FUJI CLEAN CEN-SERIES NITROGEN-REMOVAL PERFORMANCE

Original: November 30, 2018
Revised: October 3, 2023

SUMMARY

FujiClean USA, LLC,("FujiClean") is submitting an updated in accordance with the "Guidelines for Obtaining City of Austin Approval for Nitrogen Reduction Systems," dated December 29, 2014. The update is being submitted because the FujiClean, which has already received approval for its CEN5 model, is now seeking approval for the CEN7/CEN7A model. The CEN7/CEN7A is a proportionally-scaled model based on the CEN5.

This report documents increased design flows for the CEN7. The increases, which are reflected in NSF certifications, affects the CEN7, CEN10, and CEN14, which have design flows of 700, 1,000, and 1,350 gpd, respectively. NSF also accepted the CEN7A, which addresses the unique six-bedroom design capacity of 720 gpd TCEQ has adopted. NSF has extended its certification of the CEN7 and additional 20 gpd even though FujiClean limits application to Texas.

Attached are a diagram of the proposed treatment system that clearly indicates all sampling locations, operating manuals, and third party performance verification in the form of detailed analytical reports.

The report includes studies conducted for the State of Maryland and Commonwealth of Virginia. The sampling and analysis program was managed by 3-Engineering, LLC, of Richmond, VA, a consulting engineering firm that specializes in decentralized wastewater management issues. All sampling and analyses were conducted by Microbac Laboratories, Inc., which has offices in Baltimore, MD, and Richmond, VA, and is fully-certified in both states to collect and analyze samples from wastewater treatment systems. The results demonstrate that the average effluent Total Nitrogen (TN) concentration is 13.4 mg/L.

SECTION 1—VENDOR/DESIGNER CONTACTS

Manufacturer/Vendor	Austin Distributor
Scott Samuelson, General Manager Fuji Clean USA, LLC 41 Greenwood Road, Ste 2 Brunswick, ME 04011 207-406-2927 scott@fujicleanusa.com	Jim Boushka Fuji Tank of Texas, LLC 8947 Bee Caves Road, #101 Austin, TX 78746 512-789-1274 jimb@jimick.com

SECTION 2—GENERAL TECHNOLOGY DESCRIPTION

The Fuji Clean CEN-Series is a combined-process wastewater treatment system. "Combined process" [1] refers to the use elements generally described as "fixed media" and "suspended growth" wastewater treatment. Another term is an Integrated Fixed-Film Activated Sludge (IFAS) process. Fixed media designs typically apply wastewater to a medium, on which the microbes attach themselves. Suspended growth refers to a technique of suspending microbes in a tank of water using aeration. Models consist of a single tank divided into three chambers, some containing proprietary media, to treat the wastewater. The design is a variation of the Modified Ludzak-Ettinger (MLE) process. [2] The design incorporates a diaphragm compressor to supply oxygen and energize an air lift pump to recirculate treated wastewater back to the influent chamber. A separate air lift pump regulates effluent discharge. The integrated nature of the design precludes the need for additional upstream tankage, which is common for many onsite wastewater treatment products. Figure 1 provides a rendering of a typical series model. The attached manuals provide detailed drawings.

