**	12/15/2021
CLIENT:	ARCADIS	**REV. DATE:**	

1. ALL PRICES ARE BASED ON DECEMBER 2021 PREVAILING WAGE CONSTRUCTION COSTS.

2. THE FOLLOWING ITEMS ARE NOT INCLUDED IN THE ESTIMATE:

   - Professional Fees
   - Hazardous materials abatement and handling
   - Construction contingency costs
   - Permitting
   - Escalation
   - Rock Removal

NASCO
CONSTRUCTION SERVICES INC.

SUBJECT:	**SUMMARY - ALTERNATIVE #2 - BAF**	**EST. NO:**	21-0354
PROJECT:	NEWTOWN CREEK BNR OPTIONS	**EST. BY:**	JF
LOCATION:	BROOKLYN, NEW YORK	**CHKD. BY:**	EH
TYPE EST.:	CONCEPTUAL	**DATE:**	12/15/2021
CLIENT:	ARCADIS	**REV. DATE:**	

ITEM	DESCRIPTION	
	MAINTENANCE OF PLANT OPERATIONS	$500,000
	SECONDARY EFFLUENT PUMP STATION	$6,919,000
	NEW BAF AREA	$40,028,375
	SITE PIPING	$12,220,000
	SUBTOTAL	$59,667,375
	PHASING - 5.0%	$2,983,325
	SUBTOTAL	$62,650,700
	GENERAL CONDITIONS - 20.0%	$12,530,100
	SUBTOTAL	$75,180,800
	G.C. OH & P - 21.0%	$15,788,000
	SUBTOTAL	$90,968,800
	DESIGN CONTINGENCY - 35.0%	$31,839,100
	SUBTOTAL	$122,807,900
	BONDS & INSURANCE - 5.0%	$6,140,400
	SUBTOTAL	$128,948,300
	TOTAL (ROUNDED)	**$ 130,000,000**

N A S C O
C O N S T R U C T I O N   S E R V I C E S   I N C.

SUBJECT:	**BACKUP - ALTERNATIVE #2 - BAF**	**EST. NO:**	21-0354
PROJECT:	NEWTOWN CREEK BNR OPTIONS	**EST. BY:**	JF
LOCATION:	BROOKLYN, NEW YORK	**CHKD. BY:**	EH
TYPE EST.:	CONCEPTUAL	**DATE:**	12/15/2021
CLIENT:	ARCADIS	**REV. DATE:**	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	TOTAL
01	**MAINTENANCE OF PLANT OPERATIONS**					
	Bypass Pumping & Temporary Facilities Allowance	1	LS	500,000.00	500,000	
						$500,000
02	**SECONDARY EFFLUENT PUMP STATION**					
	Site Work					
	Support of Excavation	10,000	SF	60.00	600,000	
	Excavation	3,700	CY	50.00	185,000	
	Backfill (Clean)	1,900	CY	75.00	142,500	
	Hauling & Disposal	3,700	CY	100.00	370,000	
	Below Grade Structure					
	Foundation Slab	180	CY	750.00	135,000	
	Walls	590	CY	1,250.00	737,500	
	Floor Slab & Beams	90	CY	1,500.00	135,000	
	Waterproofing	6,400	SF	10.00	64,000	
	Above Grade Structure					
	Exterior Walls	2,400	SF	125.00	300,000	
	Roof Structure	1,600	SF	100.00	160,000	
	Roofing	1,600	SF	50.00	80,000	
	Interior Fitout	1,600	SF	100.00	160,000	
	Plumbing	1	LS	50,000.00	50,000	
	HVAC	1	LS	150,000.00	150,000	
	Electric Fitout	1	LS	150,000.00	150,000	
	Process Mechanical					
	Submersible Pumps, 20MGD x 30ft	3	EA	500,000.00	1,500,000	
	Pump Station Process Piping & Valves	1	LS	1,000,000.00	1,000,000	
	Electrical					
	Pump Station Electrical Requirements	1	LS	1,000,000.00	1,000,000	
						$6,919,000

N A S C O

C O N S T R U C T I O N   S E R V I C E S   I N C.

SUBJECT:	**BACKUP - ALTERNATIVE #2 - BAF**	**EST. NO:**	21-0354
PROJECT:	NEWTOWN CREEK BNR OPTIONS	**EST. BY:**	JF
LOCATION:	BROOKLYN, NEW YORK	**CHKD. BY:**	EH
TYPE EST.:	CONCEPTUAL	**DATE:**	12/15/2021
CLIENT:	ARCADIS	**REV. DATE:**	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	TOTAL
03	**NEW BAF AREA**					
	Site Work					
	Demolish Existing Gravity Thickner Tanks & Building	1	LS	1,000,000	1,000,000	
	Support of Excavation	19,500	SF	60.00	1,170,000	
	Excavation	21,800	CY	50.00	1,090,000	
	Backfill (Clean)	2,800	CY	75.00	210,000	
	Hauling & Disposal	21,800	CY	100.00	2,180,000	
	Below Grade Structure					
	Foundation Slab	2,860	CY	750.00	2,145,000	
	Walls	1,180	CY	1,250.00	1,475,000	
	Floor Slab & Beams	1,430	CY	1,500.00	2,145,000	
	Waterproofing	12,900	SF	10.00	129,000	
	Above Grade Structure					
	Exterior Walls	9,675	SF	125.00	1,209,375	
	Roof Structure	25,700	SF	100.00	2,570,000	
	Roofing	25,700	SF	50.00	1,285,000	
	Interior Fitout	25,700	SF	100.00	2,570,000	
	Plumbing	1	LS	250,000.00	250,000	
	HVAC	1	LS	500,000.00	500,000	
	Electric Fitout	1	LS	500,000.00	500,000	
	Process Mechanical					
	Veolia BIOSTYR	1	LS	12,000,000.00	12,000,000	
	Contractor's Installation	1	LS	1,200,000.00	1,200,000	
	Process Piping & Interconnection - 20% of Equipment Cost	1	LS	2,700,000.00	2,700,000	
	Electrical - 15% of Total Cost	1	LS	3,700,000.00	3,700,000	
						$40,028,375

N A S C O
C O N S T R U C T I O N   S E R V I C E S   I N C.

SUBJECT:	**BACKUP - ALTERNATIVE #2 - BAF**	**EST. NO:**	21-0354
PROJECT:	NEWTOWN CREEK BNR OPTIONS	**EST. BY:**	JF
LOCATION:	BROOKLYN, NEW YORK	**CHKD. BY:**	EH
TYPE EST.:	CONCEPTUAL	**DATE:**	12/15/2021
CLIENT:	ARCADIS	**REV. DATE:**	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	TOTAL
04	**SITE PIPING**					
	Site Work					
	Hardscape Cutting & Patching	31,000	SF	20.00	620,000	
	Trenching					
	Support of Excavation	62,000	SF	60.00	3,720,000	
	Excavation	9,200	CY	50.00	460,000	
	Backfill (Clean)	8,000	CY	75.00	600,000	
	Hauling & Disposal	9,200	CY	100.00	920,000	
	36" Secondary Effluent Piping	1,300	LF	1,500.00	1,950,000	
	48" Treated Effluent Piping	1,800	LF	2,000.00	3,600,000	
	10" Backwash Water Piping	500	LF	300.00	150,000	
	Connection to Existing Plant Effluent	2	LOC	100,000.00	200,000	
						$12,220,000

NASCO
CONSTRUCTION SERVICES INC.

SUBJECT:	**SUMMARY - ALTERNATIVE #3 - MBR**	**EST. NO:**	21-0354
PROJECT:	NEWTOWN CREEK BNR OPTIONS	**EST. BY:**	JF
LOCATION:	BROOKLYN, NEW YORK	**CHKD. BY:**	EH
TYPE EST.:	CONCEPTUAL	**DATE:**	12/15/2021
CLIENT:	ARCADIS	**REV. DATE:**	

ITEM	DESCRIPTION	
	MAINTENANCE OF PLANT OPERATIONS	$25,000,000
	AERATION BASIN	$13,727,500
	SEDIMENTATION BASIN	$363,614,900
	BLOWER ROOM	$7,565,000
	SITE PIPING	$46,935,000
	SUBTOTAL	$456,842,400
	PHASING - 5.0%	$22,842,100
	SUBTOTAL	$479,684,500
	GENERAL CONDITIONS - 20.0%	$95,936,900
	SUBTOTAL	$575,621,400
	G.C. OH & P - 21.0%	$120,880,500
	SUBTOTAL	$696,501,900
	DESIGN CONTINGENCY - 35.0%	$243,775,700
	SUBTOTAL	$940,277,600
	BONDS & INSURANCE - 5.0%	$47,013,900
	SUBTOTAL	$987,291,500
	TOTAL (ROUNDED)	**$ 990,000,000**

NASCO
CONSTRUCTION SERVICES INC.

SUBJECT:	**BACKUP - ALTERNATIVE #3 - MBR**	**EST. NO:**	21-0354
PROJECT:	NEWTOWN CREEK BNR OPTIONS	**EST. BY:**	JF
LOCATION:	BROOKLYN, NEW YORK	**CHKD. BY:**	EH
TYPE EST.:	CONCEPTUAL	**DATE:**	12/15/2021
CLIENT:	ARCADIS	**REV. DATE:**	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	TOTAL
01	**MAINTENANCE OF PLANT OPERATIONS**					
	Bypass Pumping & Temporary Facilities Allowance	1	LS	25,000,000.00	25,000,000	
						$25,000,000
02	**AERATION BASIN**					
	Site Work					
	Demolish Existing Baffles	12	EA	10,000.00	120,000	
	Demolish Existing Ceramic Diffusers	12	LOC	25,000.00	300,000	
	Demolish Sedimentation Tank Influent Channel Walls	12	LOC	10,000.00	120,000	
	Process Mechanical					
	Sanitaire Membrane Diffuser System	1	EA	2,250,000.00	2,250,000	
	Contractor's Installation	1	EA	337,500.00	337,500	
	Mixers, 7.5hp	60	EA	100,000.00	6,000,000	
	Contractor's Installation	60	EA	15,000.00	900,000	
	Process Piping & Interconnection - 20% of Equipment Cost	1	LS	1,900,000.00	1,900,000	
	Electrical - 15% of Total Cost	1	LS	1,800,000.00	1,800,000	
						$13,727,500

N A S C O
C O N S T R U C T I O N   S E R V I C E S   I N C.

SUBJECT:	**BACKUP - ALTERNATIVE #3 - MBR**	**EST. NO:**	21-0354
PROJECT:	NEWTOWN CREEK BNR OPTIONS	**EST. BY:**	JF
LOCATION:	BROOKLYN, NEW YORK	**CHKD. BY:**	EH
TYPE EST.:	CONCEPTUAL	**DATE:**	12/15/2021
CLIENT:	ARCADIS	**REV. DATE:**	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	TOTAL
03	**SEDIMENTATION BASIN**					
	Site Work					
	Remove sludge collection mechanisms (per Battery)	3	EA	200,000.00	600,000	
	Remove existing piping (per Battery)	3	EA	100,000.00	300,000	
	Structural					
	Drum Screen Concrete Diversion Structures	24	EA	250,000.00	6,000,000	
	Channel Walls	1,400	CY	1,250.00	1,750,000	
	Concrete Deck over Channels	5,500	CY	1,500.00	8,250,000	
	Membrane Influent Channels	1,000	CY	1,250.00	1,250,000	
	Membrane Tank Walls	1,250	CY	1,250.00	1,562,500	
	RAS Channels	500	CY	1,250.00	625,000	
	Pre Engineered Building over Screens (Approximately 50,000 SF Each)	3	EA	12,500,000.00	37,500,000	
	Pre Engineered Equipment Building (Approximately 35,000 SF Each)	3	EA	8,750,000.00	26,250,000	
	Odor Control for Buildings	255,000	GSF	50.00	12,750,000	
	Process Mechanical					
	Drum Screens - Ovivo (Per Battery)	3	EA	9,368,000.00	28,104,000	
	Contractor's Installation (per Battery)	3	EA	936,800.00	2,810,400	
	Ancillary Screens - JDV (Per Battery)	3	EA	1,640,000.00	4,920,000	
	Contractor's Installation	3	EA	246,000.00	738,000	
	Suez ZeeWeed Membrane Filter System (per Battery)	3	EA	43,800,000.00	131,400,000	
	Contractor's Installation (per Battery)	3	EA	4,380,000.00	13,140,000	
	RAS Pumps, 2000hp	12	EA	1,000,000.00	12,000,000	
	Contractor's Installation	12	EA	100,000.00	1,200,000	
	Hypo Tanks, 1200 gallon, Furnished & Installed	3	EA	20,000.00	60,000	
	Citric Acid Tanks, 6,000 gallon, Furnished & Installed	3	EA	60,000.00	180,000	
	Bridge Crane	3	EA	75,000.00	225,000	
	Process Piping & Interconnection - 20% of Equipment Cost	1	LS	39,000,000.00	39,000,000	
	Electrical - 15% of Total Cost	1	LS	33,000,000.00	33,000,000	
						$363,614,900

NASCO
CONSTRUCTION SERVICES INC.

SUBJECT:	**BACKUP - ALTERNATIVE #3 - MBR**	**EST. NO:**	21-0354
PROJECT:	NEWTOWN CREEK BNR OPTIONS	**EST. BY:**	JF
LOCATION:	BROOKLYN, NEW YORK	**CHKD. BY:**	EH
TYPE EST.:	CONCEPTUAL	**DATE:**	12/15/2021
CLIENT:	ARCADIS	**REV. DATE:**	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	TOTAL
04	**BLOWER ROOM**					
	Site Work					
	Demolish Existing 2000hp Blowers	3	EA	25,000.00	75,000	
	Process Mechanical					
	New Blowers, 4000hp	4	EA	1,225,000.00	4,900,000	
	Contractor's Installation	4	EA	122,500.00	490,000	
	Process Piping & Interconnection - 20% of Equipment Cost	1	LS	1,300,000.00	1,300,000	
	Electrical - 15% of Total Cost	1	LS	800,000.00	800,000	
						$7,565,000
05	**SITE PIPING**					
	RAS Piping					
	Hardscape Cutting & Patching	75,000	SF	20.00	1,500,000	
	Trenching					
	Support of Excavation	60,000	SF	60.00	3,600,000	
	Excavation	27,800	CY	50.00	1,390,000	
	Backfill (Clean)	19,000	CY	75.00	1,425,000	
	Hauling & Disposal	27,800	CY	100.00	2,780,000	
	60" RAS Piping	12,000	LF	3,000.00	36,000,000	
	Connections	24	LOC	10,000.00	240,000	
						$46,935,000

NASCO
CONSTRUCTION SERVICES INC.

SUBJECT:	**SUMMARY - ALTERNATIVE #4 - IFAS**	**EST. NO:**	21-0354
PROJECT:	NEWTOWN CREEK BNR OPTIONS	**EST. BY:**	JF
LOCATION:	BROOKLYN, NEW YORK	**CHKD. BY:**	EH
TYPE EST.:	CONCEPTUAL	**DATE:**	12/15/2021
CLIENT:	ARCADIS	**REV. DATE:**	

ITEM	DESCRIPTION	
	MAINTENANCE OF PLANT OPERATIONS	$5,000,000
	INFLUENT SCREENS	$7,735,988
	AERATION BASIN	$88,770,000
	BLOWER ROOM	$12,082,500
	SUBTOTAL	$113,588,488
	PHASING - 5.0%	$5,679,412
	SUBTOTAL	$119,267,900
	GENERAL CONDITIONS - 20.0%	$23,853,600
	SUBTOTAL	$143,121,500
	G.C. OH & P - 21.0%	$30,055,500
	SUBTOTAL	$173,177,000
	DESIGN CONTINGENCY - 35.0%	$60,612,000
	SUBTOTAL	$233,789,000
	BONDS & INSURANCE - 5.0%	$11,689,500
	SUBTOTAL	$245,478,500
	TOTAL (ROUNDED)	**$ 250,000,000**

N A S C O

C O N S T R U C T I O N   S E R V I C E S   I N C.

SUBJECT:	**BACKUP - ALTERNATIVE # 4 - IFAS**	**EST. NO:**	21-0354
PROJECT:	NEWTOWN CREEK BNR OPTIONS	**EST. BY:**	JF
LOCATION:	BROOKLYN, NEW YORK	**CHKD. BY:**	EH
TYPE EST.:	CONCEPTUAL	**DATE:**	12/15/2021
CLIENT:	ARCADIS	**REV. DATE:**	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	TOTAL
01	**MAINTENANCE OF PLANT OPERATIONS**					
	Bypass Pumping & Temporary Facilities Allowance	1	LS	5,000,000.00	5,000,000	
						$5,000,000
02	**INFLUENT SCREENS**					
	Site Work					
	Demolish Existing Screens	12	EA	25,000.00	300,000	
	Structural					
	Screen Channel Modifications	24	EA	25,000.00	600,000	
	Process Mechanical					
	(12)	1	LS	4,578,171.00	4,578,171	
	Contractor's Installation (12)	1	LS	457,817.10	457,817	
	Process Piping & Interconnection - 20% of Equipment Cost	1	LS	1,000,000.00	1,000,000	
	Upgrade Screen Management System	1	LS	100,000.00	100,000	
	Electrical - 15% of Total Cost	1	LS	700,000.00	700,000	
						$7,735,988

NASCO
CONSTRUCTION SERVICES INC.

SUBJECT: **BACKUP - ALTERNATIVE # 4 - IFAS**
PROJECT: NEWTOWN CREEK BNR OPTIONS
LOCATION: BROOKLYN, NEW YORK
TYPE EST.: CONCEPTUAL
CLIENT: ARCADIS

EST. NO: 21-0354
EST. BY: JF
CHKD. BY: EH
DATE: 12/15/2021
REV. DATE:

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	TOTAL
03	**AERATION BASIN**					
	Site Work					
	Demolish Existing Baffles (2 Per basin x 12 Basins)	24	EA	10,000.00	240,000	
	Demolish Existing Ceramic Diffusers	12	LOC	25,000.00	300,000	
	Structural					
	Baffle Walls w/ screens (8 per Basin x 12 Basins)	96	EA	40,000.00	3,840,000	
	Process Mechanical					
	IFAS Media -World Water Works Budget	1	LS	47,500,000.00	47,500,000	
	Contractor's Installation	1	LS	4,750,000.00	4,750,000	
	Mixers, 7.5hp	96	EA	100,000.00	9,600,000	
	Contractor's Installation	96	EA	15,000.00	1,440,000	
	Process Piping & Interconnection - 20% of Equipment Cost	1	LS	12,500,000.00	12,500,000	
	Electrical - 15% of Total Cost	1	LS	8,600,000.00	8,600,000	
						$88,770,000
04	**BLOWER ROOM**					
	Site Work					
	Demolish Existing 2000hp Blowers	6	EA	25,000.00	150,000	
	Process Mechanical					
	New Blowers, 4000hp	7	EA	1,225,000.00	8,575,000	
	Contractor's Installation	7	EA	122,500.00	857,500	
	Process Piping & Interconnection - 20% of Equipment Cost	1	LS	1,500,000.00	1,500,000	
	Electrical - 15% of Total Cost	1	LS	1,000,000.00	1,000,000	
						$12,082,500

Appendix F

Vendor Quotes

Submitted to: Mariana Tomazelli, Arcadis

Submitted by: Robby Bailey
Application Engineer

Date: November 29, 2021

This document is confidential and may contain proprietary information.
It is not to be disclosed to a third party without the written consent of Veolia Water Technologies.

Veolia Water Technologies, Inc. (dba Kruger)
4001 Weston Parkway
Cary, NC 27513
tel. +1 919-677-8310 • fax. +1 919-677-0082
www.veoliawatertech.com

Water Technologies

Dear Ms. Tomazelli:

Veolia Water Technologies, Inc (dba Kruger) appreciates the project opportunity and is pleased to present this budgetary proposal for our BIOSTYR® DUO System for your kind consideration for this important project.

The BIOSTYR DUO system is the most elegant wastewater treatment technology in the market that combines the smallest possible footprint, full automation and zero odor with the best aesthetics and cleanest working/living environment for the plant operators and surrounding community.

The BIOSTYR installations at Metropolitan Syracuse WWTP, New Rochelle WWTP and Binghamton-Johnson City Joint STP (DUO) are among the 150 worldwide installations that provide either secondary nitrification/denitrification or tertiary nitrification/denitrification treatment to these very large municipalities. We appreciate the fact that GHD was the designer of some of these elegant systems.

Based on the influent criteria and plant conditions that you have provided, we have proposed a BIOSTYR DUO system that provides the following unique benefits:

- Fully automated system to remove thousands of pounds of total nitrogen everyday.
    - Kruger is proposing a two stage system consisting of a BIOSTYR DUO for tertiary nitrification and conventional BIOSTYR for denitrification. The two systems are arranged to fit within the footprint requested. The system will treat 30 - 33 MGD depending on influent load and water temperature and produce an effluent TIN <= 3 mg/L. THis is equivalent to about 3,700 to 4,000 lbs of total nitrogen removed everyday. This removal number can potentially be higher if the influent TKN number is higher than the design value shown in Table 1 of this proposal. The design assumes the system is constantly loaded and not subjected to diurnal or wet weather flow variations. Supplemental carbon addition is assumed to be methanol.
- Achieves the effluent limits within an extremely compact footprint and enables the plant to solve the plant's tight space issue.
    - The BIOSTYR DUO system combines biological treatment with filtration in one step and completely eliminates the need of secondary clarifiers. Preliminary layout sketches have been provided in the proposal showing the total footprint of the proposed system.
- Provides a pleasant working/living environment for the operators and the surrounding residents/community with minimum odor from the system.
    - The BIOSTYR DUO treatment cells are completely enclosed and do not expose untreated wastewater to the atmosphere. This significantly minimizes the potential for odor issues. Most other technologies having open tank aeration

steps will have a potential odor issue, which can affect the residents and businesses close to the plant.

- Lower operation and maintenance costs.
  - The BIOSTYR DUO system is a biofiltration system that can be fully automated. It poses less demand on operating skills and requires less maintenance/monitoring than other activated sludge based technologies. Because it's a high rate system with an extremely compact footprint, it consumes less aeration energy than most other systems.

In addition to the project specific design information, we hope that you find the following extra information helpful and convincing in understanding the advantages and benefits of our design and system. We also hope that our successful track record, superior product quality, technical and financial capabilities and excellent customer service offer your team and the owner an extra measure of assurance in delivering a successful project.

PROVEN PERFORMANCE AND UNPARALLELED EXPERIENCE

BIOSTYR DUO systems are able to treat wide ranges of loads and flows for a variety of applications.

- Veolia's BIOSTYR DUO has been a proven and accepted solution for the removal of carbon and nitrogenous pollutants from wastewater for more than 30 years.
- The BIOSTYR DUO system can achieve effluent CBOD/TSS/NH_3-N/TIN limits of 10/10/1/2 mg/L, respectively, without subsequent clarification or filtration processes.
- There are more than 150 BIOSTYR DUO Biological Aerated Filter (BAF) installations all over the world, including 20 fully operational US facilities. US installations are designed to treat a collective peak flow of over 400 MGD.
- The BIOSTYR DUO is ideally suited for meeting stringent Nitrogen limits even in very cold climates (down to 5°C or less).

ENGINEERING EXPERTISE AND VERSATILE APPLICATIONS

All components and design approaches for the different BIOSTYR DUO configurations have been meticulously engineered based on our expertise and decades of experience to offer our clients a system that provides the most value to their specific application needs.

- Following primary clarification, the BIOSTYR DUO can provide secondary treatment with the removal of carbon, suspended solids, and ammonia accomplished in a single step, providing a compact solution.
- BIOSTYR DUO can also be used to expand an existing secondary treatment process to provide tertiary removal of ammonia while further polishing suspended solids and carbon.
- BIOSTYR DUO denitrification applications may be arranged in several configurations, with the most prominent being as a tertiary denitrification system (i.e. denitrification filter) following virtually any nitrifying secondary treatment process.

- For all process configurations and objectives, BIOSTYR DUO loading rates, media depth and diameter, nozzle deck loads, and all other key engineering factors have been fully and expertly optimized.

UNIQUE SYSTEM BENEFITS

The BIOSTYR DUO system offers the following major benefits:

- Smallest Possible Footprint: BIOSTYR DUO treatment is generally referred to as “high rate” application and with the elimination of secondary clarifiers and tertiary filters the flow capacity per unit area footprint is a fraction (20 to 30%) of that required for activated sludge processes.
- Higher Oxygen Transfer Efficiency: For secondary carbon and ammonia removal BIOSTYR DUO systems oxygen transfer efficiencies far exceed those achieved with fine bubble diffusers used in activated sludge systems.
- Reduced O&M Costs: Combining biological treatment and solids separation into a single step and having major maintenance-free components maximize reduction in O&M costs by eliminating separate unit operations and needs for system maintenance.
- Pleasant Working Environment: The BIOSTYR DUO’s compact design also allows for the process to be easily enclosed which will reduce waste odors emitted to the atmosphere, creating an environment that is pleasant for a neighborhood.

FULL AUTOMATION WITH MINIMAL MAINTENANCE

- No Media Replacement Needed throughout the lifetime of the system. BIOSTYR utilizes an inert, BIOSTYRENE material, retained in position by a physical barrier (the nozzle deck). The media does not degrade over time nor does it need any maintenance.
- Maintenance-Free Components. The air diffusers are stainless steel media bubble diffusers that do not need any maintenance during the lifetime of the system. Flow distribution piping and any other necessary in-basin components are also stainless steel and maintenance-free.
- The BIOSTYR DUO system is completely automated and individual treatment cells are periodically backwashed by gravity to remove the solids captured by filtration as well as the excess biomass.

SAVINGS AND VALUE

- Low Life Cycle Costs: BIOSTYR DUO systems offer exceptional savings on life cycle costs for facilities when compared to alternative technologies due to the key footprint and O&M benefits noted previously.
- Ability to Fit: The value presented by the BIOSTYR DUO system is contained in the ability to provide a complete treatment system with minimal footprint, low energy consumption and low operational requirements that can achieve effective, reliable treatment to today’s and the future’s most stringent nutrient limits across a wide range of flows and temperatures. Veolia’s knowledge and expertise in BAF technology add further

value and assurances that the BIOSTYR DUO system will provide years of exceptional performance for your treatment facility.

EXCELLENT DESIGN SUPPORT AND CUSTOMER SERVICE

- Veolia Cary NC office has a staff of over 100 people, including Project Management, Process Engineering, I&C Engineering, Mechanical Engineering and Field Service that are all located within the area of Cary, NC headquarters, providing a coordinated effort and single point of contact to Veolia's technical expertise for your team.
- This project has been assigned to a dedicated Process Manager and a team whose main function is to ensure proper process design, modeling and support for the Biosytr system. The team will continue to work closely with your team and the owner to go through the commissioning, startup and performance testing stages.
- This project will have a dedicated Project Manager whose main function is to ensure best communication, on-time equipment delivery, proper installation and startup of the system. Field service is a major component of project execution. Our field service personnel are thoroughly trained and have enormous experience in commissioning BIOSTYR DUO plants. It is crucial to tap into the team's experience and fully inspect the system components before, during and after the installation.

FINANCIAL BACKING AND PROCESS GUARANTEE

- By collaborating with Veolia, your team and the owner will have access to Veolia, the world's #1 ranked water company. Veolia is a $26B company with strong financial security. Veolia Water Technologies Inc, dba Kruger, is a leader in engineering and technical solutions in wastewater treatment.
- We are financially strong and capable of supporting this and any other project through design, construction, and completion. You can be rest assured that we will stand behind our system through the warranty period and beyond.
- We recommend bid and performance bonds and/or process guarantee bonds to protect the owner and your teams' interests.
- We can guarantee the performance of this system as we do for all of our other installations.

THANK YOU

The Veolia team provides the highest dependability and reliability with the best value: having more than 30 years of engineering and design experiences and more than 150 worldwide installations, being engineered as a complete system with superior quality and excellent performance, and being the beneficiary of decades of wisdom earned from the largest install base, Veolia's BIOSTYR DUO technology has earned the trust of numerous customers. We wish the information in this proposal offers your firm and the owner a unique technology option with an extra measure of assurance on this important project.

We appreciate the opportunity to provide this proposal to you and look forward to assisting you with any requests. If you have any questions or need further information, please contact our local Representative, Gregg Palmer of Koester Associates, or our Regional Sales Manager, Brad Mrdjenovich, at (919)-653-4531 (brad.mrdjenovich@veolia.com).

Respectfully,

cc: LL, KK, LW, PP, project file (Kruger)
Gregg Palmer (Koester Associates)

Version	Date	Process Eng.	Comments
0	10/25/2021	LGW	Initial, budgetary proposal.

Company Introduction

With 160 years of expertise in the areas of water, energy and waste, Veolia applies its capacity for innovation to pursuing human progress and wellbeing, and improving the performance of businesses and regions. To make the switch from a resource consumption rationale to a use-and-recover approach in today's circular economy, Veolia designs and implements solutions aimed at improving access to resources while at the same time protecting and renewing those same resources.

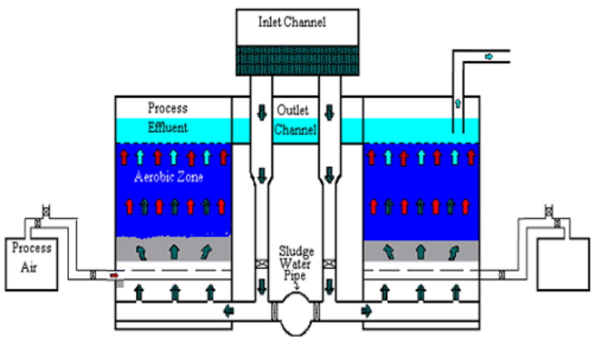
As the world's leading provider of environmental solutions to cities and businesses, we blend our skills in operations, engineering and technology with an unrivaled international network to offer a wide range of service delivery models to our clients. Whether we're reducing our customers' energy consumption to control costs or helping them meet strict water quality standards, we provide performance and reliability guarantees and measure our work by our customers' satisfaction.