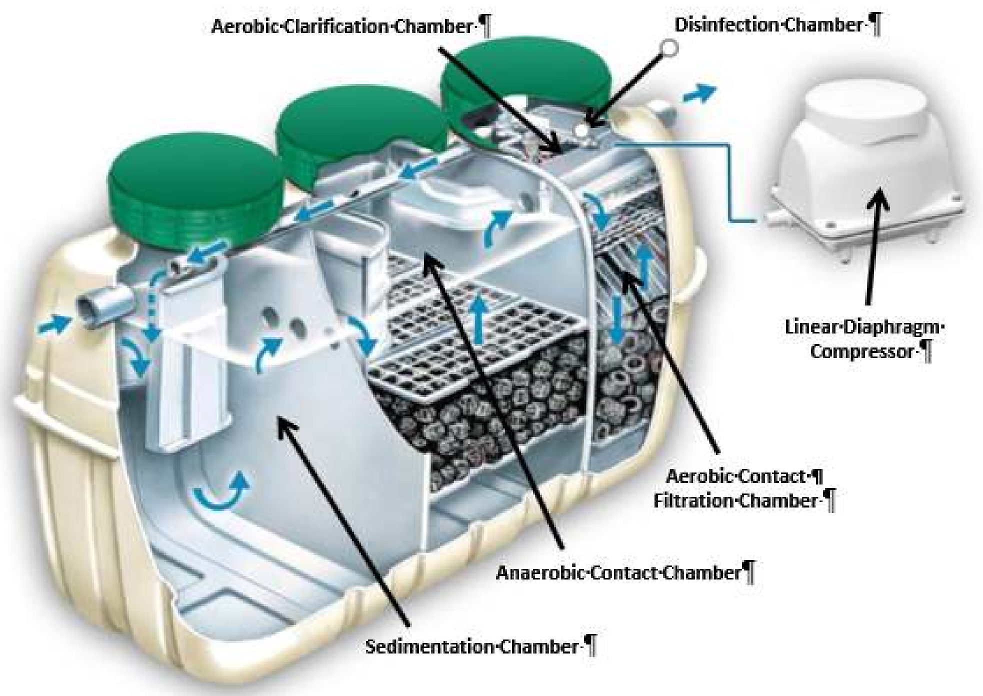


Figure 1—Fuji Clean CEN-Series Rendering

The system operates between a minimum and maximum elevation, known as the Low Water Elevation (LWL) and High Water Elevation (HWL). The effluent air lift pump will not operate

---

[1] Tchobanoglous, G. *Wastewater Engineering: Treatment and Reuse*, Fourth Edition. New York: McGraw Hill. See Chapter 9, for a further discussion of combined process design.

[2] Tchobanoglous, Page 616-623.

unless the water elevation exceeds the LWL, and an open weir allows free flow of effluent is the water level exceeds the HWL.

All models are proportionally sized such that critical process parameters are identical. Table 1 provides process details for each model. Treated wastewater recirculation is continuous and adjustable to maximize treatment performance. Typically, the recirculation ratio is set between four and six times the influent flow.

Table 1—CEN-Series Model Details

	CEN5	**CEN7**[1]	**CEN10**	**CEN14**	**CEN21**
HYDRAULIC RATING (GPD)	500	700	1,000	1,350	1,900
SEDIMENTATION CHAMBER (GAL)	277	397	558	837	1,200
% OF TOTAL VOLUME	37%	37%	37%	37%	38%
DETENTION TIME (HRS)	13.30	13.61	13.39	14.88	15.16
ANAEROBIC CHAMBER (GAL)	278	396	558	839	1,198
% OF TOTAL VOLUME	37%	37%	37%	37%	37%
DETENTION TIME (HRS)	13.34	13.58	13.39	14.92	15.13
ANAEROBIC MEDIA (TAPERED COLUMN SKELETON)					
SPECIFIC SURFACE (M2/M3)	41	41	41	41	41
PACKING RATIO (%)	46%	46%	46%	46%	46%
AEROBIC CONTACT FILTRATION CHAMBER (GAL)	127	181	248	378	550
PERCENT OF TOTAL VOLUME	17%	17%	17%	17%	17%
DETENTION TIME (HRS)	6.10	6.21	5.95	6.72	6.95
AEROBIC MEDIA 1. (SHEET TYPE)					
SPECIFIC SURFACE (M2/M3)	71	71	71	71	71
PACKING RATIO (%)	16%	17%	17%	17%	17%
AEROBIC MEDIA 2. (NET-HOLLOW-CYLINDRICAL)					
SPECIFIC SURFACE (M2/M3)	107	107	107	107	107
PACKING RATIO (%)	57%	55%	55%	55%	55%
AEROBIC CLARIFICAITON CHAMBER (GAL)	63	90	124	186	268
% OF TOTAL VOLUME	8%	8%	8%	8%	8%
DETENTION TIME (HRS)	3.02	3.09	2.98	3.31	3.39
DISINFECTION CHAMBER (GAL)	4	6	12	12	17
% OF TOTAL VOLUME	1%	1%	1%	1%	1%
DETENTION TIME (HRS)	0.19	0.21	0.29	0.21	0.21
TOTAL VOLUME INCLUDING SURGE FLOW (GAL)	749	1,070	1,498	2,252	3,199
TOTAL TREATMENT TIME (HRS)	35.95	36.69	35.95	40.04	40.41
Note: The CEN7 is also approved with a design flow of 720 gpd and called the CEN7A for Texas.					

Please note that Table 1 reflects revised design flows for the CEN7, CEN10, CEN14, and CEN21, all of which have been approved by NSF International as reflected on the NSF website. Further, NSF recognizes a design flow of 720 gpd for the CEN7, which is designated as the CEN7A.

Treatment Chambers

The five chambers of each CEN-model are the Sedimentation Chamber, Anaerobic Contact Chamber, and Aerobic Contact Filtration Chamber, Aerobic Clarification Chamber, and Disinfection Chamber. Each is described below and shown in Figure 1.

Sedimentation Chamber

The Sedimentation Chamber receives and conditions influent wastewater. Wastewater discharged directly from the dwelling enters the chamber when it is diverted downward by an influent baffle. The influent mixes with recirculated treated wastewater, which is also discharged in front of the influent baffle. This mixing conditions the influent such that concentrations are attenuated. The mixed water passes beneath the baffle into the chamber, where heavier solids settle (sedimentation) and lighter solids float (flotation). Clarified wastewater moves from the chamber through two 3.0625-in holes centered 12 inches below the low water elevation.

The Sedimentation Chamber has a detention time of 13.3 hours based on the design flow, This detention time is associated with an approximate BOD removal of 45 percent and a TSS removal of 65 percent. Taking a typical 4.5 recirculation ratio into account, the instantaneous detention time will be approximately 3.0 hours, which is associated with BOD and TSS removals in the range of 35 and 55 percent, respectively. [3] Both values are in keeping with typical wastewater engineering practice.

Anaerobic Contact Filtration Chamber

The Anaerobic Contact Chamber receives conditioned wastewater directs and it using a baffle to the chamber floor for flow up through the tapered column skeleton media. Technically, this tank may be considered anoxic and not anaerobic. Fuji Clean uses the term in a general sense to distinguish the chamber from the aerated chamber.

Upflow contact filtration is a well-documented process. Microbes floating in or attached to the skeletal media use recirculated nitrate as the terminal electron and hydrogen acceptor. The electron donor is BOD in the wastewater. Nitrate is the terminal electron and hydrogen acceptor when free oxygen is not available and when facultative heterotrophs are present. The pass through and instantaneous detention times in the chamber is identical to the Sedimentation chamber, 8.9 and 2 hours, respectively. Generally, a three-hour detention time is required to achieve denitrification; the time spent in both chambers will be approximately four hours under instantaneous flow conditions, sufficient to facilitate denitrification.

Aerobic Contact Filtration Chamber

Wastewater passes to the Aerobic Contact Filtration Chamber by passing through one of two 3.0635-in holes located on each side chamber wall into the Aerobic Contact Filtration Chamber,

[3] Tchobanoglous, Page 405.

which is divided by the Aerobic Clarification Chamber, and moves downward through two different media located in each side. The first media is a sheet-type while the second media is hollow cylindrical. The downward flowing wastewater passes through upward-flowing air bubbles supplied by a diaphragm compressor attached to supply piping. The pass through and instantaneous detention times are 4 hours and 53 minutes, respectively.

Aerobic Clarification Chamber

Aerobic Contact Filtration effluent passes to an aerobic clarification chamber located in the middle. Clarification uses gravity separation to clarify the effluent. Fuji Clean engineers called this area the "Storage Chamber." An airlift pump lifts effluent into the Disinfection Chamber. The airlift pump inlet height establishes the LWL. When influent flow ceases, the tank volume will eventually drop to the LWL. All treated wastewater will be recycled at that point and continue until influent flow resumes. The openings also moderate outflow as they act as a construction. The water level can raise only as far as the HWL. Water higher than the HWL will spill into the Aeration Chamber over the dividing wall.

Disinfection Chamber

The disinfection chamber is the last chamber in each unit. Disinfection is provided by a removable tablet feeder. Disinfection is optional. The chamber also serves as a convenient effluent sampling location. The chamber has an approximate 8-minute detention time.