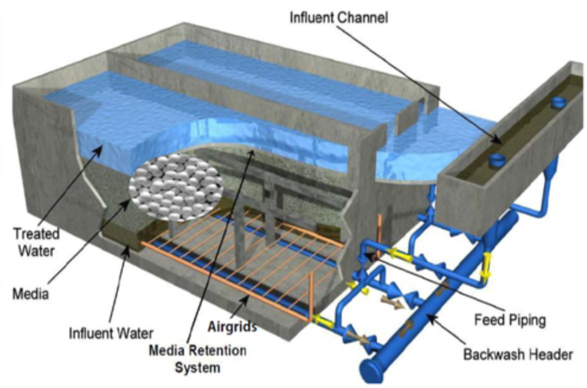
10 MGD Tahoe-Truckee SD BIOSTYR - Truckee, CA

We specialize in providing advanced and differentiating technologies that range from biological nutrient removal to mobile surface water treatment. The ACTIFLO® Microsand Ballasted Clarifier, BioCon® Biosolids Dryer, BIOSTYR®/BIOSTYR DUO™ Biological Aerated Filter (BAF) and Hydrotech Discfilter are just a few of our innovative technologies. Based on this expertise, we believe that we have developed the best solution for your application.

BIOSTYR Process Overview

The BIOSTYR DUO and BIOSTYR systems are up-flow submerged fixed-film processes that biologically treat carbonaceous and nitrogenous wastes (CBOD, NH_4-N, NO_3-N) and remove insoluble pollutants (TSS) through the filtering mechanism of the process. A distinguishing feature of these processes is the ability of the submerged media to provide for both biological treatment and filtration in a single step.





The above figure depicts the general flow path of water through a BIOSTYR or BIOSTYR DUO system. Influent wastewater is typically pumped to a common inlet feed channel above the BIOSTYR cells where it flows down to the individual cells by gravity, although direct pumping to the cells is also common. Within each BIOSTYR cell, the wastewater flow must be distributed evenly across the bottom of the cell, which is accomplished most commonly by a set of distribution troughs cast into the bottom of the cell. As wastewater enters a cell, water flows upwards through the filter media, which may vary in depth from 2.0 to 4.2 m depending on the media used and the application. Biological growth on the surface of the media provides treatment of the wastewater as it flows through the cells. Ceiling plates with regularly spaced nozzles are used to retain the filter media. The nozzles allow the treated water to enter a common water reservoir above the filters, which in turn is used to provide water during backwash sequences.

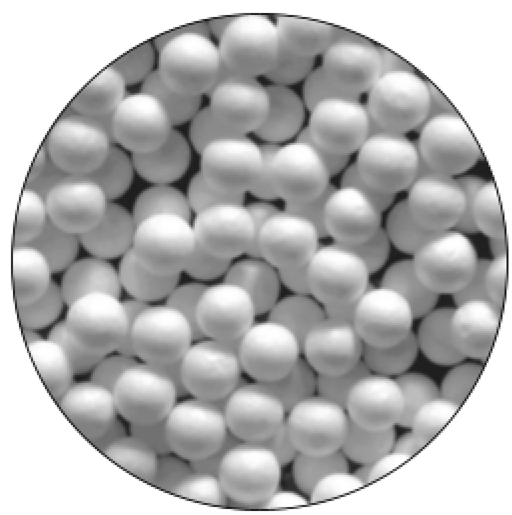
Interior of BIOSTYR Cell

The media contained in the cells is composed of specially manufactured high-density polystyrene beads (BIOSTYRENE) covered by active biomass.

In a system designed for nitrification only, a process air grid is placed below the filter media so that the entire filter bed is aerobic. BOD is oxidized by the biomass in the lower section of the filter. As the wastewater continues up the filter, additional BOD is consumed. When the BOD:TKN ratio falls below a certain limiting level, nitrification occurs, thereby converting the ammonia to nitrate.

Growth of biomass and the retention of suspended solids in the filter media make periodic backwashing necessary. The BIOSTYR DUO process is designed for a backwash interval of 24 hours or more. The backwash sequence is performed automatically and is triggered either when a preset time limit has expired or when the head loss across the filter exceeds a pre-determined setpoint. Water from the common treated water reservoir flows down through the filter by gravity, thereby expanding the media bed. The air grid located below the media is used to supply scouring air during the backwash sequence. This grid is composed of perforated stainless steel piping that allows air to be injected into the filters.

Like other filtration processes, high TSS and BOD concentrations in the influent waste stream can increase the rate of clogging. If the influent waste stream contains high levels of TSS or BOD, it is desirable to install clarification to partially treat the wastewater.



The BIOSTYR DUO process provides several significant improvements over other fixed film systems. First, using a floating media bed in conjunction with an up-flow system ensures that the nozzles used to retain the media are only in contact with treated water. This prevents the nozzles from clogging and provides easy access for nozzle maintenance or replacement.

Second, the counter-current backwashing sequence ensures efficient removal of accumulated solids. During backwashing sequences, the downward flow expands the filter media and utilizes gravity to aid in flushing solids from the bottom of the filter. Additionally, the backwash water is supplied from a common reservoir above the filter cells, eliminating the costs associated with backwash pumping. Finally, used backwash water is collected in drainpipes at the bottom of the filters. It is not exposed to the atmosphere, so the potential for odor problems is dramatically reduced.

Design Summary

The design assumes that the raw influent wastewater is biodegradable, no toxic compounds are present, sufficient alkalinity is available to avoid pH depressions, that the COD/BOD ratio is between 1.7 and 2.3, and that none of the equipment provided would be used in a classified area (e.g. Class 1, Division 1 or Class 1, Division 2) except for methanol feed equipment.

Tertiary BIOSTYR cells do not require dedicated influent screens. Kruger recommends the site have 10 mm fine screening, bar or mesh screens, which could occur upstream of the filters, for instance at the plant headworks. Kruger understands that influent will be fed to the BIOSTYR system by pumping.

The influent design basis is summarized in Table 1. The target effluent criteria for the BIOSTYR system are listed in Table 2. The process design is summarized in Table 3.

Table 1: Influent Design Basis - Secondary Effluent Values

Parameter	Units	Current
Design Flow[1], winter / summer	MGD	33 / 30
Flow, Peak Hourly	MGD	35
BOD_5, Max Month	mg/L	12
TSS, Max Month	mg/L	11
TKN, Max Month	mg/L	18
PO4P, Max Month	mg/L	⋝ 1.2
Elevation	ft	< 50
Temperature (Min/Max)	°C	15 / 28

1. Constant flow scalped from the main plant secondary effluent stream.

Table 2 : BIOSTYR DUO Effluent Concentrations- Monthly Average Basis

Parameter	Summer	Winter
BOD (mg/L)	≤ 20	
TIN (mg/L)	≤ 3.0	
TSS (mg/L)	≤ 20	

* Listed values represent anticipated performance; any performance guarantees may be different.
** External carbon dosing is required.

Table 3: BIOSTYR DUO Design Summary

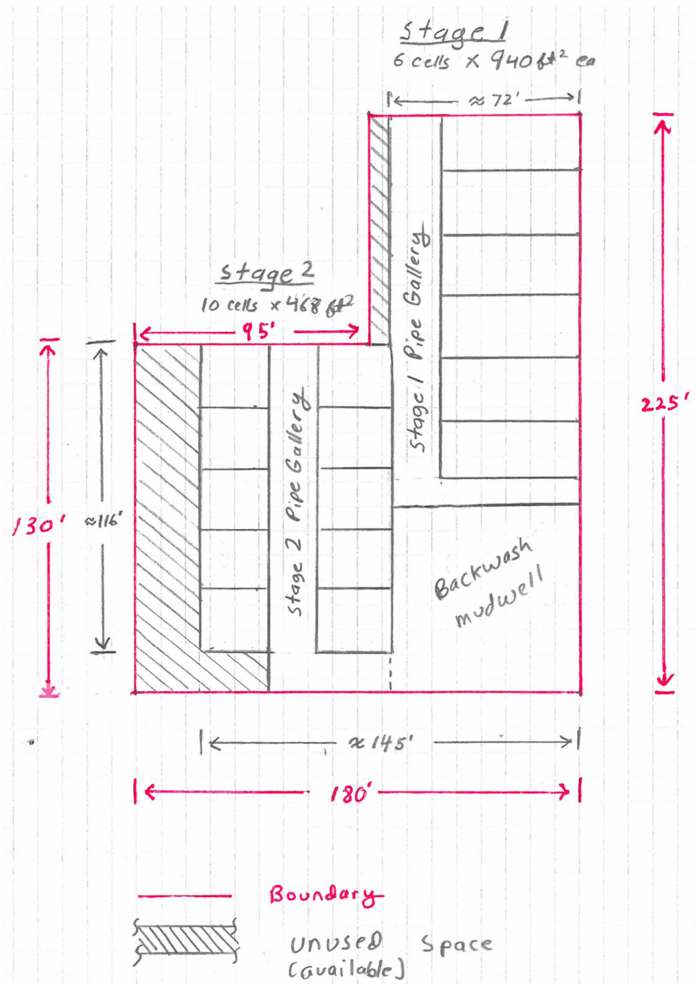
Parameter	Stage 1 BIOSTYR DUO	Stage 2 BIOSTYR
Number of Cells	6	10
Size of Cells (ft^2)	940	468
Size of BioStyrene Media (mm)	4	4.5
Height of Biostyrene Media (ft)	11.5	8.2
Height of AnoxK5 Media (ft)	2.5	NA
Total Media Volume (ft3), [Biostyrene and K5]	79,000	38,400
Filtration Velocity, Peak N-1 Cells in Filtration (gpm/ft^2) [1]	4.9	5.4
Filtration Velocity, annual average N Cells in Filtration (gpm/ft^2)[1]	3.7	4.2
Methanol Consumption (lbs/day)	NA	10,000
Filtration Air / Cell (SCFM) [2]	650	NA
Backwash Air / Cell (SCFM)	990	400
Backwash Wastewater Production (MGD)	1.2	0.72
Number of BW Tanks	1	
Backwash Tank Working Volume (gal)	350,000	
Daily Backwash Pumping Time (hrs/Day)[2]	18	
Backwash Pumping Rate (GPM)	1,800	

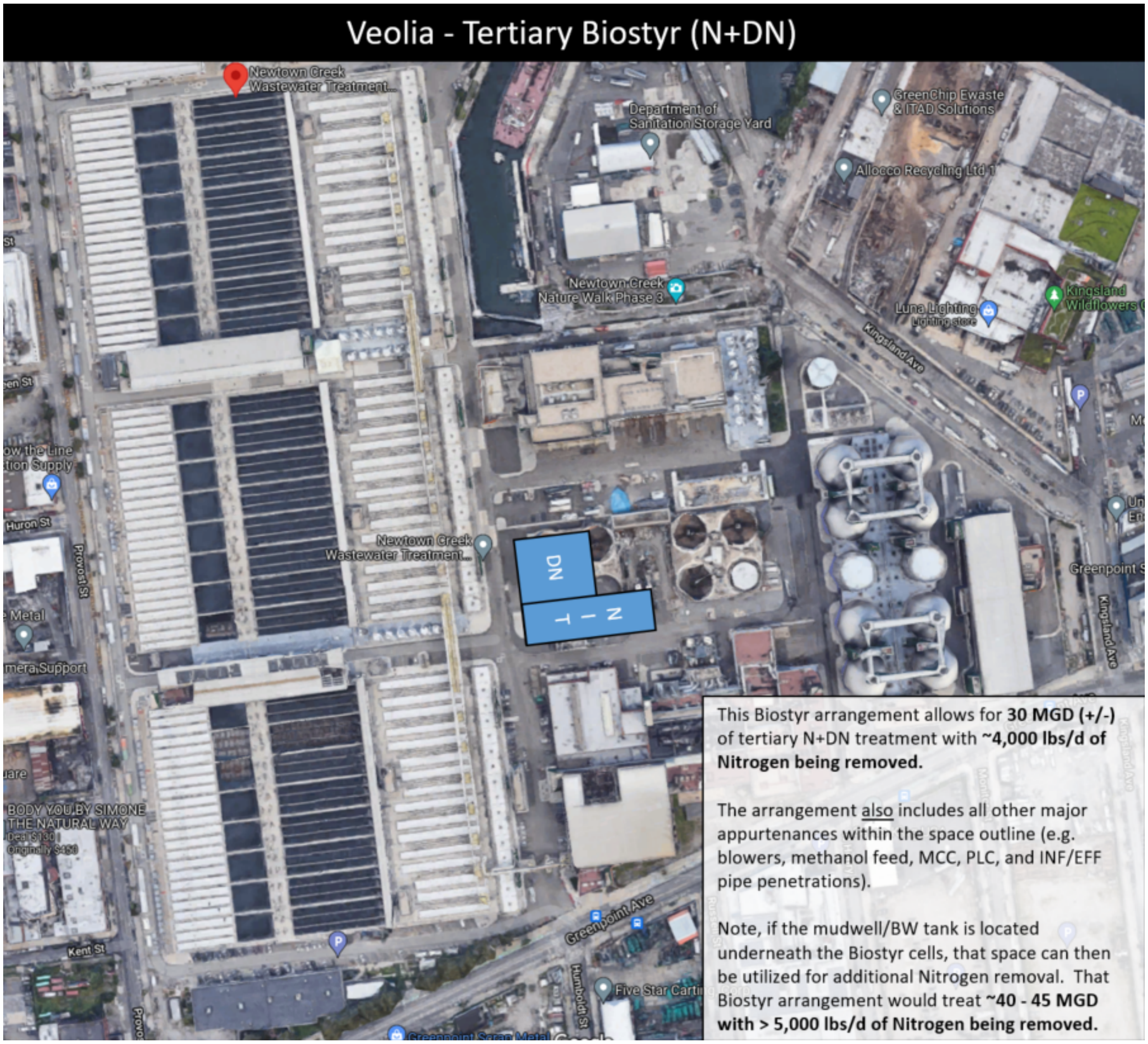
1. Treatment of backwash water must be conducted by a solids separation process elsewhere in the plant.
2. Based upon maximum month values.

Layout

The following is a preliminary schematic diagram showing the layout that fits within the available space and maximizes treated flow. The overall footprint may be adjusted to better accommodate site constraints if necessary. Below are a few alternatives

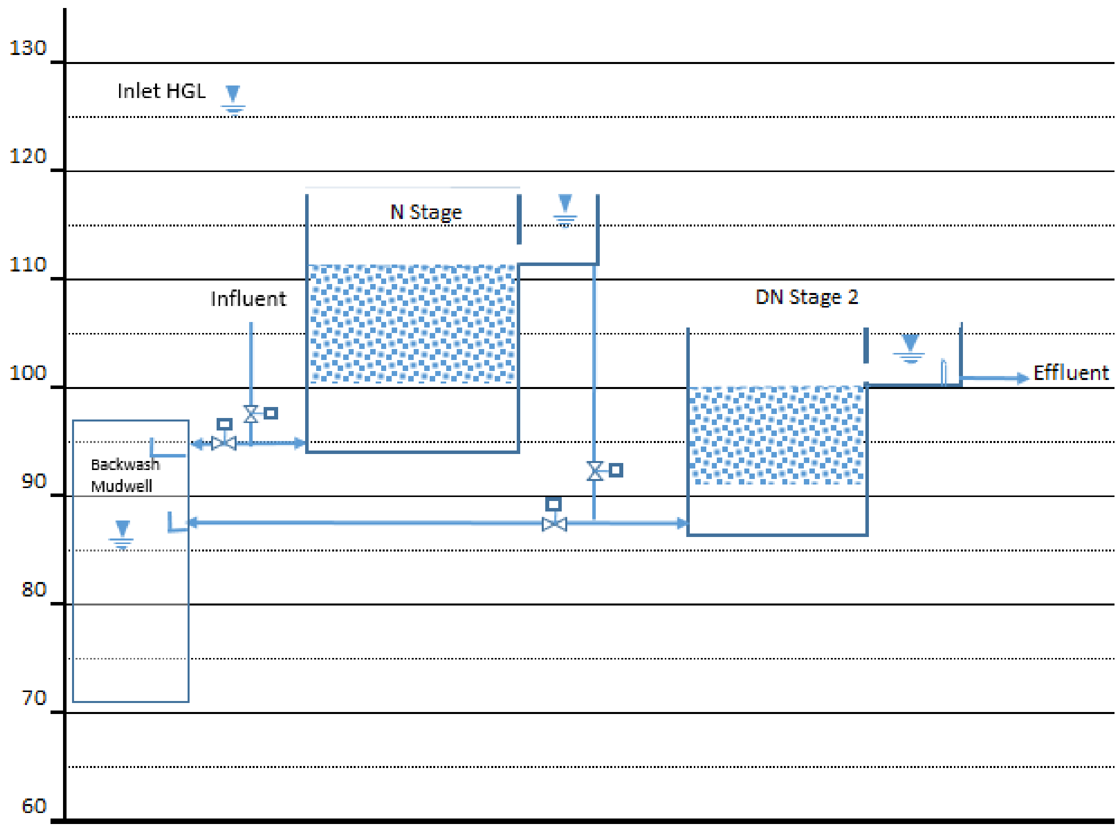
- Cells can be aligned in one row or multiple rows
- The quantity and size of cells can be adjusted as long as the same overall filter area remains the same. It is not recommended to have less than six cells.
- The cells may be separated into two or more batteries and located apart from each other if scatter spaces are to be utilized.
- The pipe gallery length and widths may be adjusted.
- **The backwash mudwell is built underground, or at grade, and sometimes even underneath the Biostyr cells to further reduce footprint.**
- **The space above the backwash tank is typically used for equipment and/or office space (i.e. blower station, chemical feed and/or storage, control room, and/or office space).**




Veolia - Tertiary Biostyr (N+DN)
Newtown Creek Wastewater Treatment...
Department of Sanitation Storage Yard
GreenChip Ewaste & ITAD Solutions
Allocco Recycling Ltd 1
Newtown Creek Nature Walk Phase 3
Luna Lighting
Kingsland Ave
Newtown Creek Wastewater Treatment...
DN
N I T
Greenpoint Ave
Five Star Carting
Huron St
Kent St
Provost St
Humboldt St
This Biostyr arrangement allows for **30 MGD (+/-)** of tertiary N+DN treatment with **~4,000 lbs/d of Nitrogen being removed.**
The arrangement also includes all other major appurtenances within the space outline (e.g. blowers, methanol feed, MCC, PLC, and INF/EFF pipe penetrations).
Note, if the mudwell/BW tank is located underneath the Biostyr cells, that space can then be utilized for additional Nitrogen removal. That Biostyr arrangement would treat **~40 - 45 MGD with > 5,000 lbs/d of Nitrogen being removed.**

Preliminary Hydraulic Profile

	Stage 1 inlet	Stage 1 Eff Channel	Stage 2 Eff Channel
Hydraulic Elevation (ft)	126.2	115.6	103.9



Scope of Supply

Kruger is pleased to present our scope of supply which includes process engineering design, equipment procurement, and field services required for the proposed treatment system, as related to the equipment specified. The work will be performed to Kruger's high standards under the direction of a Project Manager. All matters related to the design, installation, or performance of the system shall be communicated through the Kruger representative giving the Engineer and Owner ready access to Kruger's extensive capabilities.

Process and Design Engineering

Kruger can provide process engineering and design support for the system as follows:

- Design submittal for the Engineer's review and approval. Submittal included process sizing criteria, hydraulic profile, preliminary BIOSTYR DUO building layout, detailed cell layout, and details of cell internals.
- Shop drawing submittal for Engineer's review and approval. Includes detailed equipment information for all equipment supplied by Kruger.
- Equipment installation instructions for all equipment supplied by Kruger.

Field Services

Kruger will furnish a Service Engineer as specified at the time of start-up to inspect the installation of the completed system, place the system in initial operation, and to instruct operating personnel on the proper use of the equipment.

Extended Services

The Supplier shall include an extended service plan, featuring a blend of remote and on-site services, to support the Owner in the proper operation, maintenance and optimization of the process and equipment. The active service plan period shall be one (1) year and will start upon completion of Supplier's commissioning activities for the process. The plan shall include the following:

A. Two (2) trips to the project site consisting of two (2) days onsite for process and equipment (e.g. instruments/analyzers) inspections and follow-up training in process control and optimization

B. Remote quarterly review of operating data (Owner to provide data to Supplier) with issuance of summary report by a process engineer, noting key observations and recommendations

Twenty (20) hours of remote support conducted via phone and/or video conferencing for assistance in further optimization, troubleshooting, training or other needs of the Owner. The Supplier shall include the use of app-based augmented reality tools where such tools would be beneficial, such as FieldBit or equal, at no additional charge. Minimum of 1 hr charged per call.

VEOLIA

BIOSTYR System Equipment

Kruger will supply the following equipment:

Mechanical Equipment Items	Description
Nozzle Slabs	Precast reinforced concrete. For all BIOSTYR DUO and BIOSTYR cells.
Nozzle Slab Manways	Two (2) per cell.
Nozzles and Gaskets	For all BIOSTYR DUO and BIOSTYR cells.
Pipe Gallery Manways	One (1) per cell. Stainless steel.
Site Glasses	One (1) per cell. Stainless steel. Cast in concrete pipe gallery wall of cells.
Pressure Port Inserts	One (1) per cell.
Sample Ports	Three (3) ports per cell on two cells per battery. For profile sampling.
Process/Backwash Aeration Grids	One (1) per cell, including inlet header, purge header, lateral distribution lines, couplings, wall brackets, floor stand support structure, and wall inserts. Piping is stainless steel. Anchor bolts provided by Contractor.
BIOSTYR Media	Stage 1: 4 mm Biostyrene media at 11.5 ft depth and K5 media at 2.5 ft depth Stage 2: 4.5 mm BioStyrene media at 8.2 ft depth Installation of BioStyrene media is included.
Aeration Blower Station	Aeration blower station. VFDs by others. Process air and scour air during the backwash cycles
Aeration Grids	The aeration grid includes inlet header, purge header, lateral distribution lines, couplings, wall brackets, floor stand support structure, and wall inserts. Piping is 316 stainless. Anchor bolts provided by others.
Backwash Pipes or Channel Cover Plates	One (1) set per cell. Anchor bolts provided by Contractor.
Backwash Pumps	2 duty + 1 standby for the backwash tank. To transfer backwash water from the backwash mud wells to the primary treatment facility.
Automatic Process Valves	• 1x Feed valve / cell, modulating. • 2x Backwash valve / cell, open/close. • 1x Air supply / air grid, modulating. • 1x Air grid purge / cell, open/close. • 1x Backwash header flow valve / stage, modulating. All modulating valves have pneumatic actuators.
Effluent Gates	Two (2) manual effluent gates and frames for each BIOSTYR DUO and BIOSTYR cell.
Instrument Air System	To provide compressed air for pneumatic actuators. System includes a backup/duplex compressor, receiving tank, refrigerated air dryer, controller, regulator, and necessary filters.

I&C Equipment Items	Description
Submersible Pressure Transducers	In-Tank Liquid Level Measurement, Influent & Effluent Channels and Backwash Tanks.
Inline pH/ Temperature Probes	Two (2) total. Stage 1 Influent and Effluent
DO Probes (LDO)	Two (2) One (1) for Stage 1 Effluent and one for Stage 2 effluent
Thermal Mass Flowmeters	One (1) per cell
Magnetic Flowmeters	One (1) per cell
Ammonia Analyzers	One (1) for Stage 1 effluent
NO3N probes	Two (2): One for Stage 1 effluent and one for Stage 2 effluent.
In-Line Pressure Transmitters	One (1) per cell
PLC Control Cabinet	NEMA 12; ControlLogix PLC; Panelview HMI; 120V Feed.

Contractor's Scope of Supply

The contractor's scope of supply for the BIOSTYR system should include, but is not limited to, the following items:

- Concrete construction of the BIOSTYR cells, including assembly of the nozzle decks using the prefabricated, modular slabs.
- Aluminum slide gates in the BIOSTYR cell effluent channel.
- All piping, up to the walls of the BIOSTYR cells.
- Anchor bolts for all equipment installation.
- Installation of nozzles in the nozzle slabs.
- Installation of K5 media in the BIOSTYR
- Aluminum stop logs in the BIOSTYR influent channel.
- Feed pump station (*can be included in Kruger's scope upon request*).
- Mechanical structures such as handrails, stairways, and platforms.
- Chemical feed systems.
- All electrical and mechanical hardware with the exception of the equipment that is identified above.
- HVAC for the building pipe gallery, equipment rooms, and control room.

BIOSTYR system collectively includes both the Stage 1 BIOSTYR DUO system and the Stage 2 conventional BIOSTYR system.

Schedule

- Shop drawings will be submitted within 6-12 weeks of receipt of an executed contract by all parties.
- All equipment will be delivered within 18-30 weeks after receipt of written approval of the shop drawings.
- Installation manuals will be furnished upon delivery of equipment.
- Operation and Maintenance Manuals will be submitted within 90 days after receipt of approved shop drawings.

Pricing

The price for the BIOSTYR/DUO system, as defined herein, including process and design engineering, field services, and equipment supply is

$TBD

Vendor did not authorize official proposal with pricing to be included in this report.

Please note that the above pricing is expressly contingent upon the items in this proposal and are subject to Kruger Standard Terms of Sale detailed herein.

This pricing is FOB shipping point, with freight allowed to the job site. This pricing does not include any sales or use taxes. In addition, price is valid for 60 days from the date of this Proposal and is subject to negotiation of a mutually acceptable contract. The proposed goods may be affected by the ongoing market fluctuations impacting material and shipping costs. Kruger reserves the right to re-evaluate the Proposal price prior to order acceptance.

Terms of Payment

The terms of payment are as follows:

- 10% on receipt of fully executed contract
- 15% on submittal of shop drawings
- 75% on the delivery of equipment to the site

Payment shall not be contingent upon receipt of funds by the Contractor from the Owner. There shall be no retention in payments due to Kruger. All other terms per our Standard Terms of Sale are attached.

All payment terms are net 30 days from the date of invoice. Final payment not to exceed 120 days from delivery of equipment.

Veolia's scope of supply includes equipment and related site services as provided herein. To the extent engineering services are required for Veolia's scope of work, they will be performed by a properly licensed entity in the State of New York.

Statement Regarding Competitive Transparency

Veolia takes all issues surrounding probity and confidentiality very seriously in all of its dealings with competitors and stakeholders. In this spirit and for the sake of transparency, we inform you that the publicly traded parent company Veolia Environnement S.A., recently acquired a 29.9% interest in Suez S.A ("Suez") and launched a public bid for the remainder of Suez' share capital. Consistent with our commitment to competition law compliance, Veolia will continue to act entirely independent of Suez until all relevant antitrust approvals of Veolia's acquisition of Suez have been obtained and we will of course let you know if this would change before the end of the tender proceedings.

Specifically, none of Veolia's representatives sit on the board of Suez, Veolia has no influence over the strategy or operations of Suez, and Veolia has no access to competitively sensitive information about Suez's operations. Accordingly, Veolia's ongoing project to acquire Suez will have no effect on our participation in, or response to, this tender.

Kruger Standard Terms of Sale

1. Applicable Terms. These terms govern the purchase and sale of the equipment and related services, if any (collectively, "Equipment"), referred to in Seller's purchase order, quotation, proposal or acknowledgment, as the case may be ("Seller's Documentation"). Whether these terms are included in an offer or an acceptance by Seller, such offer or acceptance is conditioned on Buyer's assent to these terms. Seller rejects all additional or different terms in any of Buyer's forms or documents.

2. Payment. Buyer shall pay Seller the full purchase price as set forth in Seller's Documentation. Unless Seller's Documentation provides otherwise, freight, storage, insurance and all taxes, duties or other governmental charges relating to the Equipment shall be paid by Buyer. If Seller is required to pay any such charges, Buyer shall immediately reimburse Seller. All payments are due within 30 days after receipt of invoice. Buyer shall be charged the lower of 1 ½% interest per month or the maximum legal rate on all amounts not received by the due date and shall pay all of Seller's reasonable costs (including attorneys' fees) of collecting amounts due but unpaid. All orders are subject to credit approval.

3. Delivery. Delivery of the Equipment shall be in material compliance with the schedule in Seller's Documentation. Unless Seller's Documentation provides otherwise, Delivery terms are F.O.B. Seller's facility.

4. Ownership of Materials. All devices, designs (including drawings, plans and specifications), estimates, prices, notes, electronic data and other documents or information prepared or disclosed by Seller, and all related intellectual property rights, shall remain Seller's property. Seller grants Buyer a non-exclusive, non-transferable license to use any such material solely for Buyer's use of the Equipment. Buyer shall not disclose any such material to third parties without Seller's prior written consent.

5. Changes. Seller shall not implement any changes in the scope of work described in Seller's Documentation unless Buyer and Seller agree in writing to the details of the change and any resulting price, schedule or other contractual modifications. This includes any changes necessitated by a change in applicable law occurring after the effective date of any contract including these terms.

6. Warranty. Subject to the following sentence, Seller warrants to Buyer that the Equipment shall materially conform to the description in Seller's Documentation and shall be free from defects in material and workmanship. The foregoing warranty shall not apply to any Equipment that is specified or otherwise demanded by Buyer and is not manufactured or selected by Seller, as to which (i) Seller hereby assigns to Buyer, to the extent assignable, any warranties made to Seller and (ii) Seller shall have no other liability to Buyer under warranty, tort or any other legal theory. If Buyer gives Seller prompt written notice of breach of this warranty within 18 months from delivery or 1 year from beneficial use, whichever occurs first (the "Warranty Period"), Seller shall, at its sole option and as Buyer's sole remedy, repair or replace the subject parts or refund the purchase price therefore. If Seller determines that any claimed breach is not, in fact, covered by this warranty, Buyer shall pay Seller its then customary charges for any repair or replacement made by Seller. Seller's warranty is conditioned on Buyer's (a) operating and maintaining the Equipment in accordance with Seller's instructions, (b) not making any unauthorized repairs or alterations, and (c) not being in default of any payment obligation to Seller. Seller's warranty does not cover damage caused by chemical action or abrasive material, misuse or improper installation (unless installed by Seller). THE WARRANTIES SET FORTH IN THIS SECTION ARE SELLER'S SOLE AND EXCLUSIVE WARRANTIES AND ARE SUBJECT TO SECTION 10 BELOW. SELLER MAKES NO OTHER WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR PURPOSE.