Process Considerations

Fuji Clean treats design elements, particularly as they relate to the selection and use of synthetic media, as trade secrets. A complete analysis is not possible though sufficient information is available to confirm that the designs conform to general design practice for synthetic media.

Figure 2 is a process diagram of the CEN-Series. This diagram is generally representative of IFAS systems incorporating attached-growth denitrification. [4] The distinguishing characteristics include the use of submerged media, aerobic and anoxic zones, and recirculation. [5] Some design parameters have been previously discussed; others are noted below.

Synthetic Media

The exact properties of the synthetic media are a closely guarded secret. Their specific surface, packing ratio, and chamber detention times are provided in Table 1. All values are within the range of values documented as successful for other synthetic media. Synthetic media

[4] Tchobanoglous, Page2 952-971 discuss various IFAS considerations and process variations.

[5] The words "anoxic" and "anaerobic" are used interchangeably though they mean different conditions. "Anoxic" is the correct term to describe conditions facilitating denitrification. "Anaerobic" is the term used in this document because it is the term the Japanese use to describe the compartments. Laypersons and non-native speakers often use the term "anaerobic" to distinguish when air is supplied to the treatment tank—"aerobic."

recommendations are typically provided as a range. Manufacturers and engineers anticipate adjustment of application and recirculation ratios based on actual flow and loading regimes. Fuji Clean units are similarly designed, so recirculation rates and aeration can be set based on the actual performance of the system.

Sedimentation and Recirculation

The detention time for Sedimentation and Aerobic Sedimentation chambers are reasonable. Fuji Clean engineers have indicated but do not generally publicize that their design allows for sludge digestion, which reduces solids, including TSS (total suspended solids). Moreover, flow paths through synthetic media facilitate capture and retention of TSS. The result is that CEN-unit effluent has fewer TSS than other systems relying on gravity sedimentation.

The Aerobic Sedimentation Gravity Chamber also controls dissolved oxygen (DO) concentrations to facilitate influent denitrification. This author has observed that the DO level within the Aerobic Contact Filtration Chamber will be near saturation but falls within the range of 2 mg/L in the Disinfection Chamber. This drop is a result of residual BOD removal that occurs within the Aerobic Sedimentation Chamber. This phenomenon has two effects. First, BOD is reduced further before treated wastewater is discharged. Second, recirculated wastewater will lack sufficient oxygen to maintain aerobic conditions within the Sedimentation chamber. Aerobic conditions would inhibit denitrification, so low DO in recirculated wastewater is essential to denitrification.