7. Indemnity. Seller shall indemnify, defend and hold Buyer harmless from any claim, cause of action or liability incurred by Buyer as a result of third party claims for personal injury, death or damage to tangible property, to the extent caused by Seller's negligence. Seller shall have the sole authority to direct the defense of and settle any indemnified claim. Seller's indemnification is conditioned on Buyer (a) promptly, within the Warranty Period, notifying Seller of any claim, and (b) providing reasonable cooperation in the defense of any claim.

8. Force Majeure. Neither Seller nor Buyer shall have any liability for any breach (except for breach of payment obligations) caused by extreme weather or other act of God, strike or other labor shortage or disturbance, fire, accident, war or civil disturbance, delay of carriers, failure of normal sources of supply, act of government or any other cause beyond such party's reasonable control.

9. Cancellation. If Buyer cancels or suspends its order for any reason other than Seller's breach, Buyer shall promptly pay Seller for work performed prior to cancellation or suspension and any other direct costs incurred by Seller as a result of such cancellation or suspension.

10. LIMITATION OF LIABILITY. NOTWITHSTANDING ANYTHING ELSE TO THE CONTRARY, SELLER SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL, SPECIAL, PUNITIVE OR OTHER INDIRECT DAMAGES, AND SELLER'S TOTAL LIABILITY ARISING AT ANY TIME FROM THE SALE OR USE OF THE EQUIPMENT SHALL NOT EXCEED THE PURCHASE PRICE PAID FOR THE EQUIPMENT. THESE LIMITATIONS APPLY WHETHER THE LIABILITY IS BASED ON CONTRACT, TORT, STRICT LIABILITY OR ANY OTHER THEORY.

11. Miscellaneous. If these terms are issued in connection with a government contract, they shall be deemed to include those federal acquisition regulations that are required by law to be included. These terms, together with any quotation, purchase order or acknowledgement issued or signed by the Seller, comprise the complete and exclusive statement of the agreement between the parties (the "Agreement") and supersede any terms contained in Buyer's documents, unless separately signed by Seller. No part of the Agreement may be changed or cancelled except by a written document signed by Seller and Buyer. No course of dealing or performance, usage of trade or failure to enforce any term shall be used to modify the Agreement. If any of these terms is unenforceable, such term shall be limited only to the extent necessary to make it enforceable, and all other terms shall remain in full force and effect. Buyer may not assign or permit any other transfer of the Agreement without Seller's prior written consent. The Agreement shall be governed by the laws of the State of North Carolina without regard to its conflict of laws provisions.

VEOLIA

BIOSTYR® Biologically Active Filter (BAF)
BIOSTYR® DUO BAF + MBBR

WATER TECHNOLOGIES

BIOSTYR® Combines Biological Treatment and Upflow Filtration for High Quality Effluent

The BIOSTYR® process combines biological treatment, clarification, and filtration into one compact system. With over 150 installations throughout the world in operation for over 25 years, BIOSTYR is proven to be an exceptional technology for meeting today's stringent effluent limits. BIOSTYR's compact footprint makes it an ideal process solution for new plants, upgrades or existing plants.

The BIOSTYR® Process

The BIOSTYR process is a biological aerated filter (BAF) with a submerged media bed. Wastewater flows upward through the media bed. Air is injected through an air grid located below the bed at the bottom of the cell and rises upward concurrently with the wastewater.

The BIOSTYR media, BIOSTYRENE™, are buoyant polystyrene beads that provide the surface area for biomass attachment. The BIOSTYRENE media is retained in the BIOSTYR cell by a pre-cast concrete nozzle deck located above the media. The nozzle deck contains nozzle-type strainers that allow water and air to pass through the cell.

The BIOSTYR backwash is a counter-current flow. The backwash water (system effluent) is stored above the media, so no separate clearwell is necessary. Backwashing is accomplished by a series of valve operations that are controlled by the PLC. Gravity assists in removing stored solids as the media bed expands during backwash; thus, BIOSTYR does not require dedicated pumps, piping, valves, blowers or controls for backwashing.

BIOSYTR® DUO

Ground-Breaking Fusion of BAF + MBBR

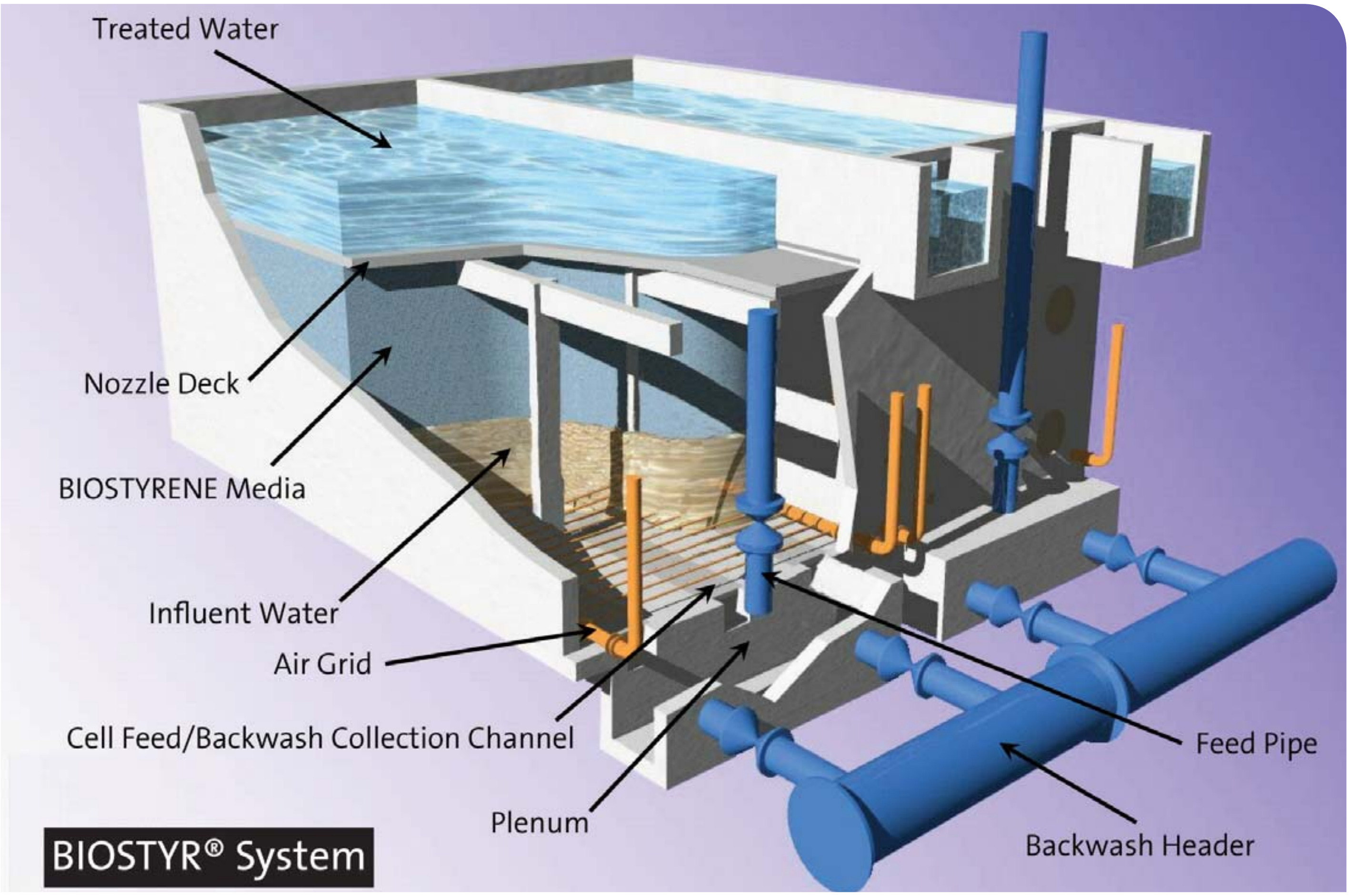
BIOSTYR® DUO adds a second media layer for increased carbon, solids and nitrogen loading capabilities. The added layer of AnoxKaldnes™ media functions as a Moving Bed Biofilm Reactor (MBBR) within the lower portion of the BIOSTYR, providing impressive results:

- Up to 100% increase in BOD loading compared to traditional BAF
- Up to 40% increase in NH_3–N loading compared to traditional BAF
- Negligible impact to system headloss for DUO media layer

Treated effluent at top of cells

Empty cell

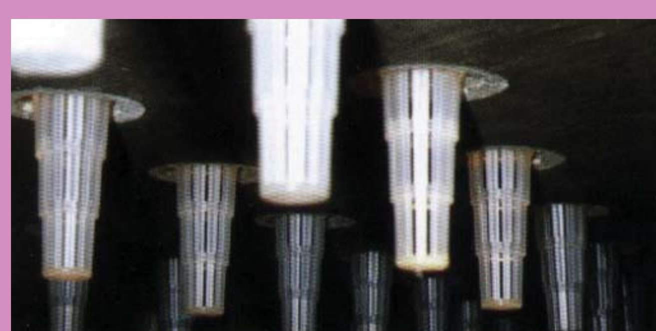
Dual media in BIOSTYR® DUO



Engineered to Provide Value

- Multiple, parallel filter cells, allowing for flexible operational strategies and efficient treatment of variable flows
- Low weight BIOSTYRENE media (~3 lbs/ft³) minimizes foundation and other construction costs such as piles.
- Nozzle-type strainers in the precast concrete nozzle slabs only contact clean, treated effluent; not susceptible to fouling
- Robust stainless steel aeration grid resists clogging, requiring no routine maintenance
- Gravity backwash effectively cleans media with no pumping energy needed
- Fully automated PLC-based control system and centralized SCADA system, easing operation

Precast Media Retention Slabs for Nozzle Deck



Nozzles for Media Retention

Applications

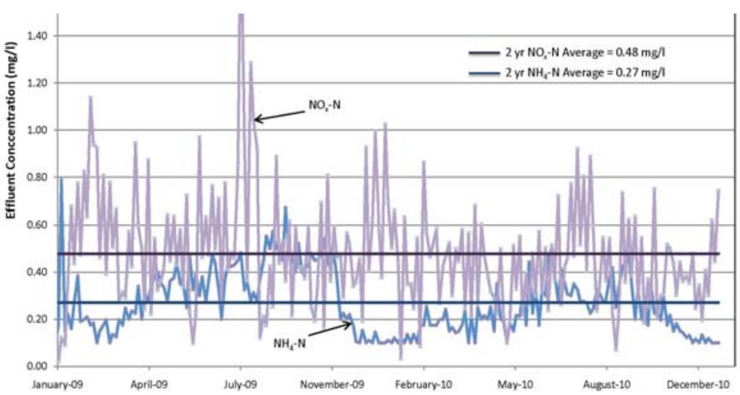
Kaukana, WI

Secondary Treatment

For facilities requiring increased capacity, particularly where primary clarification is already used and where a small footprint can provide significant value, the BIOSTYR DUO system can be used to provide complete secondary treatment. Carbon (BOD), ammonia (NH_3) and suspended solids (TSS) removal are all achieved with a single process that can realize average capacities of over 100 MGD per acre of treatment system area, compared to 5-10 MGD per acre for conventional activated sludge technologies.

Nitrification

BIOSTYR is the optimal approach to expand an existing secondary treatment process to provide tertiary removal of NH_3 with further polishing of TSS and BOD. The system is often identified as the best available technology to add nitrification to existing high purity oxygen systems and other processes that remove only BOD. BIOSTYR is a very efficent method to accomplish nitrification for reuse water production for power plants and other facilities.



Nitrogen removal at Tahoe-Truckee S.A.

Tahoe-Truckee, CA

Denitrification

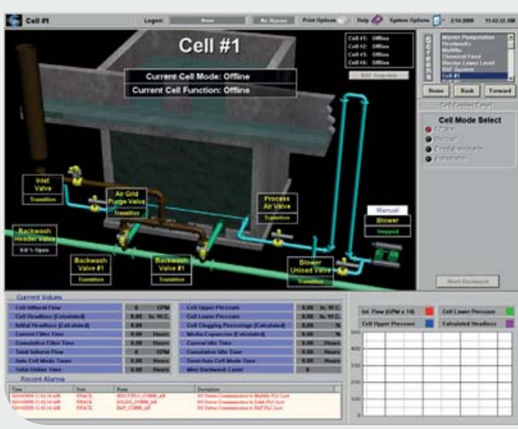
The BIOSTYR system can also meet the needs of facilities requiring denitrification. When added to the end of existing treatment systems, including any activated sludge plant or BIOSTYR system for secondary treatment, BIOSTYR provides all of the functions of traditional denitrification filters at a fraction of the footprint. It can also be coupled with secondary BIOSTYR systems as a Pre-Denitrification reactor to minimize the need for supplemental carbon.

Cheshire, CT

BIOSTYR® & BIOSTYR® DUO: Compact, Efficient, Operator-Friendly Processes

- Footprint allows for reduced civil works, total system enclosures, and site flexibility
- Downstream clarifiers not necessary, significantly decreasing operation and maintenance requirements
- High quality effluent does not depend on solids settleability
- Treated water of exceptional quality, even in very cold climates
- Compact footprint; savings on excavation, space requirements
- Replenishment or replacement of media is not required as media is not lost or degraded
- Cell depth, which provides increased hydrostatic pressure and opportunities for air bubbles to contact media, leads to extremely efficient oxygen transfer and minimal aeration power requirements.

Process Control Features



SCADA screen shot

- SCADA system customized for each particular application
- Automatic flow and load-based process controls
- Process diagnostic tools and data trending
- Automated cell headloss monitoring and backwash routines
- 24-hour alarm monitoring and notification
- KrugerLink™ remote process monitoring and control
- System-certified integrators

BIOSTYR® Improves Health of the Long Island Sound

Biological Treatment | Case Study

Westchester County, NY

The Client

The New Rochelle Wastewater Treatment Plant is located in the Westchester County, New York, discharging to the Long Island Sound. It serves a population base of 65,000 people and is permitted to treat average flows of up to 20.6 MGD. Operating with primary clarification and pure oxygen-based activated sludge treatment since a 1979 upgrade, the plant only removed BOD and TSS from the wastewater.

The Benefits

- Guaranteed compliance with TN limits
- Minimal footprint
- Integrates well with existing treatment system
- Odor free treatment

The Client's Needs

It has long been known that nitrogen discharges into the Long Island Sound are a key factor in its water quality. New SPDES limits issued in 2005 and a negotiated Order-of-Consent would require an upgrade to the New Rochelle WWTP to remove nitrogen from its discharge. On average, the mass-based nitrogen requirement would require the facility to meet a TN discharge of 4.0 mg/L or less. In addition, tighter restrictions on CBOD and TSS would be included in the new permit. Land availability in New York is scarce, so the solution needed to fit on the existing site. Dozens of technologies were evaluated to determine the preferred solution, including pilot scale testing. At the conclusion of the evaluation phase, Veolia's BIOSTYR® Biologically Active Filter (BAF) technology was selected as the preferred alternative due to its compact footprint and proven reliability removing nitrogen.

The Solution

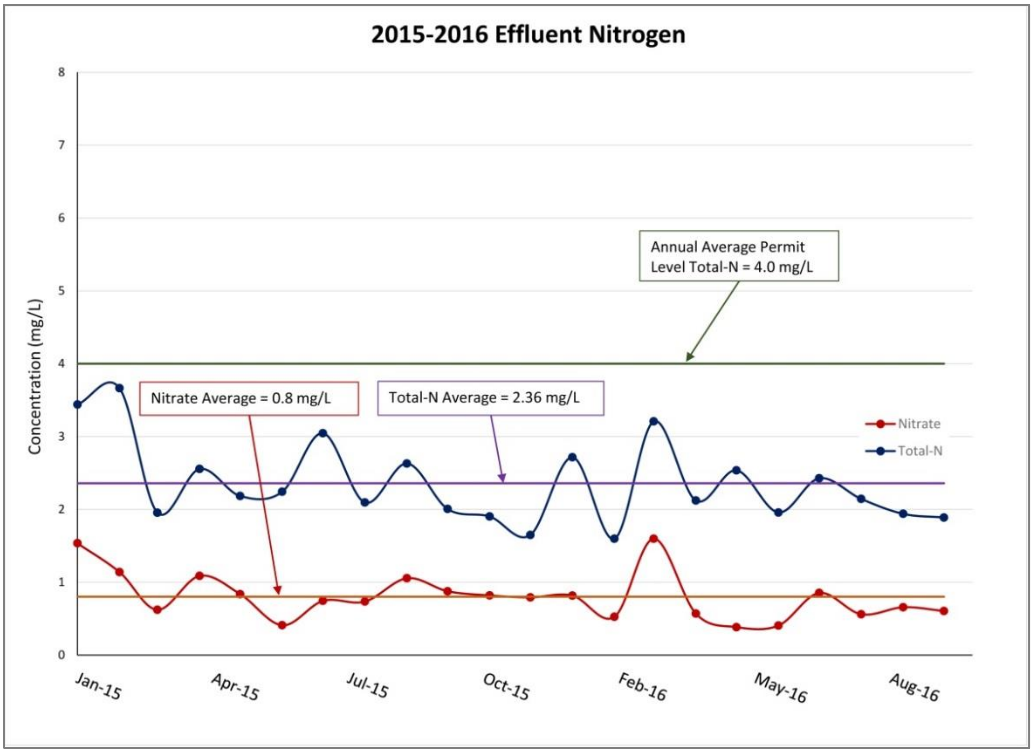
BIOSTYR® is a high-rate biological system for treating wastewater that offers full treatment capabilities for BOD, TN and TSS removal in a single process; in 10% of the footprint of other technologies. The system utilizes multiple treatment cells operating in parallel to biologically treat and simultaneously filter the wastewater, producing an effluent free of contaminants and solids. Biological growth occurs on a fixed bed of innovative BIOSTYRENE® media, which is contained within each cell and not exposed to the atmosphere. Flow enters at the bottom of each cell and clean effluent collects at the top of each cell. This makes for a very clean and odor-free installation that fits well into facilities with nearby communities such as urban, densely populated areas.

Process Description

To meet the new SPDES permit requirements of this facility, Veolia designed a BIOSTYR® system containing 2 distinct stages of operation. The first stage is fully aerobic and targets complete nitrification to convert incoming ammonia into nitrate. This stage consists of 12 parallel cells, each with a footprint of 940 ft^2. The second stage is anoxic in the lower portion of the BIOSTYRENE® biological filter bed to target denitrification of the incoming nitrates. Methanol is fed to the influent of this stage to serve as a carbon source for the microorganisms as the influent to this stage contains very little BOD. To protect against increased BOD levels in the effluent due to unused methanol, the second stage cells include an aeration grid within the filter media to allow fully aerobic operation of only the upper-most layer of media. The system was designed to meet future flow needs of up to 31 MGD average and 61.5 MGD peak with guaranteed effluent nitrogen performance. In addition to the BIOSTYR® system, Veolia provided an upgrade to the existing pure-oxygen activated sludge system. This upgrade to the OASES® pure oxygen system included new oxygen supply control equipment, new instrumentation for monitoring oxygen levels, and new aerator/mixer equipment. This system provides improved CBOD removal and more stable influent to the BIOSTYR® process.

Results

The New Rochelle WWTP has been operational since late 2014 and has been a tremendous success, reducing the plant TN discharge from 2,000 lb/day in 2014 to 200 lb/day in 2015. Summer and winter performance tests were completed in 2015 to fully demonstrate the system's capabilities, and exceptional nitrogen removal has continued throughout 2016. Thus, the BIOSTYR® system is allowing Westchester County to improve the health of the Long Island Sound.



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www.veoliawatertech.com

The Power of Bundling: BIOSTYR® + ACTIFLO®

Biological Treatment / Clarification | Case Study

Onondaga County, NY

The Client

The Metropolitan Syracuse Wastewater Treatment Plant (Metro) provides wastewater treatment for approximately 270,000 residents of the City of Syracuse and surrounding communities. The plant is designed to treat an average monthly flow of 84 million gallons per day (MGD), with a peak flow of 126 MGD and a hydraulic capacity of 240 MGD.

The Benefits

- Highly efficient tertiary ammonia removal below 1.0 mg/L in smallest of footprints
- Extremely low TSS effluent
- Consistently produces effluent phosphorus levels below 0.08 mg/L

The Client's Needs

In 1998, Onondaga County signed an Amended Consent Judgment with the State of New York to significantly increase the level of treatment at its Metropolitan Syracuse Wastewater Treatment Plant (Metro). Since then, the addition of North America's largest biological aerated filter system (BIOSTYR®) and the largest tertiary ballasted settling system (ACTIFLO®) in the U.S. has allowed the Metro plant to consistently meet very low effluent ammonia and phosphorus limits. The bundling of Kruger's BIOSTYR and ACTIFLO processes into a combined solution has played a key role in the markedly improved water quality conditions in Onondaga Lake.

The Metro plant is next to Onondaga Lake, and the length of pilings (275-feet) required for construction dictated that the new facilities be as small in size as possible. The Kruger technologies selected for the Metro plant have the smallest footprints of any commercially available alternative and, through extensive competitive trials, were shown to provide the lowest operational costs possible for the high level of post-secondary treatment required.

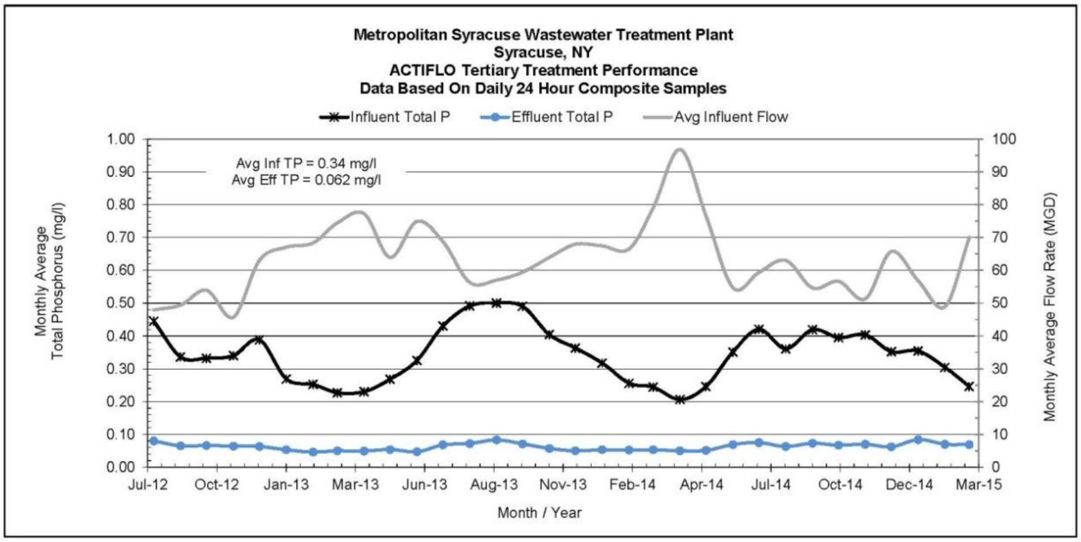
BIOSTYR® Solution

The BIOSTYR® process combines a very high density fixed film biological treatment system with filtration, minimizing reactor volume and eliminating the need for final clarifiers. Each of the plant's 18 BIOSTYR cells holds 11.5 ft of polystyrene beads held in place by a combination of concrete decking and nozzles. The beads provide a surface area for nitrifying bacteria to grow, and the bacteria converts ammonia to nitrate. Jim Jones, the Head Operator at the Metro plant, states, "The BIOSTYR (BAF) system has consistently reduced our effluent ammonia levels well below permitted levels for years with minimal operations and maintenance effort. The system is highly efficient year round, even during winter months when average effluent temperatures descend to 9 degrees C or less."

ACTIFLO® Solution

The Metro plant's ACTIFLO® ballasted flocculation and clarification system has been in service since 2006 and is used to comply with an effluent total phosphorus limit of 0.1 mg/l based on a 12 month rolling average. The treatment plant personnel operate the ACTIFLO system in a manner that produces an effluent total phosphorus level of 0.08 mg/l or less (see graph below). Jim confirms, "The ACTIFLO system packs a great deal of punch in a very small footprint. We monitor our chemical feed rates and sand concentrations on a daily basis which allows us to achieve total phosphorus results below design and permit levels. The ACTIFLO system performs exceptionally at the upper end of design hydraulic and phosphorous loadings which are often approached at this facility." The system consists of four treatment trains, each rated at 31.5 MGD and uses microsand as a ballast to greatly increase the settling velocity of the flocculated material. The process employs typical coagulation chemistry along with a polymer to flocculate material and adhere it to the microsand. The system provides a short hydraulic retention time (< 15 minutes) and high clarifier rise rates (32 gpm/sf).

The Metro plant experiences high storm flows during the spring snow melt season and during rain events throughout the summer and fall. With an average daily flow around 60 MGD, these high flows can reach 126 MGD in a very short period of time. While most treatment plants may see peak flows two or three times a year, the Metro plant can see them two or three times a month. Since the ballast material for the ACTIFLO system is always inventoried in the process tanks, a treatment train that is off-line can be brought into service quickly as the increasing flow rates require. This ability to quickly start and stop treatment trains is critical to consistently meeting a low phosphorus limit.



Results

Onondaga Lake, once considered to be the most polluted lake in the United States, has seen a steady increase in health since the Metro Syracuse plant upgrades were completed in 2006. Ammonia discharges from the plant have been reduced by up to 95% compared to pre-upgrade levels, and phosphorus by over 85%. The plant is no longer responsible for contributing a majority of all nitrogen and phosphorus discharges into the lake, as it once was, and the bundling of BIOSTYR and ACTIFLO in a combined solution has contributed significantly to the resurgence of aquatic species and drastic improvement in the overall health of the lake.

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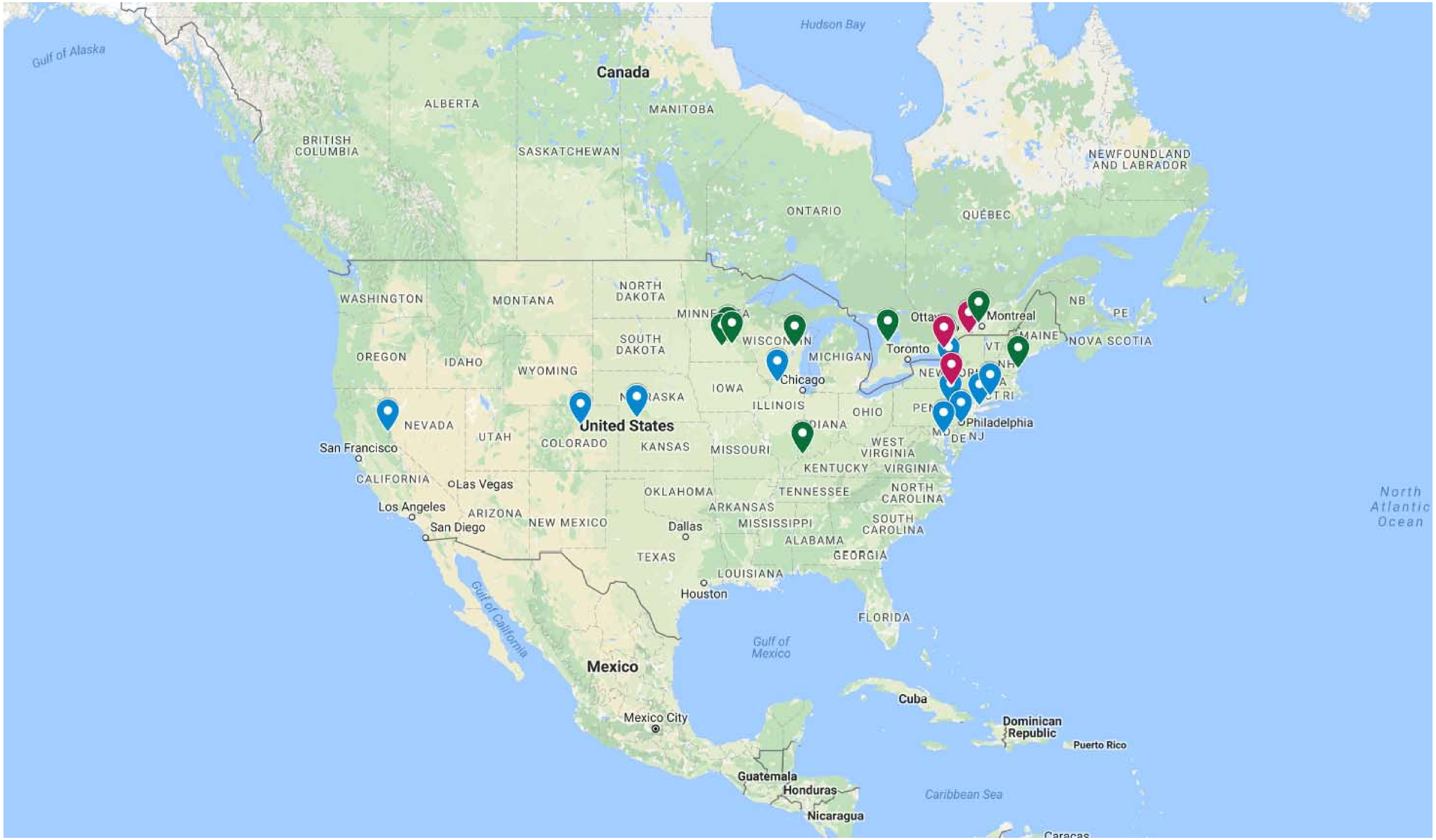
KRÜGER

BIOSTYR® Biologically Active Filter
Full-Scale US Installations



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VEOLIA

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Corporate Description

Company Overview

Veolia Water Technologies, Inc. (dba Kruger) is a water and wastewater solutions provider specializing in advanced and differentiating technologies. Kruger provides complete processes and systems ranging from biological nutrient removal to mobile surface water treatment. The AnoxKaldness Hybas and MBBR processes, ANITA Mox Deammonification Process, BioCon Dryer, BIOSTYR Biological Aerated Filter (BAF), NEOSEP MBR and HYDROTECH Discfilters are just a few of the innovative technologies offered by Kruger. Kruger is a subsidiary of Veolia Water Technologies, a world leader in engineering and technological solutions in water treatment for industrial companies and municipal authorities.