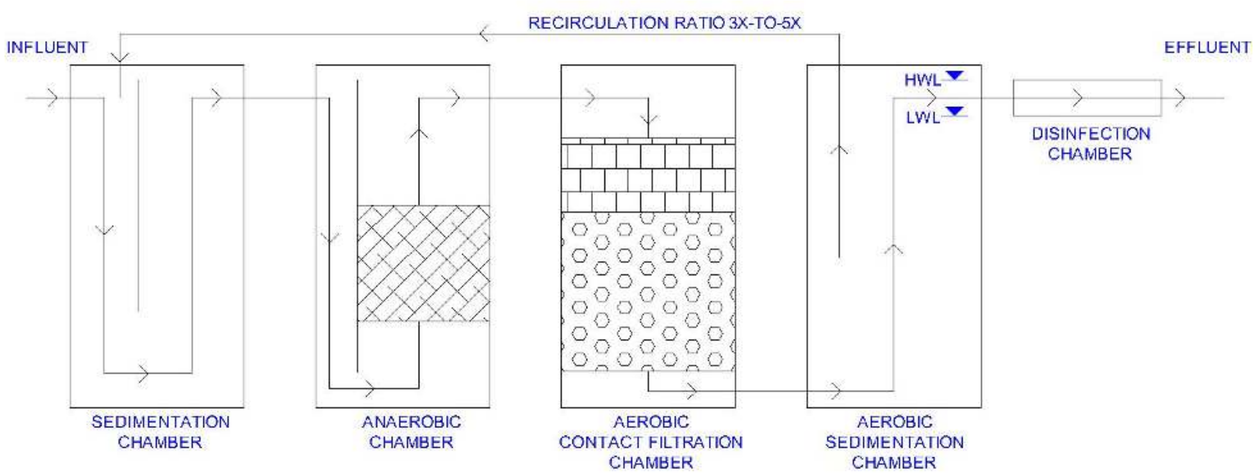


Figure 2—Fuji Clean CEN-Process Schematic

Recirculated wastewater also mitigates the effects of slug doses of cleaning products, medicines, or other substances that inhibit wastewater treatment unless the substances are diluted. Influent is constantly mixed with recirculated wastewater to dilute to the extent possible any potentially harmful concentrations of substances.

SECTION 3—DESCRIPTION OF EACH TEST SITE

All field tests were sampled were conducted at full-time residential occupancies. A comparison of the field tests with the City of Austin's requirements is provided in Table 2. An attached Excel spreadsheet contains details about each site including addresses, system model, estimated flow, sampling results, notes, and other details either required by or of interest to the City of Austin. The locations, number of bedrooms, and estimated flows are provided in Table 3.

Table 2—Field Tests Conducted vs City of Austin Requirements

Item	Austin Minimum Requirement	Fuji Clean Performance
Number of Systems Tested	5	22
Number of Sampling Events	53	105
Period of Sampling	12 months after start-up	12-months after start-up
Frequency of Sampling Events	Quarterly	Quarterly

The report contains sampling data from both Virginia and Maryland. Maryland requires 24-hour composite samples while Virginia allows grab samples. Sampling began in Maryland and was recognized under a MOU (Memorandum of Understanding) signed with "Chesapeake Bay States" (states whose watersheds discharge to the Chesapeake Bay). Sampling began in Virginia soon after under a separate MOU with the VDH. Virginia is a party to the Chesapeake Bay States MOU, so the sample protocol, sampling program manager, and third-party laboratory conducted all sampling and analysis.

Two Excel spreadsheets are provided with the report. The first spreadsheet was developed and provided by the VDH. The VDH spreadsheet is important because of its emphasis on the upper 99 percent estimate of the effluent BOD_5 and TSS [6]. Generally speaking, a technology cannot provide effective denitrification unless the technology is also providing effective BOD_5 and TSS removals. The second spreadsheet contains all sampling data from all sites. All chain-of-custody and sampling reports are provided separately.

Reported Influent TKN appears not to meet City of Austin requirements for a minimum of 36 mg/L. This seeming issue, is irrelevant given the emerging best practice—shown in Figure 1 and 2 and described in the text—of conditioning influent with recycled effluent. The City of Austin should recognize that no "pure influent" samples can be obtain and can rely on published data to estimate the undiluted influent TKN.

Installation details varied with the soil and site limitations. For example, Virginia sites ranged from enhanced flow to dripline irrigation designs. Maryland sites typically were gravity dispersal. Sites were generally for new construction. The southernmost site was in Louisa County.

[6] The VDH acknowledges that current practice is to examine effluent $cBOD_5$. The VDH requires effluent BOD_5 simply because its governing statue and rules only reference BOD_5 as the target constituent.