Veolia, present throughout the world, develops a global approach responding to specific needs of customers at each of their production facilities. This has allowed Veolia to become the world leader in design, project management and execution of projects for water and wastewater treatment plants. The company also creates dedicated technology solutions to meet its customer's needs. Its unique portfolio of differentiating technologies, developed by the group's R&D centers, ensures unsurpassed innovation and control of each treatment line for public organizations and industries. Furthermore, a whole range of associated services is offered on each site to guarantee the technical efficiency and life expectancy of the installed solutions. Veolia continually extends and enriches its offer, to guarantee expertise and competence at every step of the projects it undertakes.

Kruger prides itself for being a customer-focused organization that provides solutions to challenges faced by municipalities and not just another equipment supplier. To achieve this, Kruger has gathered a force of process experts, trained sales staff, and project managers that share our vision and priorities. Please see the attached information describing the experience and expertise of Our People. We are proud of our staff and know that they are the most qualified team in the market to provide your project the right solution to meet the plant's needs and future goals.

Location and Addresses of Corporate and Regional Offices

Kruger's corporate office is located in the Raleigh, NC area.

Kruger	Customer Support Center
4001 Weston Parkway	1500 Garner Road, Suite C
Cary, NC 27513	Raleigh, NC 27610

In addition, Veolia hosts multiple regional offices across North America in support of our clients, including the Customer Support Center (i.e. aftermarket services and equipment spare parts), within 20 minutes from Veolia's corporate office. See the Summary of Support Services section below for more details.

Date and State of Incorporation

Veolia celebrates 160 years of service to cities, regions and local communities. Established in 1853, Veolia's long history proves our stability and financial strength. Veolia Water Technologies, Inc. (dba Kruger) was incorporated on May 27, 2004 and is incorporated in Delaware. Kruger further builds on Veolia's expertise, offering more than 30 years of experience servicing the US municipal market.

Bonding Qualifications

Veolia Water Technologies, Inc. (dba Kruger) has sufficient financial stability and backing to provide the performance bond as required by the specifications. Kruger can provide a pre-qualification letter for proof of ability to provide such a bond as requested within the specifications upon request.

Corporate and Financial Stability

The Veolia companies in North America, including Veolia Water Technologies, Inc. dba Kruger (Kruger), are part of Veolia Environnement, S.A. (Veolia). Veolia traces its history to the establishment of Compagnie Générale des Eaux (CGE) on December 14, 1853. Since that time and over 160 years, Veolia has continued to focus on new frontiers of environmental business and its traditional markets, in emerging and developed countries. In support of this progress and in line with our commitments, Veolia has strengthened its operating and financial performance.

Veolia is the global leader in optimized resource management. With nearly 171,000 employees worldwide, Veolia designs and provides water, waste and energy management solutions that contribute to the sustainable development of communities and industries. Through its three complementary business activities, Veolia helps to develop access to resources, preserve available resources and replenish them.

In 2018, the Veolia group supplied 95 million people with drinking water and 63 million people with wastewater service, produced nearly 56 million megawatt hours of energy and converted 49 million metric tons of waste into new materials and energy. Veolia Environnement, operating in five continents, realized $30.1 billion (€25.91 billion) in revenue for 2018.

Kruger, as part of the Veolia family of companies, provides financial strength and stability to our customers. Veolia offers the support structure desired by municipal authorities, assuring project stakeholders of Kruger's commitment to meeting performance guarantees, extended project schedules and ongoing warranties. Veolia has been in business for over 160 years, providing the comfort to our customers that Kruger will remain supportive for the life of the project and beyond.

Veolia's 2018 financial statement is available online. Please see the following website for more information.

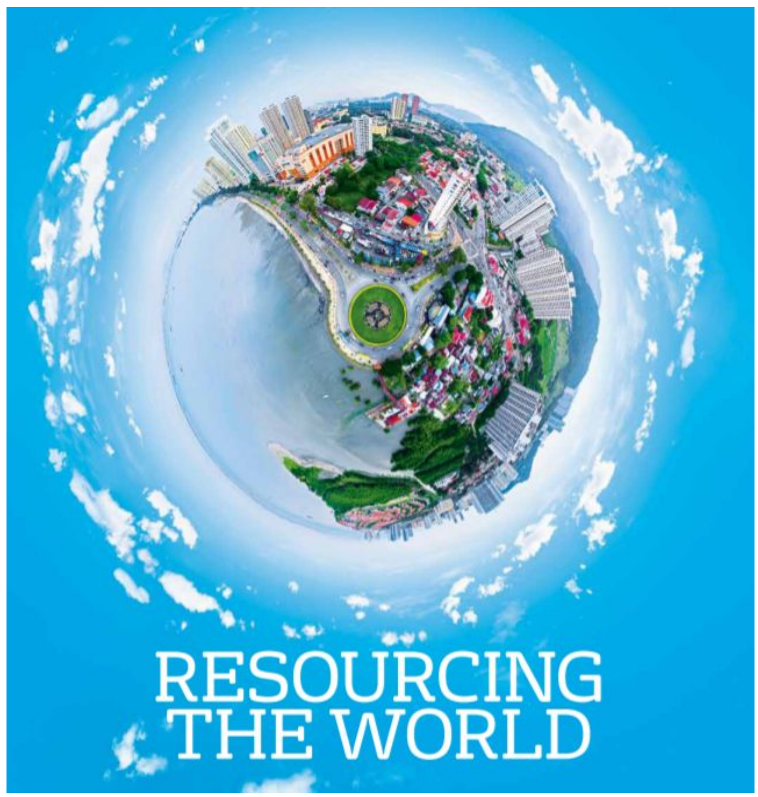
https://www.veolia.com/en/veolia-group/finance

Corporate Sustainability

Veolia's 'Resourcing the world' mission is based on a vision of our environment that is shared by our employees, including those at Kruger: the world as it should be. In this world, fewer resources are wasted and they are shared fairly; waste has a value and uses are found for wastewater; and energy is efficiently managed and reused. In this world, companies as well as government bodies play a central role in anticipating and supporting major global transitions. In this world, companies voluntarily ask themselves what is their purpose and their use. This vision both drives and commits us. Our goal is not only to be the world leader but also the standard setter for environmental businesses: *the company that resolves, prepares the ground and invents, inspires and shows the way.*

Resourcing the World

The world has to rethink its relationship with resources and come up with new social and economic growth models that are more efficient, better balanced and more sustainable.



With 160 years of expertise in the areas of water, energy and waste, Veolia applies its capacity for innovation to pursue human progress and wellbeing, and improving the performance of businesses and regions.

To make the switch from a resource consumption rationale to a use-and-recover approach in today's circular economy, Veolia designs and implements solutions aimed at improving access to resources while at the same time protecting and renewing those same resources.

This is how Veolia and its employees contribute each and every day to resourcing the world.

https://www.livingcircular.veolia.com/en

2 November 2021

Mariana Costa Tomazelli
Project Water Engineer
Arcadis U.S., Inc.
27-01 Queens Plaza North, Suite 800
Long Island City, NY 11101

Subject: Newtown Creek WPCP, NY, NY
DE NORA TETRA® ColOX™ Reactors and Denite® Filters
De Nora Proposal P-113017

Dear Ms. Costa Tomazelli:

De Nora Water Technologies, LLC (De Nora) is pleased to offer this preliminary proposal for the supply of equipment, materials and services for a ColOX and Denite system addition to the Newtown Creek WPCP in NY, NY. Our proposal is based on the criteria listed in our Design Calculation sheets attached. With these criteria we sized for six (6) 11'-8" x 100' ColOX Reactors followed by six (6) 11'-8" x 100'-0" Denite filters.

The process calculation sheets attached will provide additional information regarding hydraulic loading and backwash frequency at the various process conditions. Also attached is a typical general arrangement drawing, G301, showing the plan of the area given and how the system fits.

Our Scope of supply for the filters will be;

3 Backwash Air Blowers
Positive displacement type, two operating and one stand-by

7 Process Air Blowers (for ColOX Reactors)
Positive displacement type, one operating per reactor and one stand-by

2 Backwash Water Pumps
Submersible pumps. Operated by a VSD supplied by MCC vendor.

2 Mudwell Pumps
Submersible pumps

12 lots Reactor/Filter Internals
This includes sump cover plates, air headers and laterals, underdrain block (SNAP T®), gravel, TETRA #5 media, and stainless steel weir plate. ColOX Reactors will have 3' gravel and 10' media and Denite Filters will have 18" gravel and 8' media.

1 lot Manual Valves
These will be the check valves and isolation valves for backwash pumps, backwash blowers and mudwell pumps. Also, isolation valves for each filter control valve.

12 lots Filter Control Valves
Electric actuated AWWA butterfly valves for open/close service, modulating service and blower unloading.

1 lot Reactor/Filter Instruments
Backwash and Process Air pressure switches, backwash water flow meter, radar level elements for filters, clearwell and mudwell, and low level cut-off switches for clearwell and mudwell.

1 DE NORA TETRA® TETRAPace® Nitrate Analyzer and Sample Pumps
TETRAPace® will optimize the usage of methanol and minimize operator attention to the Denite® process, both contributing operating cost savings to the Owner.

1 Methanol Feed System
This will include skid mounted metering pumps, double contained storage tanks and accessories and filter system influent flow meter.

1 Main Control Panel
NEMA 12 enclosure with Allen-Bradley HMI and PLC

1 lot Field Service
Supervision for underdrain installation, control system start-up and operator training

The following items are not included in the De Nora package

- Receiving, unloading, storing and installation of De Nora supplied equipment.
- Concrete for filter vessels, building/architectural work and engineering thereof
- Grout after air/water distribution block placement in vessels
- Platform, walkways or stairways
- Anchor bolts for mechanical equipment
- Lubricants for mechanical equipment and motors
- Interconnecting piping and engineering thereof
- Electrical starters, motor control center, conduit and wire and engineering thereof
- Performance testing lab services
- Spare parts
- Methanol supply

De Nora will deliver the equipment, materials and service described above for a rough-order-of-magnitude lump sum (present day), including freight, and a Process Performance Warranty for $9,500,000.

Thank you for considering De Nora Water Technologies, LLC

Chris Hubbard
Regional Sales Manager- Northeast
Water Technologies Business
Mobile: 267-517-1844
E-Mail: chris.hubbard@denora.com

Attachments:

1. Notable Experience list – Denite® Projects
2. Process Spreadsheets
    a. ColOX Process Design Calculations
    b. Denite Process Design Calculations
3. Drawings:
    G301 General Arrangement – Filters, Clearwell and Mudwell
    G302 Section of Colox
4. DeepBed Denitrification TETRA® Denite® Brochure

NOTABLE EXPERIENCE LIST
FOR WWTP DENITE® PROJECTS

Plant Designation	City	Country	Description	Underdrain Type	Area (ft2)	Average Daily Flow (MGD)	Year
Shaoxing WWTP	Shaoxing	China	(40) 13'-6" X 80' Denite Filters	Snap T	43,227	105.7	2019
Back River WWTP	Baltimore	USA	(52) 11'-8" x 100'-0" Denite Filters	Snap T	60,663	188.0	2017
Zhongbai WWTP	Minsk	Belarus	(4) 9'-6" x 40'-0" Denite Filters	Snap T	1,520	3.5	2016
Northport WWTP Upgrades Phase II	Northport	USA	(3) 7'-7" x 9'-4" Denite Filters	Snap T	212	0.3	2014
Sanqiang WWTP	Xianghe	China	(4) 9'-6" x 40'-0" Denite Filters	Snap T	1,520		2011
T.P. Smith WRF	Tallahassee	USA	(10) 9'-6" x 72' Denite Filters	Snap T	6,840	26.5	2009
Cumberland WWTP	Cumberland	USA	(8) 11'-8" x 90' Denite Filters	Snap T	8,402	15.0	2009
York River Treatment Plant	Hampton Roads	USA	(9) 11'-8" x 100' Denite Filters	T Block	10,503	25.4	2008
Littleton-Englewood WWTP	Littleton-Englewood	USA	(8) 11'-8" x 96'-0" Denite Filters, TetraFlex	T Block	8,963	21.2	2008
Bundamba AWTP	Bundamba	Australia	(4) 9'-6" x 48' Denite Filters	T Block	1,368	2.7	2007
Franklin	Franklin	USA	(5) 11'-8" x 77'-0" Denite Filters	T Block	4,493	12.0	2002
South Cross Bayou AWRF	Pinellas County	USA	(12) 9'-8" x 85'-0" Denite Filters	T Block	9,863	33.0	2000
Scotts Valley	Scotts Valley	USA	(2) 9'-6" x 14' Denite Filters	T Block	266	1.0	1999
City Of Richmond	Richmond	USA	(18) Dual Cell Denite Filters, Each Cell 5' x 75'	Snap T	6,750	50.0	1990
City of Dunedin	Pinellas County	USA	(4) 10' x 50' Denite Filters	8" M Block	2,000	6.0	1989

COLOX™ DESIGN CALCULATIONS
2-Nov-2021

DE NORA

Project Name:	Newtown Creek WWTP
DNWT SF #:	P-113017
Client Engr.:	
Plant Loc.:	Brooklyn, NY
DNWT Engr.:	PAM
Comments:	ColOX-Denite System Requirements
Rev 0 (02Nov2021):	Change to 1 Process Blower per ColOX
Rev 0 (27Oct2021):	Influent: COD=72, BOD=11.3, NH4=15.3, TKN=17.4 (Org-N=2.1), TSS=10.7, PO4-P=1.27, NO3-N=0.3
	Effluent (Assumed): NH4=1, TSS=5, NO3-N=1
	How much flow can be treated in given space of 130'x180' & 85'x95'
	Given Pumped to ColOX at a constant rate for partial treatment. Full Plant Flow > 200 MGD
	Assumed sufficient Alkalinity in WW to achieve effluent requirements.

I. DESIGN BASIS

A. Pollutant Removal Capacities @ 20 deg C (prior to temp. corrections):

NH_4-N removal rate, British unit	=	50	lbs N/1000 cu.ft.-day
NH_4-N removal rate, SI units	=	0.80	kg/m^3-d
CBOD removal rate, British unit	=	125	lbs CBOD/1000 cu.ft.-day
CBOD removal rate, SI units	=	2.00	kg/m^3-d

B. General Design Parameters

		British units		SI units	
Recycle ratio	=	0.0	recycle:raw		
Sump flush at start of BW	=	2.0	minutes		
BW water duration during o'flov	=	18.7	minutes, 1.5 bed volumes		
BW water duration, final rinse	=	5.0	minutes		
Backwash water rate	=	6.0	gpm/ft^2	14.7	m/h
BW air rate (combined system)	=	5.0	icfm/ft^2	91.5	m/h
Reactor width	=	11.67	ft	3.56	m
Reactor length	=	100	ft	30.49	m
Reactor surface area	=	1167.0	ft^2	108.5	m^2
Media depth (not incl. gravel)	=	10.0	ft	3.0	m
Media specific surface area	=	250.0	ft^2/ft^3	820.0	m^2/m^3
Max. specific solids loading	=	0.10	lbs/ft^3	1.60	kg/m^3
Biomass yield from CBOD,T	=	0.80	lb. biomass/lb. CBOD ox.		
Biomass yield from NH_4-N	=	0.13	lb. biomass/lb. NH_4-N ox.		
Solids yield from TSS	=	1.0	lb. solids/lb. TSS removed		

Oxygen demand for total CBOD	=	1.2	lb. O_2/lb. CBOD removed
Oxygen demand for NH_4-N	=	4.6	lb. O_2/lb. N oxidized
Oxygen Transfer Efficiency	=	15.0	% OTE
N assimilation in biomass	=	5.0	%
P assimilation in biomass	=	1.0	%

Estimated power cost	=	$0.10	/kWh		
BW blower & pump, est. TDH	=	15.0	psig	103.4	kPa
Process blower, est. TDH	=	12.0	psig	82.7	kPa
Feed pump, est TDH	=	20.0	psig	137.9	kPa
Mudwell & recycle pump, est.	=	15.0	psig	103.4	kPa

C. Flow

		British units		SI units	
		(MGD)	(gpm)	(m^3/d)	(m^3/hr)
Average Flow	=	24.0	16,667	90,850	3,785
Peak Flow	=	24.0	16,667	90,850	3,785
Design	=	24.0	16,667	90,850	3,785

D. Influent Characteristics

Parameter		Summer	Winter	
CBOD total, mg/L	=	11.3	11.3	Given A vg
TKN, mg/L	=	17.4	17.4	Given Avg Org-N: 2.1
Ammonium as N, mg/L	=	15.3	15.3	Given Avg
TSS, mg/L	=	10.7	40.0	Given Avg / Max
pH, SU	=	6.3-7.3	6.3-7.3	NPDES Range
Total Alkalinity, mg/L $CaCO_3$	=	200	200	Assumed
Phosphate as P, mg/L	=	1.27	1.27	Given Avg (NPDES 0.4-1.7)
Min. temperature, deg.C	=	28	15.0	Given Min.

E. Desired Effluent Characteristics

Parameter		Summer	Winter
CBOD total, mg/L	=	10.0	10.0
Ammonium as N, mg/L	=	1.0	1.0
TSS, mg/L	=	10.0	10.0
pH, SU	=	6-9	6-9

III. EQUIPMENT LIST for ROM-type ESTIMATE

Final equip. selection to be made by Mechanical Dept. after design is finalized.
HP and psig values are est. operating conditions - to be finalized after piping drwgs.

Qty	Description							
6	ColOX™ reactors @	1,167.0	ft2		11.67	ft. x	100	ft.
		108.5	m^2		3.56	m. x	30.48	m.
1 lot	6 x 9 media @	3,501	tons,	10.0	ft.			
		3,176,054	kg,	3.0	m			
1 lot	gravel @	1,050	tons,	3.0	ft.			
		952,816	kg,	0.9	m			
~~1 **~~	~~Mudwell basin @~~	~~215,942~~	~~gallons~~					
~~1 **~~	~~Clearwell basin @~~	~~215,942~~	~~gallons~~					
~~2 **~~	~~BW water pumps @~~	~~7,002~~	~~gpm @~~	~~15~~	~~psig,~~	~~105.6~~	~~HP~~	
	~~(1 op / 1 stndby)~~	~~1,592~~	~~m^3/h @~~	~~103.42~~	~~kPa,~~	~~78.8~~	~~kW~~	
~~2 **~~	~~Mudwell pumps @~~	~~1,500~~	~~gpm @~~	~~15~~	~~psig,~~	~~22.6~~	~~HP~~	
	~~(1 op / 1 stndby)~~	~~341~~	~~m^3/h @~~	~~103.42~~	~~kPa,~~	~~16.9~~	~~kW~~	
~~3 **~~	~~BW air blowers @~~	~~2,506~~	~~icfm @~~	~~15~~	~~psig,~~	~~391.3~~	~~HP~~	
	~~(2 op / 1 stndby)~~	~~4,262~~	~~m^3/h @~~	~~103.42~~	~~kPa,~~	~~291.9~~	~~kW~~	
7	Process blowers @	822	icfm @	15	psig,	53.6	HP	
	(1 standby)	1,399	m^3/h @	103.42	kPa,	40.0	kW	
~~0~~	~~P Nutrient pump @~~	~~0~~	~~ml/min =~~		~~0.00~~	~~gph~~		
~~0~~	~~N Nutrient pump @~~	~~0~~	~~ml/min =~~		~~0.00~~	~~gph~~		
~~0~~	~~Alkali feed pump~~	~~0~~	~~gph~~					
~~0~~	~~Alkali day tank~~	~~0~~	~~gallons~~					
~~1 **~~	~~Control System~~							
1	Influent Inclined Screen System - down to 5-6 mm							
1	Influent Flow Meter							
6	Sets Control Valves (Inlet, Outlet, BW Air, BW Water, Flush, BW Waste)							

** Common equipment with Denite

REVISION TRACKER

Project Name: **Newtown Creek WWTP**
Filter Type: **ColOX**
Location: **Brooklyn, NY**
Sales Force #: **P-113017**

Revision	Date	Changes
Rev 0	27-Oct-2021	First Issue ColOX/Denite
Rev 1	2-Nov-2021	Change to 1 Process Blower per ColOX

DENITE® DESIGN CALCULATIONS
27-Oct-2021

Project Name:	Newtown Creek WWTP
DNWT SF #:	P-113017
Client:	
Plant Location:	Brooklyn, NY
DNWT Engineer:	PAM
Comments:	ColOX-Denite System Requirements
Rev 0 (27Oct2021):	Influent: COD=72, BOD=11.3, NH4=15.3, TKN=17.4 (Org-N=2.1), TSS=10.7, PO4-P=1.27, NO3-N=0.3
	Effluent (Assumed): NH4=1, TSS=5, NO3-N=1
	How much flow can be treated in given space of 130'x180' & 85'x95'
	Given Pumped to ColOX at a constant rate for partial treatment. Full Plant Flow > 200 MGD
	Assumed sufficient Alkalinity in WW to achieve effluent requirements.

I. DESIGN BASIS

A. General Design Parameters

Media depth	=	8.0	ft of 2-3 mm	2.44 m
Media void volume factor	=	0.4		
Media specific surface area	=	200	ft^2/ft^3	656 m^2/m^3
Reactor width	=	11.67	ft	3.56 m
Reactor length	=	100.00	ft	30.49 m
Reactor surface area	=	1,167	ft^2, 11'-8" W x 100'-0" L	
Type of supplemental carbon		MeOH		
Feed strength of supplemental C	=	100%		
Specific Gravity of supplemental C	=	0.790		
Supplemental C cost	=	$1.80	per gallon	
Supplemental C storage	=	15,000	gallons, 30-45 day storage	
COD/(NOx-N +DO) published ratio	=	4.7	lb COD/lb NOx-N & DO removed, published	
COD/NOx-N calculated ratio suppl. C	=	3.7	lb COD/lb NOx-N removed, not including DO	
COD/DO ratio for supplemental C	=	1.3	lb COD/lb DO removed	
COD content of supplemental C	=	1.50	lb COD/lb supplemental carbon	
Yield	=	0.39	lb COD biomass/lb COD oxidized	
Net Yield	=	0.28	lb VSS biomass/lb COD oxidized	
COD content of biomass VSS	=	1.42	lb COD/lb VSS	
Alkalinity generation	=	3.57	mg/L alk. as CaCO3/ mg/L N reduced	
Biomass yield temperature coefficient	=	1.00		
Decay factor for infl. TSS removed	=	0.95	lb. solids/lb. infl. TSS removed	
Decay factor for biomass generated	=	0.90	lb. solids/lb. bio VSS generated	
S.G. of dry biosolids	=	1.40		
Effective MLSS assumed	=	20,000	mg/L average	
BW initial draindown duration estimate	=	8	minutes	
BW air scour duration	=	2	minutes	
BW water rise time to trough estimate	=	4	minutes	
Initial BW water rate	=	6	gpm/ft^2	
Initial BW water duration with overflow	=	20	minutes, 2 bed volumes	
Final BW water rinse rate	=	6	gpm/ft^2	
Final BW water rinse duration	=	5	minutes	

A. General Design Parameters (con't)

Final BW draindown duration estimate	=	5	minutes		
Est. valve operating time during a BW	=	6	minutes (assuming electric actuators)		
Bump duration per filter	=	2	minutes		
BW air rate @ std. atm pressure	=	6	icfm/ft^2		
Altitude above sea level	=	0	ft	0	m
Max. spec. solids loading btw. BWs	=	1.33	lb/ft^2		
Max. spec. NO_X-N loading btw. Bumps	=	0.07	lb/ft^2		
P nutrient requirement	=	1.5%	of biomass		
Power cost	=	$0.11	per kWh	¥0.70	RMB/kWh
Nitrate analyzer power draw	=	6	amps		
Nitrate analyzer voltage	=	120	VAC		
Number of analyzer sample pumps	=	2	pumps		
Sample pump flow to analyzer	=	15	gpm	ft TDH	kPa
Sample pump head	=	15.2	psig	35.0	104.4
Carbon feed pump head	=	90.0	psig	207.9	620.1
BW pump head	=	15.2	psig	35.0	104.4
BW pump efficiency	=	70%			
BW pump motor efficiency	=	90%			
BW blower head	=	11.5	psig	26.6	79.2
Mudwell pump head	=	15.2	psig	35.0	104.4
Mudwell pump efficiency	=	70%			
Mudwell pump motor efficiency	=	90%			
Number of filter trains	=	1	train(s) with dedicated BW blowers/pumps		
Number of filter trains sharing MW	=	1	train(s) sharing Mudwell		
Number of filter trains sharing CW	=	1	train(s) sharing Clearwell		
Number of possible simultaneous BWs	=	0	simultaneous system BWs assuming 1/train		

B. Flow

		Summer	Winter		
ADF,	MGD =	24.00	24.00	90,850	m3/d
	gpm =	16,667	16,667	3,785	m3/h
Pk-Hour,	MGD =	24.00	24.00	3,785	m3/h
	gpm =	16,667	16,667	PF =	1.0

C. Hydraulic Criteria

Filtr. Rate @ ADF w/all in service	=	3.0	gpm/ft^2
Filtr. Rate @ ADF w/1 in backwash	=	6.0	gpm/ft^2
Filtr. Rate @ Pk-hr w/1 in backwash	=	6.0	gpm/ft^2

D. Influent Characteristics

Parameter		Summer	Winter	
NOx-N, mg/L @ ADF	=	14.6	14.6	BAF/Den Mass Balance
NOx-N, mg/L @ Pk-hr	=	14.6	14.6	
TSS, mg/L	=	10.0	10.0	from BAF
Ortho Phosphate as P, mg/L	=	1.24	1.24	from BAF
pH, SU	=	6.1-7.1	6.1-7.1	Assumed
DO, mg/L	=	7.0	8.0	Assumed Sat'd from BAF
Min. wastewater temperature, deg.C	=	28.0	15.0	Given Min
Avg. wastewater temperature, deg.C	=	25.0	20.0	Assumed
Min. air temperature, deg.C	=	18.0	8.0	Assumed

E. Desired Effluent Characteristics (Discharge Limits)

Parameter		Summer	Winter
NOx-N, mg/L @ ADF	=	1.0	1.0
NOx-N, mg/L @ Pk-hr	=	1.0	1.0
TSS, mg/L	=	5.0	5.0
pH, SU	=	7-9	7-9

II. DENITE® CALCULATION SUMMARY

Recommended Design

Hydraulic Loadings:

		Summer			Winter		
Number of total reactors required	=	6	reactors		6	reactors	
Number of reactors/train w/dedicated BW pump/blower	=	6	reactors		6	reactors	
Number of reactors sharing a mudwell	=	6	reactors		6	reactors	
Total surface area	=	7,002	ft^2,	m^2 = 651	7,002	ft^2,	m^2 = 651
Total media volume	=	56,016	ft^3,	m^3 = 1,587	56,016	ft^3,	m^3 = 1,587
ADF hydraulic loading	=	2.38	gpm/ft^2,	m/h = 5.8	2.38	gpm/ft^2,	m/h = 5.8
ADF hyd. loading per train w/1 filter in backwash	=	2.86	gpm/ft^2,	m/h = 7.0	2.86	gpm/ft^2,	m/h = 7.0
Pk hour hydraulic loading	=	2.38	gpm/ft^2,	m/h = 5.8	2.38	gpm/ft^2,	m/h = 5.8
Pk hour hydraulic loading per train w/1 filter in backwash	=	2.86	gpm/ft^2,	m/h = 7.0	2.86	gpm/ft^2,	m/h = 7.0
75% Pk hour hyd. loading per train w/1 filter in backwash	=	2.14	gpm/ft^2,	m/h = 5.2	2.14	gpm/ft^2,	m/h = 5.2
Empty bed contact time @ ADF	=	25.14	minutes		25.14	minutes	
Empty bed contact time @ Pk-hr	=	25.14	minutes		25.14	minutes	

Volumetric Removals:

		Summer		Winter	
Methanol equivalent BOD removal @ ADF	=	174	lb/kft^3-d, kg/m^3-d = 2.80	174	lb/kft^3-d, kg/m^3-d 2.80
NO_X-N applied load @ ADF	=	52	lb/kft^3-d, kg/m^3-d = 0.83	52	lb/kft^3-d, kg/m^3-d 0.83
NO_X-N removal/volume @ ADF	=	48	lb/kft^3-d, kg/m^3-d = 0.78	48	lb/kft^3-d, kg/m^3-d 0.78
NO_X-N removal/volume @ ADF less DO volume	=	53	lb/kft^3-d, kg/m^3-d = 0.86	56	lb/kft^3-d, kg/m^3-d 0.89
NO_X-N removal/media SA @ ADF	=	0.24	lb/kft^2-d	0.24	lb/kft^2-d
NO_X-N removal/reactor x-sectional SA @ ADF	=	0.39	lb/ft^2-d	0.39	lb/ft^2-d
Methanol equivalent BOD removal @ Pk-hr	=	175	lb/kft^3-d, kg/m^3-d = 2.80	175	lb/kft^3-d, kg/m^3-d 2.80
NO_X-N applied load @ Pk-hr	=	52	lb/kft^3-d, kg/m^3-d = 0.84	52	lb/kft^3-d, kg/m^3-d 0.84
NO_X-N removal/volume @ Pk-hr	=	49	lb/kft^3-d, kg/m^3-d = 0.78	49	lb/kft^3-d, kg/m^3-d 0.78
NO_X-N removal/media SA @ Pk-hr	=	0.24	lb/kft^2-d	0.24	lb/kft^2-d
NO_X-N removal/reactor x-sectional SA @ Pk-hr	=	0.39	lb/ft^2-d	0.39	lb/ft^2-d

Mass Removals:

		Summer		Winter	
Total NO_X-N removal @ ADF	=	2,712	lb N/day	2,712	lb N/day
Total NO_X-N removal @ Pk-hr	=	2,720	lb N/day	2,720	lb N/day
Spec. NO_X-N removal @ ADF	=	0.10	lb N/lb bio	0.10	lb N/lb bio
MESSAGE:		Rate ok		Rate ok	
Spec. NO_X-N removal @ Pk-hr	=	0.10	lb N/lb bio	0.10	lb N/lb bio
MESSAGE:		Rate ok		Rate ok	

		Summer		Winter	
Alkalinity generation @ ADF	=	48	mg/L $CaCO_3$	48	mg/L $CaCO_3$
ANX Biomass yield for selected carbon source @ 20 C	=	0.16	lb VSS/lb COD	0.16	lb VSS/lb COD
ANX Biomass yield for selected carbon source @ design T	=	0.16	lb VSS/lb COD	0.16	lb VSS/lb COD
ANX Biomass generation @ ADF	=	1,602	lb VSS/day	1,602	lb VSS/day
AER Biomass yield for selected carbon source @ 20 C	=	0.16	lb VSS/lb COD	0.16	lb VSS/lb COD
AER Biomass yield for selected carbon source @ design T	=	0.16	lb VSS/lb COD	0.16	lb VSS/lb COD
AER Biomass generation @ ADF	=	296	lb VSS/day	338	lb VSS/day
ANX +AER Biomass generation minus decay @ ADF	=	1,708	lb VSS/day	1,746	lb VSS/day
Biomass generation relative to N removed	=	0.63	lb VSS/lb N rem	0.64	lb VSS/lb N rem
Influent TSS removal @ ADF	=	1,000	lb/day	1,000	lb/day
Influent TSS removal ADF minus decay @ ADF	=	950	lb/day	950	lb/day
Alkalinity generation @ Pk-hr	=	49	mg/L $CaCO_3$	49	mg/L $CaCO_3$
ANX + AER Biomass generation @ Pk-hr minus decay	=	1,712	lb VSS/day	1,750	lb VSS/day
Influent TSS removal @ Pk-hr	=	1,000	lb/day	1,000	lb/day
Influent TSS removal minus decay @ Pk-hr	=	950	lb/day	950	lb/day

BW Air and Water Flows:

			Summer				Winter			
BW air @ standard baro psi =	14.7	=	7,002	icfm,	m^3/h =	11,908	7,002	icfm,	m^3/h =	11,908
BW air @ actual baro psia =	14.7	=	7,002	icfm,	m^3/h =	11,908	7,002	icfm,	m^3/h =	11,908
BW air rate at corrected pressure		=	6	icfm/sf,	m/h =	110	6	icfm/sf,	m/h =	110
Estimated BW blower motor		=	441	hp @ psig =		11.5	441	hp @ psig =		11.5
Initial BW water flow		=	7,002	gpm,	m^3/h =	1,590	7,002	gpm,	m^3/h =	1,590
Final BW water flow		=	7,002	gpm,	m^3/h =	1,590	7,002	gpm,	m^3/h =	1,590
Forward flow @ ADF per train		=	16,667	gpm,	m^3/h =	3,785	16,667	gpm,	m^3/h =	3,785
Estimated BW pump brake horsepower		=	88	hp @ psig =		15.2	88	hp @ psig =		15.2
Estimated electrical power to BW pump motor		=	98	hp @ psig =		15.2	98	hp @ psig =		15.2
BW water volume required per BW		=	204,960	gallons,	m^3 =	776	204,960	gallons,	m^3 =	776
Dirty BW volume discharged per BW		=	179,928	gallons,	m^3 =	681	179,928	gallons,	m^3 =	681
Clearwell size DF =	1.2	=	245,952	gallons,	m^3 =	931	245,952	gallons,	m^3 =	931
Min. Clearwell size req'd @ total ADF forward flow		=	0	gallons,	m^3 =	0	0	gallons,	m^3 =	0
@ ADF/train forward flow		=	0	gallons,	m^3 =	0	0	gallons,	m^3 =	0
Mudwell size DF =	1.2	=	215,914	gallons,	m^3 =	817	215,914	gallons,	m^3 =	817
Mudwell pump a) simultaneous BWs @min(BI or 2 hrs)		=	1,546	gpm,	m^3/h =	351	1,546	gpm,	m^3/h =	351
b) evenly spaced BWs @min(BI or 2 hrs)		=	1,546	gpm,	m^3/h =	351	1,546	gpm,	m^3/h =	351
Estimated mudwell pump brake horsepower		=	20	hp @ psig =		15.2	20	hp @ psig =		15.2
Estimated electrical power to mudwell pump motor		=	22	hp @ psig =		15.2	22	hp @ psig =		15.2

Backwash & Bump Frequencies:

Backwash frequency @ ADF	=	3.51	days/reactor	3.46	days/reactor
	=	84.29	hrs/reactor	83.11	hrs/reactor
BW Sys. Interval, <u>start</u> to next <u>start</u>, each train (MW eval)	=	14.19	hrs/train BW	13.99	hrs/train BW
, each train	=	1.71	train BW/day	1.73	train BW/day
, total system	=	14.19	hrs/system BW	13.99	hrs/system BW
, total system	=	1.71	system BW/day	1.73	system BW/day
, shared MW	=	14.19	hrs/multi train BW	13.99	hrs/multi train B\
, shared MW	=	1.71	multi train BW/day	1.73	multi train BW/day
BW sequence duration	=	49.95	minutes	49.95	minutes
BW Sys. Interval, <u>finish</u> to next <u>start</u>, each train (bump eval)	=	13.36	hrs/train BW	13.16	hrs/train BW
, total system	=	13.36	hrs/system BW	13.16	hrs/system BW
, total system	=	5.93%	BW as % op. time	6.01%	BW as % op. time
, shared MW	=	13.36	hrs/multi train BW	13.16	hrs/multi train BW
BW time consumption/train or system if simult. train BWs	=	5.93%	BW as % op. time	6.01%	BW as % op. time
BW time consumption/multi-train sharing MW w/offset BWs	=	5.93%	BW as % op. time	6.01%	BW as % op. time
BW waste generation as % of forward flow @ ADF	=	1.28%		1.30%	
SpeedBump frequency @ ADF (including all filters)	=	4.1	hrs/system SBump	4.1	hrs/system SBump
	=	5.8	SBumps/day	5.8	SBumps/day
SpeedBump duration including all filters	=	13.0	minutes	13.0	minutes
Max # SpeedBumps that can occur btw. System BWs	=	61.6	Sbumps/BI	60.7	Sbumps/BI
	=	5.24%	SBump as % op. time	5.24%	Sbump as % ot
Number of bumps btw. reactor BW if no SpeedBump	=	20.40	bumps/ BW	20.12	bumps/ BW
Biomass accum. btw BWs after decay	=	1,000	lbs	1,008	lbs
Influent TSS accum. btw BWs after decay	=	556	lbs	548	lbs
Total solids accum. btw BWs	=	1,556	lbs	1,556	lbs
Average TSS in BW	=	1,039	mg/L	1,039	mg/L

		Summer			Winter		
Backwash frequency @ Pk-hr	=	3.51	days/reactor		3.46	days/reactor	
	=	84.16	hrs/reactor		82.97	hrs/reactor	
BW Sys. Interval, start to next start, each train	=	14.17	hrs/train BW		13.97	hrs/train BW	
, each train	=	1.71	train BW/day		1.74	train BW/day	
, total system	=	14.17	hrs/system BW		13.97	hrs/system BW	
, total system	=	1.43	system BW/day		1.45	system BW/day	
BW time consumption/train or system if simult. train BWs	=	5.93%	BW as % op. time		6.02%	BW as % op. time	
, total system	=	4.95%	BW as % op. time		5.02%	BW as % op. time	
BW waste generation as % of forward flow @ Pk-hr	=	1.28%			1.30%		
Bump frequency @ Pk-hr	=	4.12	hrs/system SBump		4.12	hrs/system SBump	
	=	5.83	SBumps/day		5.83	SBumps/day	
Number of bumps btw. reactor BW if no SpeedBump	=	20.43	bumps/ BW		20.14	bumps/ BW	
Biomass accum. btw BWs after decay	=	1,001	lbs		1,009	lbs	
Influent TSS accum. btw BWs after decay	=	555	lbs		547	lbs	
Total solids accum. btw BWs	=	1,556	lbs		1,556	lbs	
Average TSS in BW	=	1,039	mg/L		1,039	mg/L	

Sidestream Clearwell Fill Rate (for UV disinfection applications, based on winter conditions):

For simultaneous BWs in trains sharing a clearwell			
Clearwell fill rate after BW	=	1,708	gpm, for simultaneous BWs in trains sharing clearwell
ADF percent of forward flow used for fill	=	10%	of flow to trains sharing a clearwell
Flow to disinfection during fill @ ADF/clearwell	=	21.5	MGD per clearwell
Total flow to disinfection during fill @ ADF	=	21.5	MGD total
For offset BWs in trains sharing a clearwell			
Clearwell fill rate after BW	=	1,708	gpm, for offset BWs in trains sharing clearwell
ADF percent of forward flow used for fill	=	10%	of flow to trains sharing a clearwell
Flow to disinfection during fill @ ADF/clearwell	=	21.5	MGD per clearwell
Total flow to disinfection during fill @ ADF	=	21.5	MGD total

Supplemental Carbon choice is MeOH

Theoretical C:N ratio @ ADF = 2.47	=	6,687	lb/d C	76.9%	6,687	lb/d C	75.3%
Theoretical C:DO ratio @ ADF = 0.87	=	1,213	lb/d C	14.0%	1,387	lb/d C	15.6%
Carbon required @ ADF conditions for N & DO, DF = 1.1	=	8,691	lb/d total C		8,881	lb/d total C	
COD/N removed @ ADF, including DO demand	=	4.81			4.91		
100% feed solution @ SG = 0.79	=	54.96	gph		56.17	gph	
Carbon pump power @ ADF conditions	=	0.08	hp@psig=	90	0.08	hp@psig=	90
Carbon storage @ ADF conditions	=	34	days		33	days	
Theoretical C:N ratio @ Pk-hr = 2.47	=	6,707	lb/d C	77.0%	6,707	lb/d C	75.3%
Theoretical C:DO ratio @ Pk-hr = 0.87	=	1,213	lb/d C	13.9%	1,387	lb/d C	15.6%
Carbon required @ Pk-hr conditions	=	8,713	lb/d total C		8,903	lb/d total C	
COD/N removed @ Pk-hr, including DO demand, DF=1.1	=	4.80			4.91		
100% feed solution @ SG = 0.79	=	55.10	gph		56.31	gph	
Carbon pump power @ Pk-hr conditions	=	0.08	hp@psig=	90	0.08	hp@psig=	90
Carbon storage @ Pk-hr conditions	=	34	days		33	days	

Nutrient Requirements:

Theoretical P required as nutrient @ ADF	=	20.23	lb/day, temp adj	30.36	lb/day, temp adj
	=	0.10	mg/L OP	0.15	mg/L OP
	=	0.007	mg OP/mg Nr	0.011	mg OP/mg Nr
Est. actual P required, DF = 1	=	20.23	lb/day	30.36	lb/day
P available @ ADF	=	248.21	lb/day	248.21	lb/day
Supplemental P required	=	0.00	lb/day	0.00	lb/day
Supplemental P as 75% H_3PO_4	=	0.00	gpd	0.00	gpd
55-gal drum of 75% H_3PO_4 will last	=	0.00	days	0.00	days
Theoretical P required as nutrient @ Pk-hr	=	20.28	lb/day, temp adj	30.44	lb/day, temp adj
Est. actual P required, DF = 1	=	20.28	lb/day	30.44	lb/day
P available @ Pk-hr	=	248.21	lb/day	248.21	lb/day
Supplemental P required	=	0.00	lb/day	0.00	lb/day
Supplemental P as 75% H_3PO_4	=	0.00	gpd	0.00	gpd
55-gal drum of 75% H_3PO_4 will last	=	0.00	days	0.00	days

III. ESTIMATED OPERATING COSTS

A. Chemical @ ADF

				Summer			Winter	
Carbon cost/gal @	$1.80		=	$433,309	per 6 mos.		$442,815	per 6 mos.
H_3PO_4 cost /lb @	$0.50		=	$0	per 6 mos.		$0	per 6 mos.
		Subtotal	=	$433,309	per 6 mos.	+	$442,815	per 6 mos.
							$876,124	per year

B. Power @ ADF

$/kWh =	$0.11							
RMB/kWh =	¥0.70							
BW pump power w/draindown			=	$1,234	per 6 mos.		$1,252	per 6 mos.
BW blower power			=	$4,870	per 6 mos.		$4,941	per 6 mos.
Bump pump power			=	$1,740	per 6 mos.		$1,740	per 6 mos.
Mudwell pump power			=	$1,130	per 6 mos.		$1,146	per 6 mos.
Nitrate analyzer power			=	$353	per 6 mos.		$353	per 6 mos.
Analyzer sample pump(s) power			=	$167	per 6 mos.		$167	per 6 mos.
Carbon feed pump(s) power			=	$30	per 6 mos.		$31	per 6 mos.
		Subtotal	=	$9,526	per 6 mos.	+	$9,631	per 6 mos.
							$19,156	per year

IV. EQUIPMENT LIST FOR ROM-TYPE ESTIMATE (based on winter conditions)

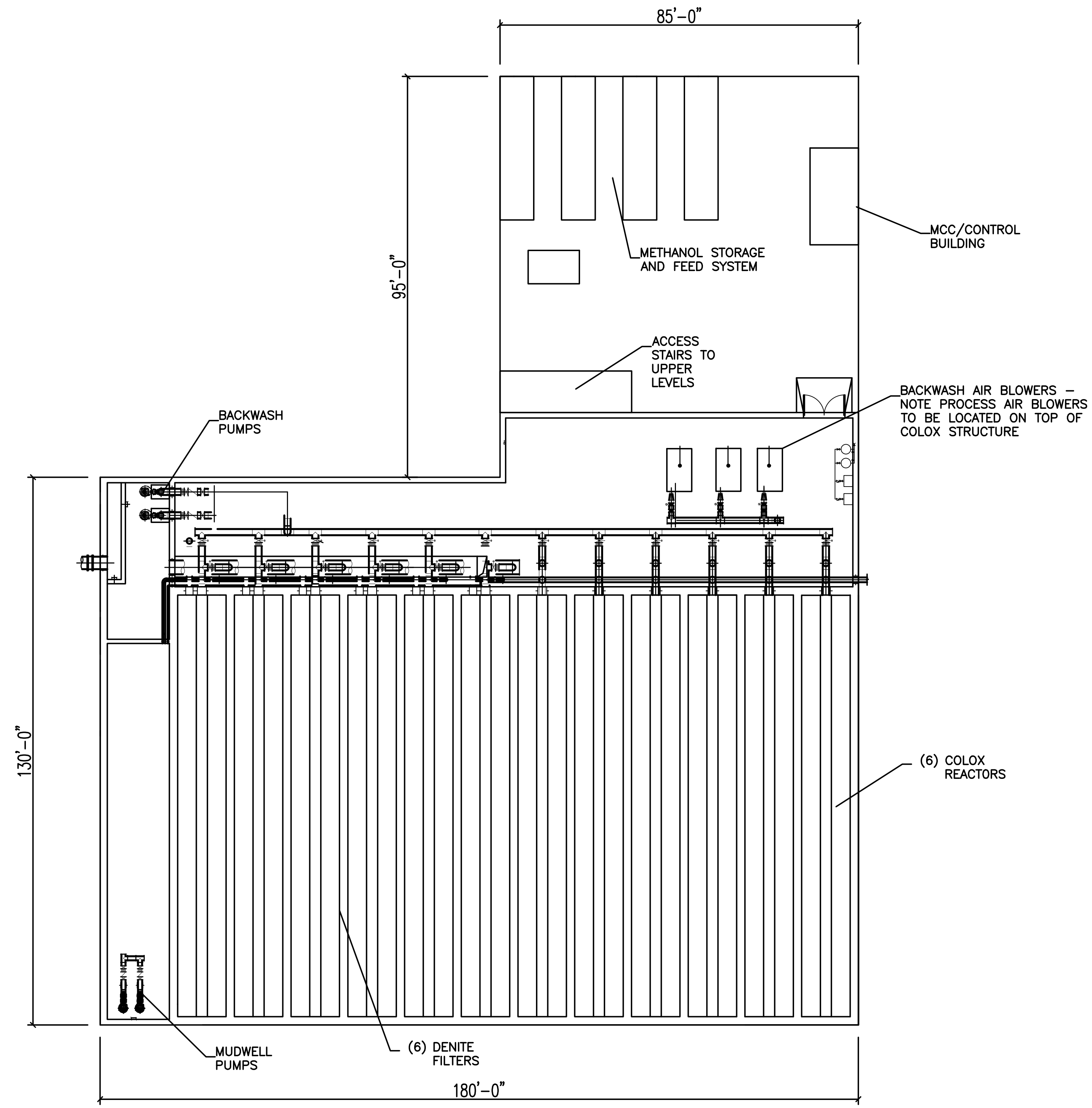
Final equip. selection to be made by Mechanical Dept. after design is finalized.
HP and psig values are estimated typical operating conditions.

Qty	Description			psig	ft TDH	kPa	hp
6	Denite® hardware @	1,167.0	ft2, 11'-8" W x 100'-0" L		1,167.0 sf,		m² 108
1 lot	TETRA #5 Denite media @	2,801	tons of 2-3 mm ES silica sand		8.0 ft ,		m 2.44
1 lot	Denite gravel @	525	tons		1.5 ft ,		m 0.46
1	Mudwell basin(s) @	215,914	gallons, m3 = 817				
1	Clearwell basin(s) @	245,952	gallons, m3 = 931				
2	BW water pumps, 1 stndby @	7,002	gpm, m3/h = 1,590	15.2	35.0	104.4	98
3	BW air blowers, 1 stndby @	3,501	icfm, m3/h = 5,954	11.5	26.6	79.2	220.5
2	Mudwell pumps, 1 stndby @	1,546	gpm, m3/h = 351	15.2	35.0	104.4	21.7
3	Carbon storage system @	15,000	gallons, m3 = 57				
2	Carbon pumps, 1 stndby @	56.17	gph, ml/min = 3,544	212.6 LPH		MeOH	100%
0	Phos. acid pumps, 1 stndby@	0.00	gph, ml/min = 0			H_3PO_4	75%
1	Filter Water Level Control (Electric Effluent Valve)						
1	Lot Weir Plate						
1	Control system						
1	TETRAPace Carbon Dosing						

REVISION TRACKER

Project Name: **Newtown Creek WWTP**
Filter Type: **Denite**
Location: **Brooklyn, NY**
Sales Force #: **P-113017**

Revision	Date	Changes
Rev 0	27-Oct-2021	First Issue ColOX/Denite Design



NO.	REVISIONS	BY	DATE	APP'D
C	ISSUED FOR PROPOSAL	SMJ	28OCT2021	

SCALE NONE
APP'D
DATE
DESIGNED
DRAFTED SMJ
CHECKED

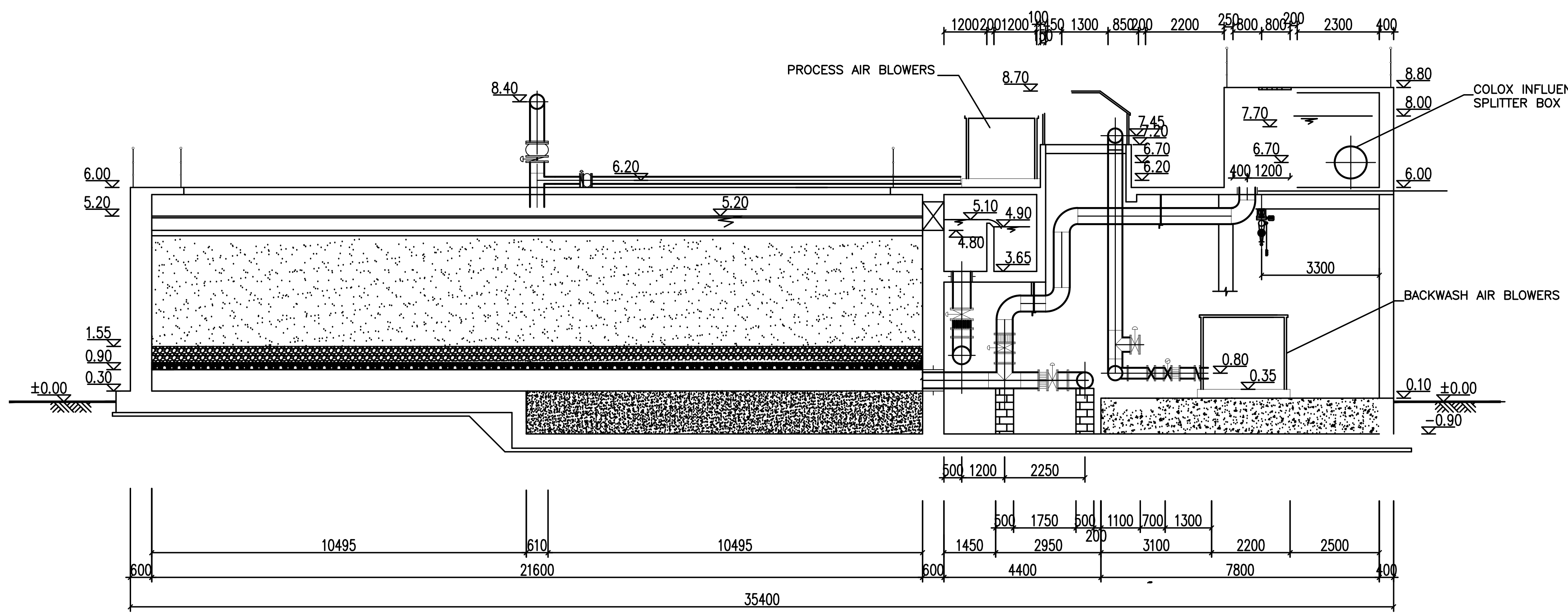
FOR PROPOSAL ONLY

NEWTOWN CREEK WWTP
NEW YORK, NEW YORK
(6) COLOX AND (6) DENITE FILTERS
GENERAL ARRANGEMENT
FILTERS, CLEARWELL AND MUDWELL

DE NORA

DE NORA
WATER TECHNOLOGIES

CONTRACT No.	DWG No.	REV.
P-113017 - G301		A



COLOX SECTION 1-1

NO.	REVISIONS	BY	DATE	APP'D
C	ISSUED FOR PROPOSAL	SMJ	2NOV2021	

SCALE NONE
APP'D
DATE
DESIGNED
DRAFTED SMJ
CHECKED

FOR PROPOSAL ONLY

NEWTOWN CREEK WWTP
NEW YORK, NEW YORK
(6) COLOX AND (6) DENITE FILTERS
GENERAL ARRANGEMENT
COLOX CROSS SECTION - PRELIMINARY

DE NORA

DE NORA WATER TECHNOLOGIES

CONTRACT No.	DWG No.	REV.
P-113017	G302	A

DE NORA
our research - your future

DeepBed™ Denitrification TETRA™ Denite®

The TETRA™ Denite® System integrates well with other plant treatment processes to provide superior nitrogen and phosphorous removal.

The De Nora TETRA™ Denite® System is a practical process for the removal of nitrate-nitrogen (NO_3-N) and suspended solids (SS) in a single treatment step.

Denite® is a fixed-film biological denitrification process that also serves as a deep bed filtration system capable of removing suspended solids to a level of 2-3 mg/L. Denite® can be used as part of a process to help facilities meet stringent TN discharge limits as low as 3 mg/L.

Denite® Process Description

Biological denitrification processes can be of the fixed-film or suspended growth type. The De Nora TETRA™ Denite® System requires one-tenth of the space used with suspended growth systems, greatly facilitating expansion or retrofitting requirements. With Denite®, the denitrification process and the filtration process are combined in a single system and provide superior process synergy. NO_3-N is converted to nitrogen gas and captured within the media bed along with suspended solids and biomass formed from the denitrification reaction. The Denite® gravity filter system operates in a downflow mode to maintain excellent suspended solids removal, thus avoiding the necessity for clarifiers or additional effluent polishing filters.

The specially sized and shaped granular media used in the fixed-film biological reactors is an excellent support medium for denitrifying bacteria and the deep bed environment is conducive to efficient NO_3-N and solids removal. The specific surface of the 2-3 mm sand is high, 300 square feet per cubic foot. A 4-8 foot depth of media is used that prevents short-circuiting and premature solids breakthrough. The contact between wastewater and biomass is excellent and hydraulic short-circuiting is negligible even during plant upsets.

The media allows for heavy capture of solids of at least 1.0 pound of solids per square foot of filter surface area before backwashing is required. The high solids capture permits operating for extended periods of time and easily handles peak flow periods or plant upsets.

As solids are captured increasing the head loss in the filters, a backwash is required to remove the solids. Despite the heavy loading capacity of the Denite® filter, an efficient backwash can be performed using concurrent air and water. Typically less than 4% (often 2-3%) of the plant's forward flow is used for backwashing.

During the denitrification reaction, nitrogen gas accumulates in the media bed and wastewater is forced to flow around the gas bubbles in the media voids. This reduces the apparent size of the media void and also improves the biomass contact and filtration efficiency. The effect of the gas bubbles increases head loss and requires periodic removal between backwashes. Removing a reactor from service and applying backwash water for a short period of time accomplish this. This nitrogen release cycle, or bump, releases the entrapped nitrogen gas into the atmosphere, reducing the head loss. The TETRA™ SpeedBump technology is utilized to conduct a complete system bump cycle without stopping flow to the reactors.

Suspended Solids Removal

The removal of suspended solids from wastewater effluent also lowers BOD since each mg/L of TSS contains 0.4-0.5 mg/L of BOD. Effluent suspended solids also contain nitrogen, phosphorous, and heavy metals. The removal of these solids often decreases 1 mg/L or more of these materials. With proper chemical treatment, effluent total phosphorous concentrations <0.3 mg/L are consistently achieved. Denite® filters can easily meet <2 NTU or < 5 mg/L TSS (<2 mg/L TSS typical). Table 1 demonstrates the final effluent quality reported by the City for the Howard Curren AWTP in Tampa, Florida during the period of 1980-2001 where the Denite® system is operating.

Nitrogen Removal

The denitrification reaction is time-dependent, and the time required for a specific removal efficiency varies according to the temperature of the wastewater being treated. In practice, filtration rates of 1-3 gpm/ft^2 are designed for water temperatures down to 8 degrees Celsius and 2-5 gpm/ft^2 in warmer waters. Table 2 demonstrates the Denite® system's capability to denitrify to low NO3-N concentrations at low wastewater temperatures. Table 1 demonstrates the consistency of yearly Denite® operations for NO3-N and SS removal.

Table 1: Howard Curren AWTP – Tampa, FL (100 MGD)

Period	MGD	BOD (mg/L)	SS (mg/L)	TN (mg/L)	TKN (mg/L)	NH_3-N (mg/L)	NO_3-N (mg/L)
1980-1988	51.3	3.4	2.8	2.8	1.7	0.17	1.06
1989-1998	55.5	2.4	1.6	2.4	1.56	0.18	0.87
1999	50.45	2.6	0.9	2.52	1.46	0.13	1.01
2000	48.5	3.1	0.7	2.24	1.29	0.14	0.95
2001	49.7	2.3	0.8	2.28	1.21	0.15	1.06
Average	51.0	2.76	1.4	2.4	1.5	0.15	0.99

Table 2. Cold Weather Performance Data – Northeast US (Monthly Averages)

	MGD	Wastewater Temperature degrees C	Influent NO_3-N mg/L	Effluent NO_3-N mg/L
Nov 2003	1.01	14.9	11.56	0.45
Dec 2003	1.77	11.6	8.25	0.47
Jan 2004*	1.13	8.5	10.91	0.48
ADF Design	1.0	8	13	0.5
Peak-Day Design	2.36	8	11	0.5

* 15 days were measured <8 degrees C with average effluent NO_3-N of 0.45 mg/L @ 1.09 MGD

TETRA™ Denite®
DeepBed™ Denitrification

Denite® System Components and Specifications

Filter Vessel: Concrete or steel, round or rectangular, usually 18-20 feet deep with free board

Filter Bottom: Nozzleless design; stainless steel air headers and pipe laterals; plastic jacketed 5000 psi concrete SNAP T® Block underdrains

Filter Media: Monomedia granular sand with 2-3 mm effective size at depths of 4-to-8 feet

Support Layers: Gravel in five layers totaling 18 inches deep in a reverse graded fashion

Filter Controls: Either constant rate filtration with constant head using modulated effluent valves controlled by level element, or constant rate with variable head using open/close effluent valves

Backwash Air: Distributed across the entire area of the filter bottom, supplied by a positive displacement blower at a rate of 3-5 icfm/ft²

Backwash Water: Supplied at a rate of 5-6 gpm/ft² with a low head centrifugal pump. The head loss across the filter bottom is 4.0 inches water column.

Filter Valves: Pneumatic or electric control valves with double acting cylinders. Isolation valves can be included.

Chemical Feed Systems: Includes a methanol storage and feed system with TetraPace™ automatic dosing control. This can be used for other chemical feeds as well.

Instrumentation: PLC with human machine interface and multiple screens included. Also includes outputs for a centralized computer control and/or SCADA system. It also includes flow meters, analyzers, level switches, local panels and system alarms.

Filter Operation: Automatic with manual overrides. Backwashing and bumping are time based.