Table 3—Test Sites Details						
Control No.	**Test Site**	**Test Site Name**	**Model**	**Bedrooms**	**Occupancy**	**Est. Flow (GPD)**
VA-01	1	150 Deane Rd, Toms Brook, VA	CEN-5	3	2	120
VA-02	2	35430 Snooty Fox Rd., Round Hill, VA	CEN-10	5	4	200
VA-03	3	35571 Sunny Ridge Rd, Round Hill, VA	CEN-10	5	3	175
VA-04	4	11924 Purcell Rd, Lovettsville, VA	CEN-5	3	2	120
VA-05	5	16028 Waterford Crest Place, Paeonian Springs, VA	CEN-10	5	5	250
VA-08	6	4621 Walton Rd, Louisa, VA	CEN-5	3	4	200
VA-09	7	38719 Morrisonville Rd., Lovettsville, VA	CEN-7	4	4	175
VA-12	8	3325 Howellsville Rd, Front Royal, VA	CEN-5	3	2	120
VA-10	9	75 Mitchell Dr, Strasburg, VA	CEN-5	3	2	120
VA-14	10	13046 April Circ, Lovettsville, VA	CEN-5	3	3	1150
MD-01	11	1715 Castleton Rd, Darlington, MD	CEN-5	3	3	150
MD-02	12	161 Antego Dr, Elkton, MD	CEN-5	3	2	120
MD-03	13	1241 Baldwin Mill Rd, Jarrettsville, MD	CEN-5	3	5	250
MD-05	14	1711 Castleton Rd, Darlington, MD	CEN-5	3	2	120
MD-07	15	3135 Copenhaver Rd, Street, MD	CEN-5	3	3	150
MD-08	16	1719 Castleton Rd, Darlington, MD	CEN-5	3	3	150
MD-09	17	3530 Scarboro Rd, Street, MD	CEN-5	3	4	200
MD-10	18	538 West Ln, Bel Air, MD	CEN-5	3	4	200
MD-11	19	410 Rockspring Church Rd, Forest Hill, MD	CEN-5	3	2	120
MD-12	20	3236 Sudath Ln, Jarrettsville, MD	CEN-5	3	3	150
MD-13	21	1723 Castleton Rd, Darlington, MD	CEN-5	3	4	150
MD-14	22	400 Rockspring Church Rd, Forest Hill, MD	CEN-5	3	2	120

Maryland and Virginia have different sampling requirements. Maryland does not recognize influent sampling results, so influent sampling was conducted for jurisdictions other than Maryland. One Maryland sampling event was blank because of a mechanical error. This should not cause an issue because influent parameters are provided for all other sampling events. Both BOD and cBOD results are provided, too.

Locations were selected based on their availability and conformance to the relevant Chesapeake Bay and Virginia MOUs: Sites were generally within the proximity of a Fuji Clean dealer. Virginia sites were generally along the I-81 and I-66 corridors. Maryland sites were located in two northeastern counties. All sampling sites are full-time residential occupancies having daily flows less than 1,000 gpd.

All systems were under operation and maintenance agreements with authorized maintenance entities. The Maryland maintenance is Dwayne C. Jones Contracting, Inc., of Jarrettsville, MD. The Virginia maintenance entity is McKim Septic & Pumping of Purcellville, VA. Each maintenance entity maintained its systems in accordance with applicable regulations and Fuji Clean instructions. Inspection reports are provided in the attached electronic files. Dwayne C. Jones and Austin Echols are the Maryland and Virginia maintenance entity representatives, respectively.