Head Requirement: Typically 6-8 feet of water but can be more or less depending on the specific application

System Integration: Works well with other treatment plant processes such as overall nitrogen removal, phosphorous removal and virus removal

info.dnwt@denora.com **www.denora.com**

DNWT - TETRA™ Denite® DeepBed™ Denitrification - 650.0001.4 - 1/2017

suez

Water Technologies & Solutions

budget proposal for the

Newtown Creek WWTP

ZeeWeed* membrane filtration system

submitted to:
Arcadis
27-01 Queens Plaza North, Suite 800
Long Island City, NY, 11101
attention: Mariana Costa Tomazelli

November 02, 2021

proposal number: 480577

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1 basis of design

The proposed ZeeWeed membrane filtration system for the Newtown Creek is offered based on using the design parameters summarized in the following sections.

1.1 influent flow data

This is a typo. Proposal was based on average flow of 242 MGD

The influent design flows are summarized in the table below.

influent design flows

flow conditions	value	units
average day flow (ADF)	142	mgd
maximum month flow (MMF)	277	mgd
maximum week flow (MWF)	338	mgd
maximum day flow (MDF)	594	mgd
peak hour flow (PHF)	700	mgd
maximum flow with four trains per battery (12 total offline for maintenance or cleaning for less than 24 hours)	594	mgd

note 1: any flow conditions that exceed the above-noted flow limits must be equalized prior to treatment in the ZeeWeed membrane filtration system.

ADF – the average flow rate occurring over a 24-hour period based on annual flow rate data.

MMF – the average flow rate occurring over a 24-hour period during the 30-day period with the highest flow based on annual flow rate data.

MWF – the average flow rate occurring over a 24-hour period during the 7-day period with the highest flow based on annual flow rate data.

MDF – the maximum flow rate averaged over a 24-hour period occurring within annual flow rate data.

PHF – the maximum flow rate sustained over a 1-hour period based on annual flow rate data.

SUEZ has assumed that influent flows to the existing three secondary batteries will be equal, i.e., each battery will receive one third of the influent plant flow.

1.2 influent quality

Below are the ultrafiltration system influent characteristics that were used for this design. Any deviation from these values may impact the membrane system design.

acceptable mixed liquor properties entering membrane tanks

properties of mixed liquor entering membrane tanks	acceptable operating range
temperature range (°C)	15-24
MLSS concentration (mg/L) [1]	≤ 10,000
pH (SU)	6.5 – 7.5
soluble $cBOD_5$ concentration (mg/L)	≤ 5

NH_3-N concentration (mg/L)	≤ 1.0
colloidal TOC (cTOC) concentration (mg/L) [2]	≤ 10
soluble alkalinity (mg/L as $CaCO_3$)	50 – 150
time to filter (TTF) (seconds) [3]	≤ 200
material greater than 2 mm in size (mg/L) [4]	≤ 1
fats, oil & grease (FOG) (mg/L)	refer to note 6

note 1: Membrane tank MLSS concentration of up to 12,000 mg/L is permissible during MDF and PHF events only. Membrane tanks MLSS concentration to be ≤10,000 mg/L during all other flow conditions.

note 2: Colloidal TOC (cTOC) is the difference between the TOC measured in the filtrate passing through a 1.5-µm filter paper and the TOC measured in the ZeeWeed membrane permeate.

note 3: Per seller's standard time to filter (TTF) procedure (available upon request).

note 4: Per seller's standard sieve test procedure (available upon request).

note 5: Chemicals that are not compatible with the ZeeWeed PVDF membrane are not permitted in the membrane tanks.

note 6: FOG concentration shall not exceed 150 mg/L of emulsified FOG in the feed with no free oil and less than 10 mg/L of mineral or non-biodegradable oil.

1.3 effluent quality

The following performance parameters are expected upon equipment startup based on the data listed in Sections 1.1 and 1.2.

membrane system effluent quality

effluent design parameters			
	Typical Value	Guaranteed Value	Unit
TSS	<1	≤ 5	mg/L
turbidity	<0.2	≤ 5	NTU

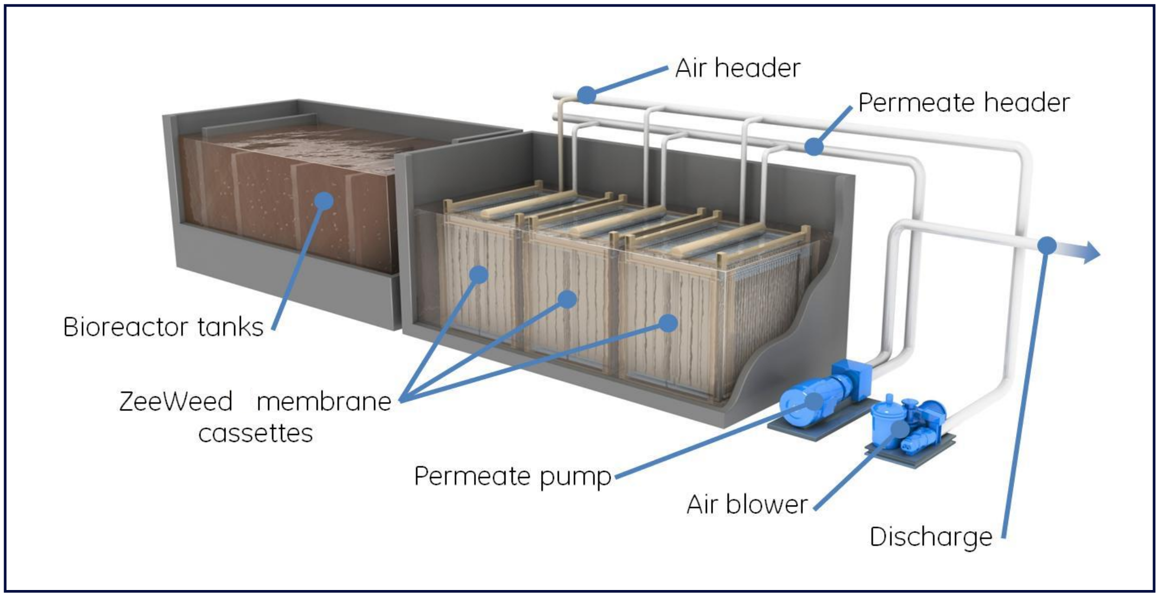
1.4 influent variability

Influent wastewater flows or loads in excess of the design criteria defined above must be equalized prior to entering the membrane tanks. In the event that the influent exceeds the specifications used in engineering this proposal, or the source of influent changes, the ability of the treatment system to produce the designed treated water quality and/or quantity may be impaired. Buyer may choose to continue to operate the system, but assumes the risk of damage to the system and/or additional costs due to increased membrane cleaning frequency, potential for biological upset and/or increased consumables usage.

2 system design and scope

The membrane bioreactor (MBR) process consists of a suspended growth biological reactor integrated with a membrane filtration system, using the ZeeWeed hollow fiber ultrafiltration membrane. The membrane filtration system essentially replaces the solids separation function of secondary clarifiers and tertiary sand filters used in a conventional activated sludge process.

ZeeWeed ultrafiltration membranes are directly immersed in mixed liquor. Using a permeate pump, a vacuum is applied to a header pipe connected to the membranes. The vacuum draws the treated water through the hollow fiber membranes. Permeate is then directed to downstream disinfection or discharge facilities. Air, in the form of large bubbles, is introduced below the bottom of the membrane modules, producing turbulence that scours the outer surface of the hollow fibers to keep them clean.



The proposed membrane filtration system design utilizes LEAPmbr aeration. LEAPmbr aeration simplifies the aeration system and reduces aeration requirements; resulting in significant capital and energy savings.

simplicity

Over the years, SUEZ has continually improved the design of ZeeWeed MBR systems, making them the simplest MBR systems in the industry to operate and maintain. The system is fully automated, with operators having the ability to review operation, adjust set points, or schedule operating tasks through the easy-to-understand HMI graphical display.

A fully automated suite of membrane maintenance procedures will ensure long-term, successful operation, including:

- in situ chemical membrane cleaning performed directly in the membrane process tanks so your operators don't waste time moving cassettes;
- the ability to increase or decrease the frequency of maintenance cleans to fit the operating conditions;

- the ability to backpulse when needed to greatly improve your operator's ability to recover from non-design conditions.

The above cleaning systems are automated resulting in operators having available a full suite of comprehensive cleaning systems which are simple to use and initiate.

reliability

SUEZ's reinforced ZeeWeed hollow fiber membrane incorporates a patented internal support to which the membrane is bonded, creating the most robust membrane in the industry. In addition, SUEZ's automated manufacturing processes ensure a consistent membrane product meeting the highest standards of workmanship and quality. This exceptionally strong and reliable membrane forms the backbone of ZeeWeed MBR systems, which consistently exceeds the toughest regulatory standards around the world.

SUEZ is the world leader in MBR technology, with the majority of the industry's largest and longest-operating MBR plants. SUEZ now has over two decades of experience with the well-proven ZeeWeed membrane. The earliest MBR plants using the ZeeWeed 500 membrane, SUEZ's current standard for MBR applications, have now been in operation for over 10 years. SUEZ's long-term and wide-ranging MBR experience ensures that plant operators can count on many years of successful operation of the proposed ZeeWeed MBR plant.

lowest lifecycle cost

LEAPmbr aeration is a significant innovation for ZeeWeed MBR technology that offers a 30% reduction in air flow versus SUEZ's previous air cycling technology. When combined with LEAPmbr's other features, membrane aeration energy savings are almost 50% compared with the previous generation of ZeeWeed membranes. In addition to the substantial energy savings, LEAPmbr requires fewer membrane modules and cassettes, smaller membrane tanks, fewer valves and pipes, and lower connected horsepower. In many cases, a ZeeWeed MBR system using LEAPmbr technology has an equivalent lifecycle cost to conventional treatment options.

2.1 membrane system design

Retrofit of the existing WWTP is proposed based on retrofitting the three existing batteries, one battery at a time.

membrane design parameters per battery

membrane design parameters	value
number of membrane trains	24
number of cassette spaces per train	20
number of cassettes installed per train	18
maximum number of modules per cassette	52
module design per train	(16x52) + (2x48)
total number of modules installed per train	928
total number of modules installed per battery	22,272
total number of cassettes installed per battery	432
Membrane module spare space	10.8%
membrane tank internal dimensions, L x W x H (ft)	~70 x 16.67 x 14.5

note 1: Tank dimensions are preliminary only and may change slightly once final detail design commences.

note 2: The ultrafiltration system is designed for installation within the existing concrete tanks. Retrofit of the tanks is by Others. The existing clarifier tank dimensions are ideal for cassette installation. The existing tank bottom slope will also allow the tank to be fully drained when required, i.e., for recovery cleans.

2.2 scope of supply by SUEZ

SUEZ's scope of supply for a ZeeWeed 500 membrane wastewater treatment system, for the Project Name project, designed to treat a net permeate flow of XX MGD is as follows.

- Electrical rating on all motors is 460V / 3ph / 60 Hz. Single phase power requirement is 120V.
- All proposed equipment and instrumentation quoted is to be installed in a NFPA 820 non classified area.
- All devices will be SUEZ standard devices and the proposed equipment will be supplied to SUEZ specifications. Any changes to the proposed equipment to meet the Buyer's specification, including custom tag numbering, will require re-evaluation.
- Equipment will be **supplied loose shipped** unless otherwise noted.

scope of supply by SUEZ per battery

quantity	description
The MBR/UF system will consist of the following equipment:	
ZeeWeed membranes	
lot	membrane tank cassette mounting assemblies (if concrete membrane tanks used)
432	ZeeWeed 500D membrane cassettes
22,272	ZeeWeed 500D membrane modules
24 sets	permeate collection & air distribution header piping within membrane tank
24	membrane tank level transmitters
ejector & associated equipment	
24	air ejector assemblies
electrical control system	
2	master control panels w/ Allen Bradley Control Logix PLC and PanelView Plus 7 HMI and Flex I/O
8	remote I/O panels - includes Allen Bradley Flex I/O.
process pump & associated equipment	
24	centrifugal process pumps w/ motors – VFDs by Others
24 lot	pump isolation valves and check valves
24 lot	pressure transmitters, pressure gauges, flow meters
24 lot	chemical injection ports and valves
24	permeate turbidimeters - includes isolation valves, throttle valve and backplate.
backpulse system	
3	centrifugal backpulse pumps w/ motors – VFDs by Others

quantity	description
3 lot	pump isolation valves and check valves
3 lot	pressure transmitters, pressure gauges, flow meters
membrane air scour blowers	
6+1	membrane air scour blowers with motors (6 duty + 1 standby) - includes isolation valves, flow switches, pressure gauges
membrane cleaning systems	
2+1	sodium hypochlorite chemical feed equipment - includes dosing pump and associated valving
2+1	citric acid chemical feed equipment - includes dosing pump and associated valving
miscellaneous	
2+1	air compressors (2 duty + 1 standby) for pneumatic valve operation and refrigerated air drier
general	
included	P&IDs and equipment general arrangement drawings for SUEZ supplied equipment
included	operating training
included	operating & maintenance manuals
included	field service and start-up assistance – 120 days support over 12 site visits from SUEZ field-service personnel for commissioning, plant start-up and operator training
included	InSight Pro – Process consulting service – 1 year
included	24/7 emergency phone support – 1 year
included	equipment mechanical warranty – 1 year or 18 months from shipment
included	membrane warranty – 10 year (2-year cliff and 8-year prorated)

note 1: Additional man-hours will be billed separately from the proposed system capital cost at a rate of $1,500 per day plus living and traveling expenses. Detailed SUEZ service rates are available upon request.

note 2: All SUEZ supplied equipment is designed for installation in an unclassified area.

note 3: To receive complete 24/7 Emergency Telephone Technical Support Service and to allow for InSight Monitor Service, a suitable secure remote internet connection, by buyer, is required.

3 buyer scope of supply

The following items are for supply by buyer and will include but are not limited to:

- overall plant design responsibility
- review and approval of design parameters related to the membrane separation system
- review and approval of SUEZ-supplied tank and equipment drawings and specifications
- detail drawings of all termination points where SUEZ equipment or materials tie into equipment or materials supplied by buyer
- design, supply and installation of lifting devices including overhead traveling bridge crane rated for 10,000 lb for membrane removal.
- civil works, provision of main plant tank structure, buildings, equipment foundation pads etc. including but not limited to:
    - common channels, housekeeping pads, equipment access platforms, walkways, handrails, stairs etc.
    - membrane tanks c/w tank covers or grating, and their support over membrane tanks
    - treated water storage tank, as required
- all chemical storage tanks, day tanks, and secondary containments
- HVAC equipment design, specifications and installation (where applicable)
- UPS, power conditioner, emergency power supply and specification (where applicable)
- 2-mm punched-hole headworks fine screens
- biological process equipment – including process blowers, RAS pumps, diffusers and mixers
- acoustical enclosures for membrane blowers as required
- VFDs and MCC for all SUEZ supplied equipment
- plant SCADA system
- process and utilities piping, pipe supports, hangers, valves, etc. including but not limited to:
    - piping, pipe supports and valves between SUEZ-supplied equipment and other plant process equipment
    - piping between any loose-supplied SUEZ equipment
    - process tank aeration system air piping, equalization tank system piping, etc.
    - interconnecting piping between SUEZ-supplied equipment (as applicable)

- electrical wiring, conduit and other appurtenances required to provide power connections as required from the electrical power source to the SUEZ control panel and from the control panel to any electrical equipment, pump motors and instruments external to the SUEZ-supplied enclosure
- supply and installation of suitable, secure remote internet connection for 24/7 emergency telephone technical support service and InSight remote monitoring & diagnostics service
- design, supply and installation of equipment anchor bolts and fasteners for SUEZ supplied equipment. All seismic structural analysis and anchor bolt sizing
- receiving (confirmation versus packing list), unloading and safe storage of SUEZ-supplied equipment at site until ready for installation
- installation on site of all SUEZ supplied loose-shipped equipment
- alignment of rotating equipment
- raw materials, chemicals, and utilities during equipment start-up and operation
- disposal of initial start-up wastewater and associated chemicals
- supply of seed sludge for biological process start-up purposes
- laboratory services, operating and maintenance personnel during equipment checkout, start-up and operation
- touch up primer and finish paint surfaces on equipment as required at the completion of the project
- weather protection as required for all SUEZ-supplied equipment. Skids and electrical panels are designed for indoor operation and will need shelter from the elements
- all permits

4 commercial

4.1 pricing

Pricing for the proposed equipment and services, as outlined in Section 2.3, is summarized in the table below. All pricing is based on the design operating conditions and influent characteristics detailed in section 1. The pricing herein is for budgetary purposes only and does not constitute an offer of sale. No sales, consumer use or other similar taxes or duties are included in the pricing below.

equipment and service pricing

price: all equipment & service per battery	
ZeeWeed membrane filtration system	$ 43,800,000 USD

Pricing is provided on a per battery basis and should be multiplied by three for total project pricing. SUEZ recognizes that implementation of this project may occur over several years, one battery at a time. Pricing is provided based on current market pricing and should be adjusted based on the Producer Price Index, or other relevant material price index based on the anticipated project timeline for each battery.

4.2 annual power & chemical consumption estimates

The data presented below is for information purposes only and is based on the design information provided by the buyer and presuming that the equipment is operated according to the design basis and in accordance with seller's operations and maintenance manuals.

annual power consumption estimate per battery [1]

equipment	kWh/year
permeate pumps [2]	918,800
membrane blowers	4,777,600
recirculation pumps (TDH estimated at 5 ft.)	2,590,900
air compressors	165,000
total	**8,452,300**

note 1: Annual power consumption estimate is calculated at ADF condition with 13 trains in operation.

note 2: Assumes membrane relaxation mode used, i.e., backpulse pumps are not in operation.

annual chemical consumption estimate

chemical	US gal/year
sodium hypochlorite (10.3% w/w, SG: 1.168)	56,800
citric acid (50.0% w/w, SG: 1.24)	44,800

note 1: Cleaning chemical consumption estimates are based on the frequencies and concentrations summarized in the table below. Frequencies are typical for ZW-MBR operation, actual frequency of maintenance and recovery cleans may change with final design, or may change once system is in operation.

basis of chemical consumption estimates

chemical		maintenance clean	recovery clean
sodium hypochlorite solution (10.3% w/w, SG: 1.168)	frequency	2 times per week	2 times per year
	concentration	200 mg/L	1,000 mg/L
citric acid solution (50.0% w/w, SG: 1.24)	frequency	N/A	2 times per year
	concentration	N/A	2,000 mg/L

4.3 equipment shipment and delivery

Equipment shipment is estimated at 28 to 37 weeks after order acceptance. The buyer and seller will arrange a kick-off meeting after contract acceptance to develop a firm shipment schedule.

typical drawing submission and equipment shipment schedule

deliverables		8-12 weeks	2-3 weeks	16-20 weeks		2 weeks
acceptance of PO						
submission of drawings						
drawings approval						
equipment manufacturing						
equipment shipment						
plant operations manuals						

The delivery schedule is presented based on current workload backlogs and production capacity. This estimated delivery schedule assumes no more than 2 weeks for buyer review of submittal drawings. Any delays in buyer approvals or requested changes may result in additional charges and/or a delay to the schedule.

4.4 freight terms

The following freight terms used are as defined by INCOTERMS 2010.

All pricing is DDP to Port of New Jersey.

4.5 terms and conditions of sale

This proposal has been prepared and is submitted based on seller's standard terms and conditions of sale.

World water works

Clean Water and Energy from Wastewater

11/24/2021

PROPOSAL
Arcadis-NewtownCreek-NYC-IFAS

CLIENT
Arcadis

END USER
New York DEP

REPRESENTATIVE
Serdar Umar, G.A. Fleet Associates, Inc-HarrisonNY

DATE: November 24, 2021
TO: Arcadis
FROM: Chandler Johnson & Sherri Caneer, World Water Works, Inc. (WWW)
RE: IFAS BUDGETARY PROPOSAL for Newtown Creek WWTP, NYC

Thank you for your interest in World Water Works and our IFAS technology. We have prepared this preliminary proposal for you based on the design criteria provided. Please review and we look forward to hearing back from you. We encourage you to reach out to our references to understand how others have enjoyed the experience of working with World Water Works.

The document has been organized to provide:
1) OVERVIEW
2) DESIGN BASIS
3) SCOPE OF SUPPLY
4) PRICING & DELIVERY
5) CONTRACTUAL

WWW has the technology, team and record of customer satisfaction to provide you the assurance of success and long-term value. WWW delivers:
- A passionate and technical team
- A track record of customer satisfaction
- Lasting technology that is capitally and operationally cost effective
- The ability to achieve the desired goals consistently
- An industry leading warranty and performance guarantee

We look forward to partnering with you for lasting success! Let's schedule a time in the near future to review this proposal in detail and to move on to the next steps of refining project details and developing a formal sales agreement.

Best Regards,

Chandler Johnson *Sherri Caneer*

Chandler Johnson
World Water Works, Inc.

Sherri Caneer
World Water Works, Inc.

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DESIGN BASIS

1. TECHNOLOGY OVERVIEW

Ideal IFAS™ – Integrated Fixed-film Activated Sludge

The Ideal IFAS™ system removes soluble materials (BOD, COD and NH_3-N) from the waste stream through highly efficient aerobic biological degradation. The Ideal IFAS process achieves high removal rates in the smallest footprint possible. This process provides for the abilty to upgrade existing tanks on site to meet new effluent standards and higher loads without having to build any new tanks. The system is tolerant of both load swings and temporary load deprivation.

The IFAS system is a portion of a conventional activated sludge system partially filled with specialized media. The media provides a highly advantageous site for the nitrification bacteria to grow and thrive. A stainless steel aeration manifold installed in the bottom of the IFAS zone provides both DO and mixing by means of a blower. A stainless steel media retention sieve near the top of the IFAS zone allows the MLSS to exit the reactor while retaining the media in the tank. The bacteria will digest the organics and ammonia in the waste stream converting the ammonia into nitrate and the soluble material to biomass, which can be removed downstream of this process typically in conventional secondary clarifiers. A dissolved oxygen meter will provide the ability to control the amount of dissolved oxygen injected into the waste stream.

2. DESIGN BASIS

It is critical that the basis of design is accurate and meets the facility's current and future demands. The following information relates to the design basis used for this proposal. Any changes will likely impact design and costs.

Project Goals:

Type of Facility:

Type of Industry	Municipal: Municipal POTW

Facility Information:

Hours Of Operation (hours/day):	24
Days Of Operation (days/week):	7
Weeks Of Operation (weeks/year):	52
Project Type:	Upgrade of Existing System
Elevation At Site (ft):	33

Plant Flow Information:

Avg. Month Flowrate (GPD):	242,000,000
Max. Month Flowrate (GPD):	277,000,000
Instant Peak Flow (GPM):	578 MGD total (48.2 MGD per IFAS zone)
Maximum Temperature (°F):	82
Minimum Temperature (°F):	59

Influent Parameters to Biological System				
	Average Month		Maximum Month	
Total BOD5	183.41 mg/L	370,408 lb/day	184.27 mg/L	425,969 lb/day
Soluble BOD5	87.31 mg/L	176,335 lb/day	87.72 mg/L	202,785 lb/day
Total COD	366.81 mg/L	740,815 lb/day	368.53 mg/L	851,937 lb/day
Soluble COD	174.62 mg/L	352,670 lb/day	175.44 mg/L	405,570 lb/day
Total Nitrogen	30.90 mg/L	62,415 lb/day	31.05 mg/L	71,777 lb/day
TKN	30.90 mg/L	62,415 lb/day	31.05 mg/L	71,777 lb/day
Organic Nitrogen	10.86 mg/L	21,926 lb/day	10.91 mg/L	25,215 lb/day
NH3-N	20.05 mg/L	40,489 lb/day	20.14 mg/L	46,562 lb/day
NO3-N	0.00 mg/L	0 lb/day	0.00 mg/L	0 lb/day
Alkalinity	350.00 mg/L	706,864 lb/day	350.00 mg/L	809,096 lb/day
TSS	162.14 mg/L	327,462 lb/day	162.90 mg/L	376,582 lb/day
VSS	144.96 mg/L	292,768 lb/day	145.64 mg/L	336,683 lb/day
Total Phosphorus	4.06 mg/L	8,196 lb/day	4.08 mg/L	9,425 lb/day
Ortho-Phosphate	2.46 mg/L	4,966 lb/day	2.47 mg/L	5,711 lb/day

	Maximum Week	
Total BOD5	177.27 mg/L	500,050 lb/day
Soluble BOD5	84.39 mg/L	238,052 lb/day
Total COD	354.55 mg/L	1,000,100 lb/day
Soluble COD	168.78 mg/L	476,104 lb/day
Total Nitrogen	29.87 mg/L	84,260 lb/day
TKN	29.87 mg/L	84,260 lb/day
Organic Nitrogen	10.49 mg/L	29,600 lb/day
NH3-N	19.38 mg/L	54,660 lb/day
NO3-N	0.00 mg/L	0 lb/day
Alkalinity	350.00 mg/L	987,273 lb/day
TSS	156.72 mg/L	442,074 lb/day
VSS	140.12 mg/L	395,237 lb/day
Total Phosphorus	3.92 mg/L	11,064 lb/day
Ortho-Phosphate	2.38 mg/L	6,704 lb/day

Biological Treatment System Proposed design for Maximum Month Conditions

Pre-Anoxic Tank dimensions	**Cell A**	= 827,820 ft3 at 14.6 ft SWD
Aerobic Tank dimensions	**Cell B IFAS**	= 1,379,700 ft3 at 15 ft SWD
	Cell C IFAS	= 1,379,500 ft3 at 15 ft SWD
Recommended freeboard		= 2 – 3 ft minimum
Aeration system	**- In IFAS Zone**	= WWW Medium Bubble Aeration System
Residual D.O. level		= 3.0 – 5.0 mg/L (depending on loading)
Total air requirement		= 240,000 SCFM – 15C - Average Month = 298,000 SCFM – 15C - Max Month = 383,000 SCFM – 15C - Max Week
Blower discharge pressure at Interface		= 6.7 psig
NH_3-N to be nitrified		= AM – 38,413 lb/day = MM – 44,185 lb/day = MW – 51,775 lb/day
Average MLSS / MLVSS		= AM – 3,000 mg/L, MM & MW – 2,000 mg/L (assume MLVSS 2,310 mg/L & 1,540 mg/L)
Aerobic MLSS SRT (Not counting biofilm on media)		= AM – 1.34 days = MM – 0.76 days = MW – 0.65 days
Estimated WAS from System (dry sludge)		= AM – 358,826 lb/day = MM – 421,631 lb/day = MW – 494,855 lb/day
Media Provided of 650 m^2/m^3 media		= 40,863 m^3; 26,560,950 m^2 of surface area
Media Nitrification Rate -IFAS #1		= 0.56 g NH_3-N/m^2-day at 15C and 3.0 mg/L DO – AM = 0.744 g NH_3-N/m^2-day at 15C and 4.0 mg/L DO – MM = 0.910 g NH_3-N/m^2-day at 15C and 5.0 mg/L DO - MW
Media Nitrification Rate -IFAS #2 – All Load conditions		= 0.655 g NH_3-N/m^2-day at 15C and 3.0 mg/L DO
MLSS Nitrification Rate		= 0.0 g NH_3-N/kg MLVSS-hr at 15C

3. SCOPE DOCUMENT

The below model numbers and equipment selection is based upon the information and data provided. In order to provide this proposal, certain assumptions were made. For example, items as transfer pump designs, blower designs and VFDs (where applicable) may be adjusted based upon final layouts, head pressures and other elements that could impact the selections.

Project Mgt, Eng & Design				
Quantity	**Model**	**Equipment Description**	**Description**	**Provided By**
1	DRAW-MBBR	Process Engineering, Design & Project Management	Drawing Package - MBBR Only	WWW

Biological Process				
Quantity	Model	Equipment Description	Description	Provided By
40,863	MBBR-MEDIA-WWW-01V	MBBR - Media	Moving Bed Biofilm Reactor Media - 650 m2/m3 - Virgin	WWW
24	MANI-LT14	MBBR Manifolds	Aeration Manifold - SS304	WWW
1080	MBBR-SIEV-1700K	MBBR Sieve	MBBR Sieve - upto 1.7 MGD 16 Inch D x 12 Foot L	WWW
72	MBBR-SIEV-Other12	MBBR Overflow Sieve	MBBR Sieve - 12 Inch D x 1 Foot L	WWW
24	MBBR-SIEV-Other6	MBBR Drain Sieve	MBBR Sieve - 6 Inch D x 1 Foot L	WWW
12	CHEM-CS1-CS	Antifoam Feed System	Chemical Feed - Standard - 1 Pump	WWW
12	*TANK-MBBR-*	*TANK*	*Anoxic Reactor Tank 827,820 ft3 Total*	*Existing*
12	*TANK-MBBR-*	*TANK*	*IFAS Zone 1 & 2 1,379,700 ft3 Total per zone*	*Existing*
12	*LC-LS-Float*	*Float Level Controls*	*Level Switch - Float*	*Others*
LOT	*BLOW-*	*Blower*	*Blower*	*Others*
LOT	*VFD-*	*Variable Frequency Drive*		*Others*
LOT	*Inst*	*DO, Temp, pH Probe(s)*		*Others*

Controls & Electrical			
Quantity	Model	Description	Provided By
1	FD	Functional Description	WWW
1	*CTRLS - LVP*	*Low Voltage Electrical Cabinet*	*Others*
1	*CTRLS-HV*	*High Voltage Control Cabinet*	*Others*

Miscellaneous

Quantity	Model	Equipment Description	Description	Provided By
1	*LAB-MBBR*	*Lab Kit*	*LK-General Kit; LK-TSS Kit; LK-Hach Kit; LK-NH3-N TNT; LK-TP TNT; LK-HRCOD Kit; LK-LRCOD Kit; LK-Port pH/DO/Cond; LK-pH Standards*	*Owner*

QC & Shipping

Quantity	Model	Equipment Description	Description	Provided By
1	QCSH-QC	Quality Control	Factory QA/QC by WWW	WWW
1	QCSH-	Freight	FOB Destination (Off-Loading BY OTHERS)	WWW

Startup and Training

Quantity	Model	Equipment Description	Description	Provided By
20	SERV-FSO-3M	Startup and Training Services	Field Service - 3 Days On Site, 2 Travel Days per Trip, Expenses Included	WWW

Warranty

Quantity	Model	Equipment Description	Description	Provided By
1	WTY-1	Warranty	1-Year Mechanical	WWW

4. UTILITIES (To Be Provided by Others; Subject to Final Design)

POWER	
High Voltage Power	480, 3 Phase, TBD Amps
Low Voltage Power	
Ancillary	110 V, 1 Phase 20 Amp
Chemical Feed(s)	110 V, 1 Phase 20 Amp

5. DRAFTING ENGINEERING SERVICES

World Water Works offers a variety of drafting and engineering package options from basic packages to full design/build engineering packages. Based upon the scope of supply and client discussions the following package has been selected. Please let us know if a different level of drawings and engineering services are required.

Basic Integrated Solution Engineering Package (limited to WWW's Scope of supply)

The Basic Integrated Solution Engineering Package includes:

- Piping & Instrument Diagrams (P&ID) for all unit processes of equipment provided
- General Equipment Layouts for all equipment provided within scope of supply
- Electrical Panel Layouts and PLC panels (if applicable)
- Equipment Cut Sheets

6. FACTORY TESTING – QUALITY CONTROL

World Water Works conducts numerous tests over the course of the manufacturing process to meet the highest of quality standards. WWW documents and keeps on record these tests, which are available to our clients. WWW invites the engineer and/or the client to witness this testing in Oklahoma City, OK.

7. FIELD SUPPORT, STARTUP & TRAINING SERVICES

The success of any system relies not only in the excellence of the technology and the proper design; it also relies upon proper operational ownership. With years of experience, WWW has developed highly effective training methods to assure success. World Water Works offers a variety of field service package options that can be tailored to best meet the project needs and treatment goals. The scope of supply lists out the services provided.

Important Notice: All onsite service is based on Travel on Monday and Fridays with days on site Tuesday, Wednesday, and Thursday. If weekend travel and/or onsite service is required, additional costs will be applied. Travel is based on notification two weeks in advance to be on site for meetings, service, etc.

PRICING and DELIVERY

8. TIMELINE

Submittal Preparation	8 weeks
Equipment Construction	26-30 weeks
Inspection & Shipment	3-4 weeks

Note: Project delivery timing will be subject to timing of the order and timely approvals and payments by the customer. WWW manufactures its technology fully in-house, which gives us greater flexibility in meeting scheduling demands. **Please inquire about special timing requirements that may be available and potentially subject to additional fees.**

9. SHIPPING

Incoterm	FOB Destination
Shipping & Handling Terms	Freight Allowed
Desired Delivery Date	TBD

10. PAYMENT TERMS

10% Down Payment - Due Upon Receipt

15% Upon Submittal Approval - Due Net 30 Days

65% Upon Delivery of System - Due Net 30 Days

10% Payment Upon Performance - Due Net 30 Days (Not to Exceed 90 Days from Shipping)

11. BUDGETARY PRICE

The following pricing is budgetary and will be finalized based upon final design and refinement of terms and options selected.

Budget Price.. $47,500,000 USD

(Startup and Training/Shipping Included) –HAS $7.5 MILLION IN EXTRA SHIPPING BASED ON CURRENT WORLD SHIPPING SITUATION. FOR THIS VOLUME OF MEDIA, US PRODUCTION WOULD BE HIGHLY INVESTIGATED

This includes the specified equipment and services in the scope section labeled “WWW”, but are not inclusive of any of the items labeled “BY OTHERS”, “OPTIONAL”, “EXISTING”, or the responsibilities of the Customer itemized in the section below titled “CUSTOMER TO SUPPLY” and “CUSTOMER RESPONSIBILITIES”. This pricing also does not include any applicable local, state, and federal sales and use taxes, tariffs, duties, import taxes, brokerage fees, bonding, system installation costs and equipment shipping costs beyond what is stated.

CONTRACTUAL INFORMATION

12.MECHANICAL WARRANTY & PERFORMANCE GUARANTEE

Equipment will be warranted from defects in materials, workmanship and design for a period of 12 months from the date upon which the goods are used or put into operation or 18 months from shipment, whichever occurs first. Warranty is contingent upon the system being stored, installed, operated and maintained in accordance with World Water Works' instructions. Extended warranties are available for an additional cost. World Water Works will provide a Performance Guarantee based upon final design and scope mutually agreed upon.

13.CUSTOMER TO SUPPLY (Unless Otherwise Specified in This Document)

- All Costs of Installation to include, but not be limited to: System Unloading, Piping and Electrical Installation, any/all Building/Foundation work, Permitting Costs, etc.
- Sufficient room for the equipment, sufficient water, sufficient heating and/or cooling, and sufficient compressed air to meet the requirements of the project.
- All utilities, sewer and solid waste disposal systems, chemicals, and laboratory testing required to operate the system to include, but not be limited to: phone/internet, electrical power supply, potable water at proper pressures and compressed air.
- Customer shall inform Company of any third-party inspection requirements. Customer shall pay any and all charges, which may be incurred for third party approval. Licenses and permits as required.
- Personnel trainable in operation and control of system and that follows WWW's recommendations.
- The above listed materials are based on the Company's interpretation of the plans and specifications. Any changes to this proposal are subject to price revision.
- Additional Customer requirements may be defined based upon final design and scope mutually agreed upon.

14.TERMS AND CONDITIONS

WWW Standard Terms and Conditions of sale are available upon request.

QUOTATION

PSI PROCESS
Pumping Services, Inc.
201 Lincoln Blvd.
Middlesex, NJ 08846
(732) 469-4540
www.psiprocess.com

Quote No. DJS004288 Job No. PSI-004288

Reference: PSI-004288 Newtown Creek Screens

To: Arcadis

Attention: Mariana Costa Tomazelli, P.E.

ITEM QTY DESCRIPTION November 24, 2021

Our proposal for equipment and services for the subject project is based on the applicable sections note below.

Section 11330 Multi-Rake Bar Screens

1 12 Headworks MS Series Screens as described in attached Scope of Supply dated November 24, 2021

- Manufactured in two (2) sections
- 316 Stainless Steel construction and components
- Lifting lugs to accommodate installation;
- Drive unit
- Bar Screen Control Panel (BSCP) NEMA 12
- Local Control Station NEMA 7
- Water Level Monitoring System
- Supports and Wall Guides (anchor bolts to be furnished by others)
- Shop Witness Test
- On-site factory technician services (total for project, NOT per screen):
    - Installation supervision, maximum of two (2) visits at three (3) days per visit;
    - Field testing, maximum of four (4) visits at two (2) days per visit;
    - Initial Equipment Startup, maximum of two (2) visits at one (1) day per visit
    - Training, maximum of two (2) visits at one (1) day per visit.
- Submittals

2 1 Lot of spare parts:

- As specified

3 1 Five (5) year limited warranty as described in attached scope.

4 1 Shipping to jobsite

Total price……………………………………………………………….$4,578,171

IMPORTANT NOTES AND EXCLUSIONS:
We include only the equipment, material and services listed above in our proposal and anything not listed is specifically excluded. The equipment offered is per the specific sections of the specifications as noted herein and it is offered either as specified or as an equal subject to engineering approval.

Credit Terms:
The price of the Equipment is based upon the following conditions:

20%	Upon Approval of Submittals
70%	due net 30 days from date of equipment shipment. Where Buyer is responsible for any delay in shipment, the date of the completion of the equipment or materials shall be the date of shipment for purposes of payment
10%	Retainage due net 30 days from date of Start-Up, but no later than 180 days from shipment.

Pricing is based on receipt of a Purchase Order within 60 days from the date of this Offer and shipment of the equipment not later than 9 months from the date of the Offer. In the event Buyer cannot take the equipment within the stipulated time, the price will escalate 0.5% per month thereafter. All storage and related insurance costs are the account of the Buyer.

These terms are independent of and not contingent upon the time and manner in which the purchaser receives payment from the site owner or any other person. Acceptance of order is subject to credit approval. All monies not paid when due will accrue interest at the rate of one and one-half percent (1.5%) per month calculated from the date of each invoice.

PRICES DO NOT INCLUDE FEDERAL, STATE OR CITY TAXES

TERMS	**F.O.B.**	**DELIVERY**
As Above	Factory	Delivery to be Coordinated

Purchase Orders should be issued to Pumping Services, Inc. unless stated otherwise in the body of this proposal. Purchase Orders are subject to final acceptance at Pumping Services, Inc., and to all of its standard terms and conditions contained on the reverse side of the initial page of this quote which the purchaser by its acceptance of this quotation constitutes an acceptance.

Respectfully submitted by ______________________________

David J. Silverman, P.E.

Acceptance of Proposal – The preceding prices, specifications and conditions including those on the reverse side of page on are satisfactory and hereby accepted. You are authorized to proceed.

Signature | Name Print/Type | Official Position | Date

Newtown Creek WPCP

11/24/2021

Project Summary	Item	Units	Budget Price
Equipment			
Bar Screen MS1 Primary 2mm Bar Screen	1	12	$4,578,171

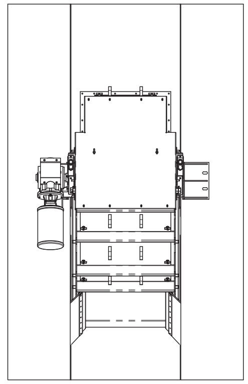
Type of Product
Bar Screen MS1

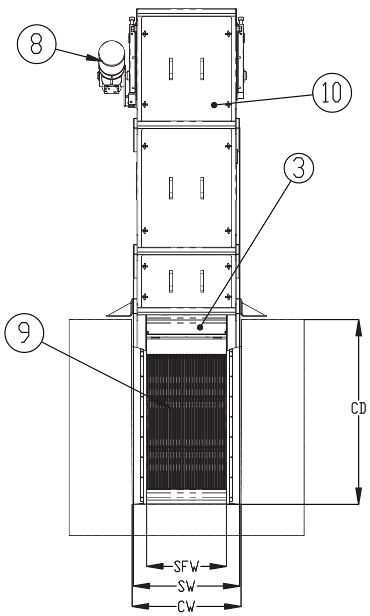
Project Name	**NC Enhanced N Removal**
Offer Number	B-2021-NYCDEP-NC-001
Screen Name	Primary Influent Screen
Item Number	1
No. of Screens	12

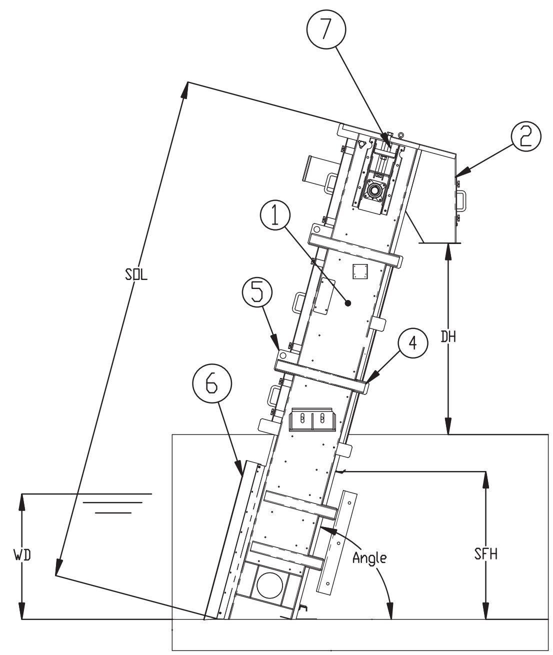
Screen Data	
Screen Overall Length (SOL)	33.41
Operating Floor to Channel Invert (OF)	23
Channel Depth (CD)	23
Channel Width (CW)	6.33
Screen Total Width (Approx)	6
Screen Field Width (SFW)	5
Water Depth (WD)	12.35
Discharge Height (DH)	4
Screen Field Height (SFH)	15
Bar Spacing (BS)	0.08
Wall Recess	No
Floor Recess	No
Screen Grouted When in Recess	No
# of Sections/Pieces	2
Material	SS 316
Chain Roller Type	Stainless
Top Enclosed	Yes
Installation Angle (deg)	80 deg
Weight (per screen)	7369 lbs.
Pull Out Type	Yes
Pivot Type	No
Q Max Specified	72.8
Q Max (V= 3 fps in channel)	184.09
Q Max (V= 2 fps in channel)	122.73
Headloss at 2 fps in channel (in.)	15.4
Headloss at 3 fps in channel (in.)	34.6

Screen Scope of Supply	Supplied?
Headworks Bar Screen MS1	Yes
Spare Parts	Yes
Ultrasonic Level Sensor	Yes
Control Panel (Main NEMA 12 and Local NEMA 7)	Yes
Interconnecting Wiring	No
O&M Manual and Training	Yes

Item No.	Part	Material
1	SIDE FRAME	304/316 SS
2	DISCHARGE CHUTE	304/316 SS
3	DEBRIS PLATE	304/316 SS
4	SIDE STIFFNER	304/316 SS
5	LIFTING PAD	304/316 SS
6	SEAL	BUNA N
7	CHAIN ADJUSTER	304/316 SS
8	GEARMOTOR	CAST IRON
9	TAPER BAR	304/316 SS
10	SCREEN COVERS	POLYCARBONATE/SS







Screenfield Width ....SFW
Screen Frame Width..........SW
Channel Depth..........CD
Channel Width..........CW
Discharge Height..........DH
Screenfield Height..........SFH
Screen Overall Length..........SOL
Water Depth..........WD

Rev	DESCRIPTION	NAME	DATE
0	FOR INFORMATION ONLY		

CHECKED BY: DATE:
DRAWN BY: DATE:

SCALE: 1:48
PROJ. NO:
PLANT:
LOCATION:

MS SERIES BAR SCREEN
MODEL MS1
TEMPLATE DRAWING

Mo. 12 Yr. 14 Rev: 0 Sht: 1 of 1

Headworks Inc.
11000 Brittmoore Park Dr.
Houston, Texas 77041

OVIVO Worldwide Experts in Water Treatment

BUDGETARY PROPOSAL REV. A

NOVEMBER 18, 2021

NEWTOWN CREEK WRF

Ovivo® Drum Screen

PREPARED FOR

Arcadis

AREA REPRESENTATIVE

Sherwood Logan & Associates

Jim Konatsotis

PREPARED BY:

RICHARD QUICK

Phone: (801) 931-3000

Richard.Quick@ovivowater.com

Ovivo USA, LLC is pleased to submit a budgetary proposal for the following equipment (the "Products") on the project indicated above (the "Project"). This proposal, either in its original form or in its "as sold" format, constitutes Ovivo's contractual offer of goods and services in connection with the Project.

While every effort has been made to ensure this quotation captures the intent of the project, we do anticipate further discussion in order to clarify and/or finalize the scope, terms & conditions and other details prior to any formal agreement. We look forward to your favorable review of our offer to further discussions on this important project.

THIS BUDGETARY PROPOSAL CONSTITUTES A NON-BINDING ESTIMATE OF PRICE(S) FOR CERTAIN GOODS AND/OR SERVICES THAT MAY BE PROVIDED BY OVIVO USA, LLC FROM TIME TO TIME, BUT SHALL NOT BE CONSTRUED AS A CONTRACTUAL OFFER FOR OVIVO USA, LLC TO PROVIDE SUCH GOODS AND/OR SERVICES. ANY CONTRACTUAL OFFER FOR THE SUPPLY OF GOODS AND/OR SERVICES BY OVIVO USA, LLC SHALL BE CONVEYED TO CUSTOMER IN THE FORM OF OVIVO USA, LLC STANDARD PROPOSAL DOCUMENT, WHICH INCLUDES, BUT IS NOT LIMITED TO, ITS STANDARD TERMS AND CONDITIONS OF SALE. SUCH PROPOSAL FORM MAY BE PROVIDED TO CUSTOMER UPON REQUEST.

Budgetary Pricing for Proposed Equipment:

ITEM	EQUIPMENT	PRICE
I	Eight (8) Ovivo® Drum Screen Systems	**$9,368,000**

ITEM I STANDARD SCOPE OF SUPPLY

ITEMS INCLUDED:

Eight (8) Each, Seven (7) Duty & One (1) Standby, Ovivo® Brackett Green Drum Screens, 316SS Fabrication, 100 MGD Max per screen

- Drum Screen Capture Rate, 98% with 2mm orifice
- Drum Screen width approximately: 13.5 Ft.
- Drum screen diameter approximately: 24.0 Ft.
- 2 HP, 1800 RPM, TEFC helical gear motor suitable for 460/3/60 supply, Outdoor/Class I Div. I
- Standard nylon rack and pinion gear drive.
- Full Covers, Spray wash hood and nozzles
- **2mm** Ovivo ProPaPanel®
- Wash water requirement of 168 GPM @ 40 psi minimum, per screen.
- Anchor and Assembly Fasteners

Eight (8) Standard Ovivo Smart NEMA 4 Control Panels:
Control panel and control system shall be designed and implemented per Ovivo standard screen system controls spec document number: CD01201. This specification shall supersede all other specification(s) related to this project, including but not limited to customer specifications and or third party engineering specifications. If the requirements of the customer are to follow a custom specification, a fill review by Ovivo must be performed. After a full review, Ovivo reserves the right to adjust this bid/proposal with a new controls system, and price.
Ovivo's standard controls package shall include at minimum the following:

- One standard main control enclosure per specification CD01201 that will include;
    a. HMI
    b. PLC
    c. E-stop Push Button
- One Operator control console (OCC) per specification CD01201, that will include;
    a. E-Stop Push Button
    b. Hand Of Auto (HOA) Selector switch
- One Interconnection document (ICD) per specification CD01201
- One programmed Programmable Logic Controller (PLC) per specification CD01201
- One programmed Human Machine Interface (HMI) per specification CD01201

Freight, FCA to job site.

ITEMS NOT INCLUDED UNLESS SPECIFICALLY NOTED ABOVE (But not limited to the following):

- Access ladder, platform, or stairs.
- Concrete, grout, or concrete design.
- Consumables.
- Control panel mounting and field wire terminations.
- Disposal of any kind.
- Dumpster.
- Field wire and field conduit
- Field or shop paint.
- Grating.
- Installation.
- Lubricants.
- Man lifts or cranes.
- Offloading at job site.
- Piping and piping insulation.
- Recordings of training sessions.
- Spares.
- Special tools.
- Special site PPE.
- Storage.
- **Taxes.**

Additional Information:

FIELD SERVICE OPTION:

2 trips of 10 days total of service, at the site for the supervision of equipment start-up, testing supervision, and instructing the operators.

Additional service days may be purchased at the current rate.

TYPICAL LEAD TIMES:

Submittals: 8 weeks after Purchaser's receipt of Ovivo's written acknowledgement of an approved purchase order.

Shipping: 36 weeks after receipt of approved drawings from Purchaser.

OVIVO
Worldwide Experts in Water Treatment

TERMS AND CONDITIONS OF SALE

1. ACCEPTANCE. The proposal of **Ovivo USA, LLC** ("SELLER"), as well as these terms and conditions of sale (collectively the "Agreement"), constitutes SELLER's contractual offer of goods and associated services, and PURCHASER's acceptance of this offer is expressly limited to the terms of the Agreement. The scope and terms and conditions of this Agreement represent the entire offer by SELLER and supersede all other solicitations, discussions, agreements, understandings and representations between the parties. Any scope or terms and conditions included in PURCHASER's acceptance/purchase order that are in addition to or different from this Agreement are hereby rejected.

2. DELIVERY. Any statements relating to the date of shipment of the Products (as defined below) represent SELLER's best estimate, but is not guaranteed, and SELLER shall not be liable for any damages due to late delivery. The Products shall be delivered to the delivery point or points in accordance with the delivery terms stated in SELLER's proposal. If such delivery is prevented or postponed by reason of Force Majeure (as defined below), SELLER shall be entitled at its option to tender delivery to PURCHASER at the point or points of manufacture, and in default of PURCHASER's acceptance of delivery to cause the Products to be stored at such a point or points of manufacture at PURCHASER's expense. Such tender, if accepted, or such storage, shall constitute delivery for all purposes of this agreement. If shipment is postponed at request of PURCHASER, or due to delay in receipt of shipping instructions, payment of the purchase price shall be due on notice from SELLER that the Products are ready for shipment. Handling, moving, storage, insurance and other charges thereafter incurred by SELLER with respect to the Products shall be for the account of PURCHASER and shall be paid by PURCHASER when invoiced. Delivery by SELLER of the Products shall constitute acceptance of the Products by PURCHASER, unless written notice of defect or nonconformity is received by SELLER within thirty (30) days of SELLER's delivery of the Products.

3. TITLE AND RISK OF LOSS. SELLER shall retain the fullest right, title, and interest in the Products to the extent permitted by applicable law, including a security interest in the Products, until the full purchase price has been paid to SELLER. The giving and accepting of drafts, notes and/or trade acceptances to evidence the payments due shall not constitute or be construed as payment so as to pass SELLER's interests until said drafts, notes and/or trade acceptances are paid in full. Risk of loss shall pass to PURCHASER at the delivery point.

4. PAYMENT TERMS. SELLER reserves the right to ship the Products and be paid for such on a pro rata basis, as shipped. If payments are not made by the due date, interest at a rate of two percent (2%) per month, calculated daily, shall apply from the due date for payment. PURCHASER is liable to pay SELLER's legal fees and all other expenses in respect of enforcing or attempting to enforce any of SELLER's rights relating to a breach or threatened breach of the payment terms by PURCHASER. In the event of nonpayment SELLER reserves the further right to seek compensation from any third party in possession of the Products.

5. TAXES. Unless otherwise specifically provided in SELLER's quotation/proposal; PURCHASER shall pay and/or reimburse SELLER, in addition to the price, for all sales, use and other taxes, excises and charges which SELLER may pay or be required to pay to any government directly or indirectly in connection with the production, sale, transportation, and/or use by SELLER or PURCHASER, of any of the Products or services dealt with herein (whether the same may be regarded as personal or real property). PURCHASER agrees to pay all property and other taxes which may be levied, assessed or charged against or upon any of the Products on or after the date of actual shipment, or placing into storage for PURCHASER's account.

6. MECHANICAL WARRANTY. Solely for the benefit of PURCHASER, SELLER warrants that new equipment and parts manufactured by it and provided to PURCHASER (collectively, "Products") shall be free from defects in material and workmanship. The warranty period shall be twelve (12) months from startup of the equipment not to exceed eighteen (18) months from the earliest of the notice of readiness to ship or the actual shipment. If any of SELLER's Products fail to comply with the foregoing warranty, SELLER shall repair or replace free of charge to PURCHASER, EX WORKS SELLER's FACTORIES or other location that SELLER designates, any Product or parts thereof returned to SELLER, which examination shall show to have failed under normal use and service operation by PURCHASER within the Warranty Period; provided, that if it would be impracticable for the Product or part thereof to be returned to SELLER, SELLER will send a representative to PURCHASER's job site to inspect the Product. If it is determined after inspection that SELLER is liable under this warranty to repair or replace the Product or part thereof, SELLER shall bear the transportation costs of (a) returning the Product to SELLER for inspection or sending its representative to the job site and (b) returning the repaired or replaced Products to PURCHASER; however, if it is determined after inspection that SELLER is not liable under this warranty, PURCHASER shall pay those costs. For SELLER to be liable with respect to this warranty, PURCHASER must make its claims to SELLER with respect to this warranty in writing no later than thirty (30) days after the date PURCHASER discovers the basis for its warranty claim and in no event more than thirty (30) days after the expiration of the Warranty Period. In addition to any other limitation or disclaimer with respect to this warranty, SELLER shall have no liability with respect to any of the following: (i) failure of the Products, or damages to them, due to PURCHASER's negligence or willful misconduct, abuse or improper storage, installation, application or maintenance (as specified in any manuals or written instructions that SELLER provides to the PURCHASER); (ii) any Products that have been altered or repaired in any way without SELLER's prior written authorization; (iii) The costs of dismantling and reinstallation of the Products; (iv) any Products damaged while in transit or otherwise by accident; (v) decomposition of Products by chemical action, erosion or corrosion or wear to Products or due to conditions of temperature, moisture and dirt; or (vi) claims with respect to parts that are consumable and normally replaced during maintenance such as filter media, filter drainage belts and the like, except where such parts are not performing to SELLER's estimate of normal service life, in which case, SELLER shall only be liable for the pro rata cost of replacement of those parts based on SELLER's estimate of what the remaining service life of those parts should have been; provided, that failure of those parts did not result from any of the matters listed in clauses (i) through (v) above. With regard to third-party parts, equipment, accessories or components not of SELLER's design, SELLER's liability shall be limited solely to the assignment of available third-party warranties. **THE PARTIES AGREE THAT ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE AND MERCHANTABILITY, WHETHER WRITTEN, ORAL OR STATUTORY, ARE EXCLUDED TO THE FULLEST EXTENT PERMISSIBLE BY LAW.** All warranties and obligations of SELLER shall terminate if PURCHASER fails to perform its obligations under this Agreement including but not limited to any failure to pay any charges due to SELLER. SELLER's quoted price for the Products is based upon this warranty. Any increase in warranty obligation may be subject to an increase in price.

7. CONFIDENTIAL AND PROPRIETARY INFORMATION. All nonpublic or proprietary information and data furnished to PURCHASER hereunder, including but not limited to price, size, type, design and other technical or business information relating to the Products is the sole property of SELLER and submitted for PURCHASER's own confidential use solely in connection with this Agreement and is not to be made known or available to any third party without SELLER's prior written consent.

8. SURFACE COATING. Any Product coating provided by SELLER shall be in accordance with SELLER's standard practice, unless otherwise agreed in writing.

9. DRAWINGS AND TECHNICAL DOCUMENTATION. When PURCHASER requests to approve drawings before commencement of manufacture, shipment may be delayed if approved drawings are not returned to SELLER within fourteen (14) days of receipt by PURCHASER of such drawings for approval. SELLER will furnish only general arrangement, general assembly, and if required, wiring diagrams, erection drawings, installation and operation-maintenance manuals for SELLER's equipment (in English language). SELLER will supply six (6) complete sets of drawings and operating instructions. Additional sets will be paid for by PURCHASER. Electronic files, if requested from SELLER, will be provided in *pdf, jpg or tif* format only.

10. SET OFF. This Agreement shall be completely independent of all other contracts between the parties and all payments due to SELLER hereunder shall be paid when due and shall not be setoff or applied against any money due or claimed to be due from SELLER to PURCHASER on account of any other transaction or claim.

11. SOFTWARE. PURCHASER shall have a nonexclusive and nontransferable license to use any information processing program supplied by SELLER with the Products. PURCHASER acknowledges that such programs and the information contained therein is Confidential Information and agrees: a) not to copy or duplicate the program except for archival or security purposes; b) not to use the program on any computer other than the computer with which it is supplied; and c) to limit access to the program to those of its employees who are necessary to permit authorized use of the program. PURCHASER agrees to execute and be bound by the terms of any software license applicable to the Products supplied.

12. PATENT INDEMNITY. SELLER will defend at its own expense any suit instituted against PURCHASER based upon claims that SELLER's Product hereunder in and of itself constitutes an infringement of any valid apparatus claims of any United States patent issued and existing as of the date of this Agreement, if notified promptly in writing and given all information, assistance, and sole authority to defend and settle the same, and SELLER shall indemnify the PURCHASER against such claims of infringement. Furthermore, in case the use of the Products is enjoined in such suit or in case SELLER otherwise deems it advisable, SELLER shall, at its own expense and discretion, (a) procure for the PURCHASER the right to continue using the Products, (b) replace the same with non-infringing Products, (c) modify the Product so it becomes non-infringing, or (d) remove the Products and refund the purchase price less freight charges and depreciation. SELLER shall not be liable for, and PURCHASER shall indemnify SELLER for, any claim of infringement related to (a) the use of the Products for any purpose other than that for which it was furnished by SELLER, (b) compliance with equipment designs not furnished by SELLER or (c) use of the Products in combination with any other equipment. The foregoing states the sole liability of SELLER for patent infringement with respect to the Products

13. GENERAL INDEMNITY. Subject to the limitations of liabilities of the parties set forth in this Agreement, each party shall protect and indemnify the other party, its parent and their respective officers, directors, employees and agents, from and against all claims, demands and causes of action asserted by, or in favor of, any entity to the extent of the indemnifying party's negligence or willful misconduct in connection with the performance of this agreement.

14. DEFAULT, TERMINATION. In the event that PURCHASER becomes insolvent, commits an act of bankruptcy or defaults in the performance of any term or condition of this Agreement, the entire unpaid portion of the purchase price shall, without notice or demand, become immediately due and payable. SELLER at its option, without notice or demand, shall be entitled to sue for said balance and for reasonable legal fees, plus out-of-pocket expenses and interest; and/or to enter any place where the Products are located and to take immediate possession of and remove the Products, with or without legal process; and/or retain all payments made as compensation for the use of the Products: and/or resell the Products, without notice or demand, for and on behalf of the PURCHASER, and to apply the net proceeds from such sale (after deduction from the sale price of all expenses of such sale and all expenses of retaking possession, repairs necessary to put the Products in saleable condition, storage charges, taxes, liens, collection and legal fees and all other expenses in connection therewith) to the balance then due to SELLER for the Products and to receive from the PURCHASER the deficiency between such net proceeds of sale and such balance. PURCHASER hereby waives all trespass, damage and claims resulting from any such entry, repossession, removal, retention, repair, alteration and sale. The remedies provided in this paragraph are in addition to and not limitations of any other rights of SELLER.

15. CANCELLATION. PURCHASER may terminate this Agreement for convenience upon giving SELLER thirty (30) days prior written notice of such fact and paying SELLER for all costs and expenses (including overhead) incurred by it in performing its work and closing out the same plus a reasonable profit thereon. All such costs and expenses shall be paid to SELLER within ten (10) days of the termination of the Agreement, or be subject to an additional late payment penalty of five percent (5%) of the total amount of costs and expenses owed.

16. REMEDIES. The rights and remedies of the PURCHASER in connection with the goods and services provided by SELLER hereunder are exclusive and limited to the rights and remedies expressly stated in this Agreement.

17. INSPECTION. PURCHASER is entitled to make reasonable inspection of Products at SELLER's facility. SELLER reserves the right to determine the reasonableness of the request and to select an appropriate time for such inspection. All costs of inspections not expressly included as an itemized part of the quoted price of the Products in this Agreement shall be paid by PURCHASER.

18. WAIVER. Any failure by SELLER to enforce PURCHASER's strict performance of any provision of this Agreement will not constitute a waiver of its right to subsequently enforce such provision or any other provision of this Agreement.

19. COMPLIANCE WITH LAWS. If applicable laws, ordinances, regulations or conditions require anything different from, or in addition to that called for by this Agreement, SELLER will satisfy such requirements at PURCHASER's written request and expense.

20. FORCE MAJEURE. If SELLER is rendered unable, wholly or in material part, by reason of Force Majeure to carry out any of its obligations hereunder, then on SELLER's notice in writing to PURCHASER within a reasonable time after the occurrence of the cause relied upon, such obligations shall be suspended. "Force Majeure" shall include, but not be limited to, acts of God, laws and regulations, strikes, civil disobedience or unrest, lightning, fire, flood, washout, storm, communication lines failure, delays of the PURCHASER or PURCHASER's subcontractors, breakage or accident to equipment or machinery, wars, police actions, terrorism, embargos, and any other causes that are not reasonably within the control of the SELLER. If the delay is the result of PURCHASER's action or inaction, then in addition to an adjustment in time, SELLER shall be entitled to reimbursement of costs incurred to maintain its schedule.

21. INDEPENDENT CONTRACTOR. It is expressly understood that SELLER is an independent contractor, and that neither SELLER nor its principals, partners, parents, subsidiaries, affiliates, employees or subcontractors are servants, agents, partners, joint ventures or employees of PURCHASER in any way whatsoever.

22. SEVERABILITY. Should any portion of this Agreement, be held to be invalid or unenforceable under applicable law then the validity of the remaining portions thereof shall not be affected by such invalidity or unenforceability and shall remain in full force and effect. Furthermore, any invalid or unenforceable provision shall be modified accordingly within the confines of applicable law, giving maximum permissible effect to the parties' intentions expressed herein.

23. CHOICE OF LAW, CHOICE OF VENUE. This Agreement shall be governed and construed in accordance with the laws of the State of Utah, without regard to its rules regarding conflicts or choice of law. The parties submit to the exclusive jurisdiction and venue of the state and federal courts located in Salt Lake City, Utah.

24. ASSIGNMENT. PURCHASER shall not assign or transfer this Agreement without the prior written consent of SELLER. Any attempt to make such an assignment or transfer shall be null and void. SELLER shall have the authority to assign, or otherwise transfer, its rights and obligations in connection with this Agreement, in whole or in part, upon prior written notice to PURCHASER.

25. LIMITATION ON LIABILITY. TO THE EXTENT PERMISSIBLE BY LAW, SELLER SHALL HAVE NO FURTHER LIABILITY IN CONNECTION WITH THIS AGREEMENT IN EXCESS OF THE AMOUNT PAID BY PURCHASER FOR THE PRODUCTS GIVING RISE TO SUCH LIABILITY. NOTWITHSTANDING ANY LIABILITIES OR RESPONSIBILITIES ASSUMED BY SELLER HEREUNDER, SELLER SHALL IN NO EVENT BE RESPONSIBLE TO PURCHASER OR ANY THIRD PARTY, WHETHER ARISING UNDER CONTRACT, TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY, OR OTHERWISE, FOR LOSS OF ANTICIPATED PROFITS, LOSS BY REASON OF PLANT SHUTDOWN, NON-OPERATION OR INCREASED EXPENSE OF OPERATION, LOSS OF DATA, SERVICE INTERRUPTIONS, COST OF PURCHASED OR REPLACEMENT POWER, COST OF MONEY, LOSS OF USE OF CAPITAL OR REVENUE OR ANY OTHER INDIRECT, INCIDENTAL, SPECIAL, PUNITIVE, EXEMPLARY, OR CONSEQUENTIAL LOSS OR DAMAGE, WHETHER ARISING FROM DEFECTS, DELAY, OR FROM ANY OTHER CAUSE WHATSOEVER.

26. PRIVACY AND DATA PROTECTION. Seller has put in place rigorous safeguards and procedures regarding privacy and data protection, notably the Ovivo Privacy Policy (ovivowater.com/privacy-policy), and requires that Purchaser adhere to its data protection principles to the extent applicable to Purchaser.

27. DATA COLLECTION. PURCHASER consents to the collection of the Product's operational data and to the use of such data for the purpose of improving the Products and other purposes stated herein. PURCHASER further agrees that such data collection does not constitute a performance monitoring service or duty by SELLER.

28. INSURANCE. SELLER shall maintain that its current levels of insurance for the duration of the Project, as set forth in its standard certificate of insurance, available upon request.

29. BONDS. If PURCHASER deems it necessary, and within ten (10) days of PURCHASER's request, SELLER shall provide one or more Bonds in favor of PURCHASER, at PURCHASER's expense, by an institution, and in a form, approved in advance by SELLER.

30. PERMITS. PURCHASER shall be solely responsible to obtain and maintain in force all necessary permits with respect to any products to be provided by SELLER hereunder and any intended use by PURCHASER.

Diffused Aeration Equipment

for

Newtown Creek WWTP

Aeration Basins - SSLP Diffusers

Prepared For:

Arcadis

Represented by:
GA Fleet Associates

Sanitaire #s31147-21
November 22, 2021
as K:\s31147-21\2021.11.19 Input_Aeration_SSLP.aer

Sanitaire Aeration Design Inputs for: Newtown Creek WWTP, Sanitaire #s31147-21

Tank Geometry

12 Trains each Consisting of:		1	1	1	1	1	1	1	1
Parameter	Units	Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	Pass 6	Pass 7	Pass 8
Parallel Reactors		1	1	1	1	1	1	1	1
Pass Process		Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic
SWD	ft	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Submergence	ft	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0
Reactor Geometry:		Rect	Rect	Rect	Rect	Rect	Rect	Rect	Rect
Length	ft	73.0	76.0	56.0	68.0	68.0	97.0	48.0	48.0
Width	ft	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0

Oxygen/Air Distribution

	Zone	1	2	3	4	5	6	7	8
	Pass	1	2	3	4	5	6	7	8
Default		19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%

Oxygenation

Parameter	Units	Current Min Day	Current Average Annual	Current Max 30 Day	Current Max 7 Day	Current Max Day	Current Max Day (no denite)	2050 Min Day	2050 Average Annual	2050 Max 30 Day	2050 Max 7 Day	2050 Max Day	Max Day (no denite)
No. Trains Operating		12	12	12	12	12	12	12	12	12	12	12	12
Oxygen Requirement	lb/day	414,933.0-S	975,240.0-S	1,120,698.0-S	1,320,713.0-S	1,987,735.0-S	2,336,650.0-S	472,803.0-S	1,111,460.0-S	1,277,238.0-S	1,505,174.0-S	2,265,248.0-S	2,663,803.0-S

Standard Oxygen Correction Factor Parameters

Parameter	Units	Current Min Day	Current Average Annual	Current Max 30 Day	Current Max 7 Day	Current Max Day	Current Max Day (no denite)	2050 Min Day	2050 Average Annual	2050 Max 30 Day	2050 Max 7 Day	2050 Max Day	Max Day (no denite)
Site Elevation	FASL	15	15	15	15	15	15	15	15	15	15	15	15
Ambient Pressure	PSIA	14.69	14.69	14.69	14.69	14.69	14.69	14.69	14.69	14.69	14.69	14.69	14.69
Water Temperature	°C	***21***	***21***	***21***	***21***	***21***	***21***	***21***	***21***	***21***	***21***	***21***	***21***

Notes:
Bold, Italicized text indicate assumptions made by Sanitaire
A - Indicates Actual (AOR) Requirement.
S - Indicates Standard Condition (SOR) Oxygen requirement.
If the AOR/SOR parameter is not given, then its value will be evaluated later if suitable alpha, beta, D.O., theta, pressure, and temperature data is supplied.
Round tanks are evaluated as rectangular tanks diameter equal to length and equal surface area.
Annular tanks are evaluated as rectangular tanks of width equal to the annular width and equal surface area.

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21
Design Summary

		Operating Point & O2 Distribution											
	Units	Current Min Day Default	Current Average Annual Default	Current Max 30 Day Default	Current Max 7 Day Default	Current Max Day Default	Current Max Day (no denite) Default	2050 Min Day Default	2050 Average Annual Default	2050 Max 30 Day Default	2050 Max 7 Day Default	2050 Max Day Default	Max Day (no denite) Default
No. Trains in Operation		12	12	12	12	12	12	12	12	12	12	12	12
No. Grids in Operation		96	96	96	96	96	96	96	96	96	96	96	96
No. Operating Diffusers		54,972	54,972	54,972	54,972	54,972	54,972	54,972	54,972	54,972	54,972	54,972	54,972
SOR	lb/day	410,784	965,488	1,109,491	1,307,506	1,967,858	2,313,283	468,075	1,100,345	1,264,466	1,490,122	2,242,596	2,637,165
SOTE	%	27.6	24.7	24.2	23.7	22.5	22.0	27.2	24.3	23.8	23.3	22.1	21.6
Total Air Rate	scfm	59,349	156,167	182,787	220,136	349,706	419,972	68,803	181,082	211,950	255,254	405,472	487,135
Min.Diffuser Air Rate	scfm/diff.	1.07	2.81	3.29	3.96	6.29	7.56	1.24	3.26	3.81	4.59	7.3	8.77
Max. Diffuser Air Rate	scfm/diff.	1.09	2.88	3.37	4.06	6.45	7.75	1.27	3.34	3.91	4.71	7.48	8.99
Static Pressure	psig	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Diffuser DWP @ Min Air	psig	0.48	0.63	0.67	0.72	0.91	1.02	0.5	0.66	0.71	0.77	1.0	1.12
Diffuser DWP @ Max Air	psig	0.48	0.63	0.67	0.73	0.93	1.03	0.5	0.67	0.72	0.78	1.01	1.13
Pressure @ Top of Dropleg	psig	5.74	6.25	6.44	6.75	8.13	9.05	5.77	6.43	6.68	7.08	8.85	10.02
Est. Blower Efficiency		70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
Est. Motor Efficiency		90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Shaft Power	Bhp	1,961	5,541	6,655	8,336	15,461	20,276	2,285	6,581	7,954	10,058	19,225	25,546
Est. Motor Electrical Load	kW	1,626	4,593	5,516	6,909	12,816	16,807	1,894	5,455	6,593	8,337	15,935	21,175
Est. Standard Aeration Efficiency	#SOR/BHP-hr	8.73	7.26	6.95	6.54	5.30	4.75	8.53	6.97	6.62	6.17	4.86	4.30

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
and the aeration assembly dropleg connections.
Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other
Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21
Consulting Engineer: Arcadis
Operating Condition: Current Min Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	78,837.3	58,090.6	49,792.0	53,941.3	49,792.0	45,642.6	37,344.0	37,344.0	410,783.7
Air Rate (7)	scfm									

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	11,274.0	8,394.6	7,165.6	7,787.0	7,220.9	6,736.9	5,385.0	5,385.0	
Design Air (1,7)	scfm	11,274.0	8,394.6	7,165.6	7,787.0	7,220.9	6,736.9	5,385.0	5,385.0	59,348.9
Diffuser Air Rate	scfm/Diff.	1.08	1.08	1.09	1.08	1.09	1.08	1.07	1.07	1.08
Delivered SOR	lb/day	78,837.3	58,090.6	49,792.0	53,941.3	49,792.0	45,642.6	37,344.0	37,344.0	410,783.7
Delivered SOTE	%	27.9%	27.6%	27.7%	27.6%	27.5%	27.0%	27.7%	27.7%	27.6%
Pressure @ Top of Dropleg	psig	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74
Shaft Power	Bhp	372.5	277.4	236.7	257.3	238.6	222.6	177.9	177.9	1,961.3

Notes:
(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21

Consulting Engineer:	Arcadis
Operating Condition:	Current Average Annual
Oxygen Distribution:	Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	185,295.6	136,533.6	117,028.8	126,781.2	117,028.8	107,276.4	87,771.6	87,771.6	965,487.6
Air Rate (7)	scfm									

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	29,608.9	22,088.0	18,837.3	20,484.7	19,007.1	17,808.1	14,166.6	14,166.6	
Design Air (1,7)	scfm	29,608.9	22,088.0	18,837.3	20,484.7	19,007.1	17,808.1	14,166.6	14,166.6	156,167.2
Diffuser Air Rate	scfm/Diff.	2.83	2.84	2.85	2.85	2.88	2.84	2.81	2.81	2.84
Delivered SOR	lb/day	185,295.6	136,533.6	117,028.8	126,781.2	117,028.8	107,276.4	87,771.6	87,771.6	965,487.6
Delivered SOTE	%	25.0%	24.7%	24.8%	24.7%	24.6%	24.0%	24.7%	24.7%	24.7%
Pressure @ Top of Dropleg	psig	6.24	6.25	6.23	6.24	6.25	6.24	6.23	6.23	6.25
Shaft Power	Bhp	1,049.4	783.7	667.4	726.1	674.4	631.6	501.5	501.5	5,541.3

Notes:
(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21

Consulting Engineer: Arcadis
Operating Condition: Current Max 30 Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	212,932.6	156,897.7	134,483.8	145,690.7	134,483.8	123,276.8	100,862.8	100,862.8	1,109,491.0
Air Rate (7)	scfm									

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	34,645.2	25,852.9	22,044.9	23,975.3	22,248.3	20,859.1	16,580.8	16,580.8	
Design Air (1,7)	scfm	34,645.2	25,852.9	22,044.9	23,975.3	22,248.3	20,859.1	16,580.8	16,580.8	182,787.2
Diffuser Air Rate	scfm/Diff.	3.31	3.32	3.34	3.33	3.37	3.33	3.29	3.29	3.33
Delivered SOR	lb/day	212,932.6	156,897.7	134,483.8	145,690.7	134,483.8	123,276.8	100,862.8	100,862.8	1,109,491.0
Delivered SOTE	%	24.5%	24.2%	24.3%	24.3%	24.1%	23.6%	24.3%	24.3%	24.2%
Pressure @ Top of Dropleg	psig	6.43	6.44	6.43	6.43	6.44	6.44	6.42	6.42	6.44
Shaft Power	Bhp	1,259.4	941.1	801.0	871.8	810.0	759.1	601.9	601.9	6,654.6

Notes:
(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21
Consulting Engineer: Arcadis
Operating Condition: Current Max 7 Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	250,935.5	184,899.8	158,485.6	171,692.7	158,485.6	145,278.4	118,864.2	118,864.2	1,307,505.9
Air Rate (7)	scfm									

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	41,708.7	31,135.1	26,544.4	28,872.6	26,795.9	25,143.3	19,967.8	19,967.8	
Design Air (1,7)	scfm	41,708.7	31,135.1	26,544.4	28,872.6	26,795.9	25,143.3	19,967.8	19,967.8	220,135.6
Diffuser Air Rate	scfm/Diff.	3.99	4.00	4.02	4.01	4.06	4.01	3.96	3.96	4.00
Delivered SOR	lb/day	250,935.5	184,899.8	158,485.6	171,692.7	158,485.6	145,278.4	118,864.2	118,864.2	1,307,505.9
Delivered SOTE	%	24.0%	23.7%	23.8%	23.7%	23.6%	23.1%	23.8%	23.8%	23.7%
Pressure @ Top of Dropleg	psig	6.73	6.75	6.73	6.74	6.75	6.75	6.72	6.72	6.75
Shaft Power	Bhp	1,576.1	1,179.0	1,002.5	1,091.5	1,014.6	951.9	753.2	753.2	8,335.7

Notes:
(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21

Consulting Engineer: Arcadis
Operating Condition: Current Max Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	377,669.6	278,282.9	238,528.2	258,405.5	238,528.2	218,650.8	178,896.2	178,896.2	1,967,857.6
Air Rate (7)	scfm									

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	66,197.4	49,459.8	42,149.3	45,860.6	42,574.7	40,029.8	31,717.3	31,717.3	
Design Air (1,7)	scfm	66,197.4	49,459.8	42,149.3	45,860.6	42,574.7	40,029.8	31,717.3	31,717.3	349,706.3
Diffuser Air Rate	scfm/Diff.	6.33	6.36	6.39	6.37	6.45	6.39	6.29	6.29	6.36
Delivered SOR	lb/day	377,669.6	278,282.9	238,528.2	258,405.5	238,528.2	218,650.8	178,896.2	178,896.2	1,967,857.6
Delivered SOTE	%	22.8%	22.5%	22.6%	22.5%	22.4%	21.8%	22.5%	22.5%	22.5%
Pressure @ Top of Dropleg	psig	8.08	8.13	8.07	8.09	8.12	8.13	8.06	8.06	8.13
Shaft Power	Bhp	2,912.8	2,185.5	1,852.5	2,019.8	1,880.5	1,769.8	1,391.5	1,391.5	15,461.4

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21
Consulting Engineer: Arcadis
Operating Condition: Current Max Day (no denite)
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	443,963.5	327,131.0	280,398.0	303,764.5	280,398.0	257,031.5	210,298.5	210,298.5	2,313,283.5
Air Rate (7)	scfm									

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	79,469.4	59,397.1	50,609.2	55,072.4	51,132.3	48,114.4	38,088.6	38,088.6	
Design Air (1,7)	scfm	79,469.4	59,397.1	50,609.2	55,072.4	51,132.3	48,114.4	38,088.6	38,088.6	419,971.9
Diffuser Air Rate	scfm/Diff.	7.60	7.64	7.67	7.65	7.75	7.68	7.56	7.56	7.64
Delivered SOR	lb/day	443,963.5	327,131.0	280,398.0	303,764.5	280,398.0	257,031.5	210,298.5	210,298.5	2,313,283.5
Delivered SOTE	%	22.3%	22.0%	22.1%	22.0%	21.9%	21.3%	22.0%	22.0%	22.0%
Pressure @ Top of Dropleg	psig	8.98	9.04	8.96	8.99	9.03	9.05	8.94	8.94	9.05
Shaft Power	Bhp	3,812.3	2,864.6	2,424.2	2,645.0	2,464.2	2,322.9	1,821.1	1,821.1	20,276.0

Notes:
(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21

Consulting Engineer: Arcadis
Operating Condition: 2050 Min Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	89,832.6	66,192.4	56,736.4	61,464.4	56,736.4	52,008.3	42,552.3	42,552.3	468,075.0
Air Rate (7)	scfm									

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	13,066.1	9,731.8	8,305.8	9,027.1	8,371.6	7,815.5	6,242.6	6,242.6	
Design Air (1,7)	scfm	13,066.1	9,731.8	8,305.8	9,027.1	8,371.6	7,815.5	6,242.6	6,242.6	68,803.1
Diffuser Air Rate	scfm/Diff.	1.25	1.25	1.26	1.25	1.27	1.25	1.24	1.24	1.25
Delivered SOR	lb/day	89,832.6	66,192.4	56,736.4	61,464.4	56,736.4	52,008.3	42,552.3	42,552.3	468,075.0
Delivered SOTE	%	27.4%	27.1%	27.3%	27.2%	27.0%	26.6%	27.2%	27.2%	27.2%
Pressure @ Top of Dropleg	psig	5.77	5.77	5.77	5.77	5.77	5.77	5.77	5.77	5.77
Shaft Power	Bhp	433.9	323.2	275.8	299.8	278.1	259.5	207.2	207.2	2,285.5

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21
Consulting Engineer: Arcadis
Operating Condition: 2050 Average Annual
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	211,177.4	155,604.4	133,375.2	144,489.8	133,375.2	122,260.6	100,031.4	100,031.4	1,100,345.4
Air Rate (7)	scfm									

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	34,322.6	25,611.8	21,839.4	23,751.8	22,040.7	20,663.7	16,426.2	16,426.2	
Design Air (1,7)	scfm	34,322.6	25,611.8	21,839.4	23,751.8	22,040.7	20,663.7	16,426.2	16,426.2	181,082.3
Diffuser Air Rate	scfm/Diff.	3.28	3.29	3.31	3.30	3.34	3.30	3.26	3.26	3.29
Delivered SOR	lb/day	211,177.4	155,604.4	133,375.2	144,489.8	133,375.2	122,260.6	100,031.4	100,031.4	1,100,345.4
Delivered SOTE	%	24.6%	24.2%	24.4%	24.3%	24.2%	23.6%	24.3%	24.3%	24.3%
Pressure @ Top of Dropleg	psig	6.42	6.43	6.41	6.42	6.43	6.42	6.40	6.40	6.43
Shaft Power	Bhp	1,245.6	930.8	792.2	862.2	801.0	750.7	595.3	595.3	6,581.2

Notes:
(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21

Consulting Engineer:	Arcadis
Operating Condition:	2050 Max 30 Day
Oxygen Distribution:	Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	242,675.2	178,813.3	153,268.6	166,040.9	153,268.6	140,496.2	114,951.4	114,951.4	1,264,465.6
Air Rate (7)	scfm									

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	40,160.8	29,977.3	25,558.3	27,799.2	25,799.1	24,204.0	19,225.5	19,225.5	
Design Air (1,7)	scfm	40,160.8	29,977.3	25,558.3	27,799.2	25,799.1	24,204.0	19,225.5	19,225.5	211,949.7
Diffuser Air Rate	scfm/Diff.	3.84	3.86	3.87	3.86	3.91	3.86	3.81	3.81	3.86
Delivered SOR	lb/day	242,675.2	178,813.3	153,268.6	166,040.9	153,268.6	140,496.2	114,951.4	114,951.4	1,264,465.6
Delivered SOTE	%	24.1%	23.8%	23.9%	23.8%	23.7%	23.2%	23.9%	23.9%	23.8%
Pressure @ Top of Dropleg	psig	6.66	6.68	6.66	6.67	6.68	6.68	6.65	6.65	6.68
Shaft Power	Bhp	1,504.4	1,125.0	956.9	1,041.7	968.2	908.2	718.9	718.9	7,954.5

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21
Consulting Engineer: Arcadis
Operating Condition: 2050 Max 7 Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972
Oxygen Transfer										
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	285,983.1	210,724.4	180,620.9	195,672.6	180,620.9	165,569.1	135,465.7	135,465.7	1,490,122.3
Air Rate (7)	scfm									
Performance										
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	48,348.2	36,101.7	30,774.6	33,477.1	31,072.2	29,174.7	23,152.5	23,152.5	
Design Air (1,7)	scfm	48,348.2	36,101.7	30,774.6	33,477.1	31,072.2	29,174.7	23,152.5	23,152.5	255,253.5
Diffuser Air Rate	scfm/Diff.	4.63	4.64	4.66	4.65	4.71	4.66	4.59	4.59	4.64
Delivered SOR	lb/day	285,983.1	210,724.4	180,620.9	195,672.6	180,620.9	165,569.1	135,465.7	135,465.7	1,490,122.3
Delivered SOTE	%	23.6%	23.3%	23.4%	23.3%	23.2%	22.6%	23.4%	23.4%	23.3%
Pressure @ Top of Dropleg	psig	7.06	7.08	7.05	7.06	7.08	7.08	7.04	7.04	7.08
Shaft Power	Bhp	1,900.1	1,422.5	1,208.6	1,316.3	1,224.2	1,149.5	907.9	907.9	10,057.7

Notes:
(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21
Consulting Engineer: Arcadis
Operating Condition: 2050 Max Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	430,397.1	317,134.7	271,829.8	294,482.2	271,829.8	249,177.3	203,872.3	203,872.3	2,242,595.5
Air Rate (7)	scfm									

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	76,731.0	57,346.5	48,863.5	53,171.5	49,366.4	46,445.5	36,773.9	36,773.9	
Design Air (1,7)	scfm	76,731.0	57,346.5	48,863.5	53,171.5	49,366.4	46,445.5	36,773.9	36,773.9	405,472.3
Diffuser Air Rate	scfm/Diff.	7.34	7.37	7.40	7.38	7.48	7.41	7.30	7.30	7.38
Delivered SOR	lb/day	430,397.1	317,134.7	271,829.8	294,482.2	271,829.8	249,177.3	203,872.3	203,872.3	2,242,595.5
Delivered SOTE	%	22.4%	22.1%	22.2%	22.1%	22.0%	21.4%	22.1%	22.1%	22.1%
Pressure @ Top of Dropleg	psig	8.79	8.84	8.77	8.80	8.83	8.85	8.75	8.75	8.85
Shaft Power	Bhp	3,616.1	2,716.4	2,299.5	2,508.6	2,336.8	2,202.1	1,727.3	1,727.3	19,224.6

Notes:
(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: Newtown Creek WWTP
Sanitaire Project #s31147-21

Consulting Engineer: Arcadis
Operating Condition: Max Day (no denite)
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Pass		1	2	3	4	5	6	7	8	
SWD	ft	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	
Subm	ft	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
Volume	ft³	22,776.0	23,712.0	17,472.0	21,216.0	21,216.0	30,264.0	14,976.0	14,976.0	1,999,296.0
No. Parallel Tanks		1	1	1	1	1	1	1	1	
No. Trains in Operation		12	12	12	12	12	12	12	12	
Grid Count		1	1	1	1	1	1	1	1	96
Dropleg Diameter	inches	12	10	10	10	10	10	8	8	
At/Ad		4.906051357	6.865401987	5.960088692	6.634146341	7.237250554	10.87748809	6.68989547	6.68989547	
Diffuser Density	% Floor	20.38%	14.57%	16.78%	15.07%	13.82%	9.19%	14.95%	14.95%	
Diffusers/Grid		871	648	550	600	550	522	420	420	54,972

Oxygen Transfer

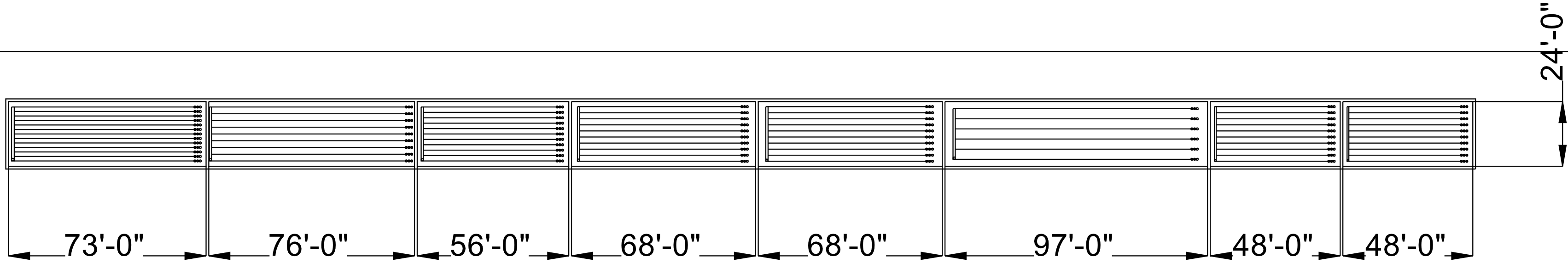
Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Diffuser Type		SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	SSLP	
Alpha										
Beta										
Theta										
D.O.	mg/l									
Water Temp	°C	21	21	21	21	21	21	21	21	
AOR/SOR										
Oxygen Distribution	%/Zone	19.0%	14.0%	12.0%	13.0%	12.0%	11.0%	9.0%	9.0%	99.0%
AOR	lb/day									
SOR	lb/day	506,122.6	372,932.4	319,656.4	346,294.4	319,656.4	293,018.3	239,742.3	239,742.3	2,637,165.0
Air Rate (7)	scfm									

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%									
Mixing Air (8)	scfm	2,522.9	2,626.6	1,935.4	2,350.1	2,350.1	3,352.3	1,658.9	1,658.9	
Process Air (for SOR)	scfm	92,151.1	68,895.5	58,694.2	63,876.9	59,312.6	55,848.0	44,178.3	44,178.3	
Design Air (1,7)	scfm	92,151.1	68,895.5	58,694.2	63,876.9	59,312.6	55,848.0	44,178.3	44,178.3	487,134.8
Diffuser Air Rate	scfm/Diff.	8.82	8.86	8.89	8.87	8.99	8.92	8.77	8.77	8.86
Delivered SOR	lb/day	506,122.6	372,932.4	319,656.4	346,294.4	319,656.4	293,018.3	239,742.3	239,742.3	2,637,165.0
Delivered SOTE	%	21.9%	21.6%	21.7%	21.6%	21.5%	20.9%	21.7%	21.7%	21.6%
Pressure @ Top of Dropleg	psig	9.92	10.00	9.90	9.94	9.98	10.02	9.87	9.87	10.02
Shaft Power	Bhp	4,794.8	3,607.3	3,048.6	3,328.3	3,102.2	2,928.7	2,290.3	2,290.3	25,545.8

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²



Single Train Information

Grid No	Grid Count	Drop Leg Ø"	Header Count	Header Spc,ft.	Header Len,ft.	Discs/ Grid	At/ Ad	Discs/ Train
1	1	12	13	1.67	69.75	871	4.91	871
2	1	10	9	2.50	74.75	648	6.87	648
3	1	10	11	2.00	52.25	550	5.96	550
4	1	10	10	2.25	62.75	600	6.63	600
5	1	10	10	2.25	61.58	550	7.24	550
6	1	10	6	3.75	90.25	522	10.88	522
7	1	8	10	2.25	44.25	420	6.69	420
8	1	8	10	2.25	44.25	420	6.69	420

Total Discs/Train 4581

Note: Some headers may be omitted for clarity

PRELIMINARY - THIS DRAWING IS NOT INTENDED FOR CONTRACT DOCUMENTS, SUBMITTALS OR CONSTRUCTION

Sanitaire
a xylem brand
BROWN DEER, WISCONSIN 53223

CUST NO.

DWG NO.

Newtown Creek WWTP
9" Disc Aeration System

DRAWN BY AS	DATE 11/22/21	MODEL	JOB s31147-21
CHKD BY	DATE		SHEET
APPVD BY	DATE		