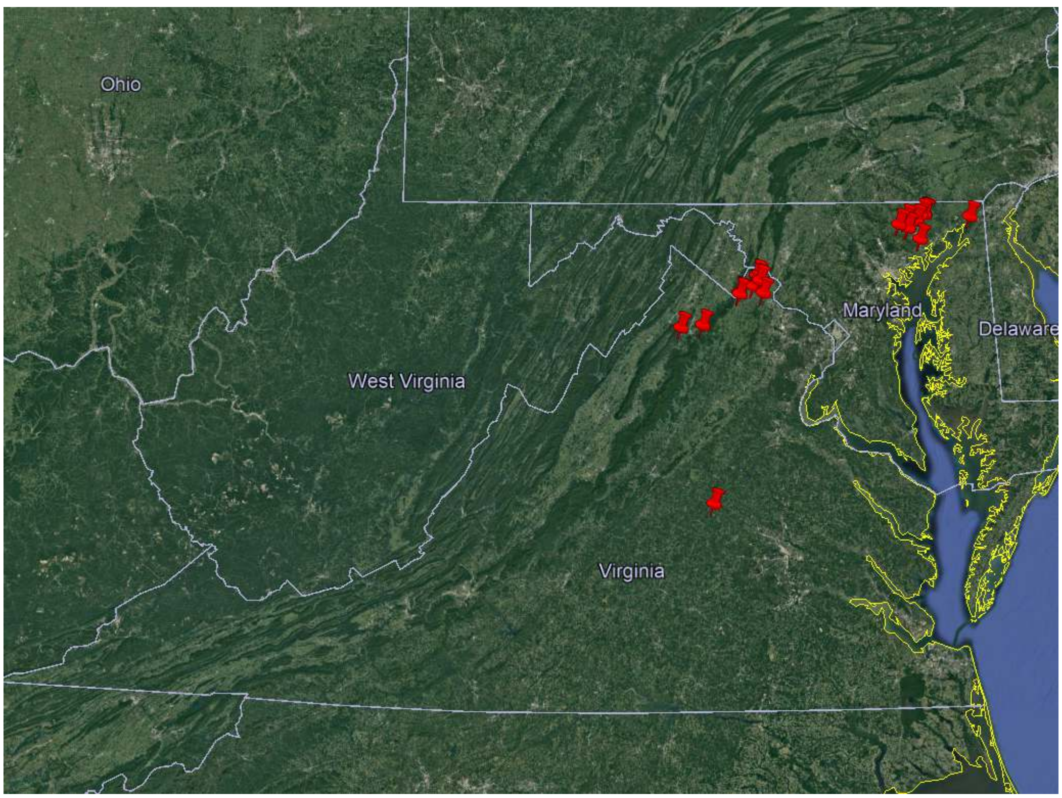


Figure 3—Sampling Locations

Microbac Laboratories collected and analyzed all samples. Microbac laboratories are accredited and/or certified under applicable Maryland and Virginia regulations. Properly credentialed staff collected and transported samples in accordance with applicable practices. QA/QC procedures are attached. Field measurements were taken with calibrated equipment, and analyses were conducted in accordance with applicable analysis protocols. The Virginia contact is Caliesha Scott, who manages the Richmond office. Chain of custody and chemical analysis report forms are attached in electronic files and provide details related to the analysis methods.

Duplicates and blanks were analyzed, too, to confirm the accuracy of the results, and results are provided in the electronic files, too.

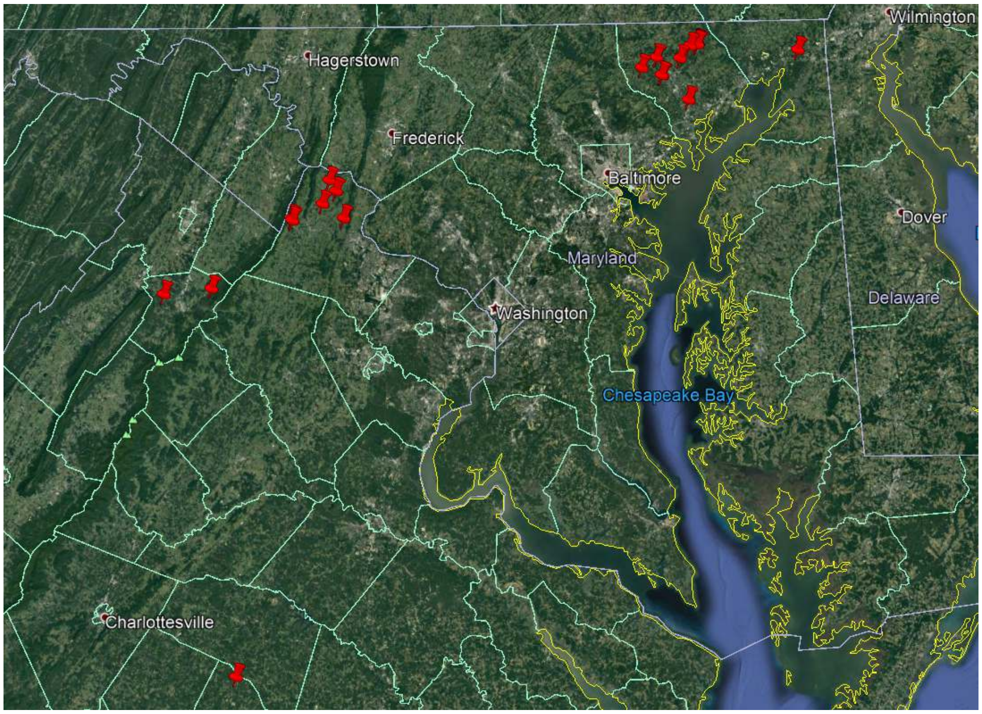


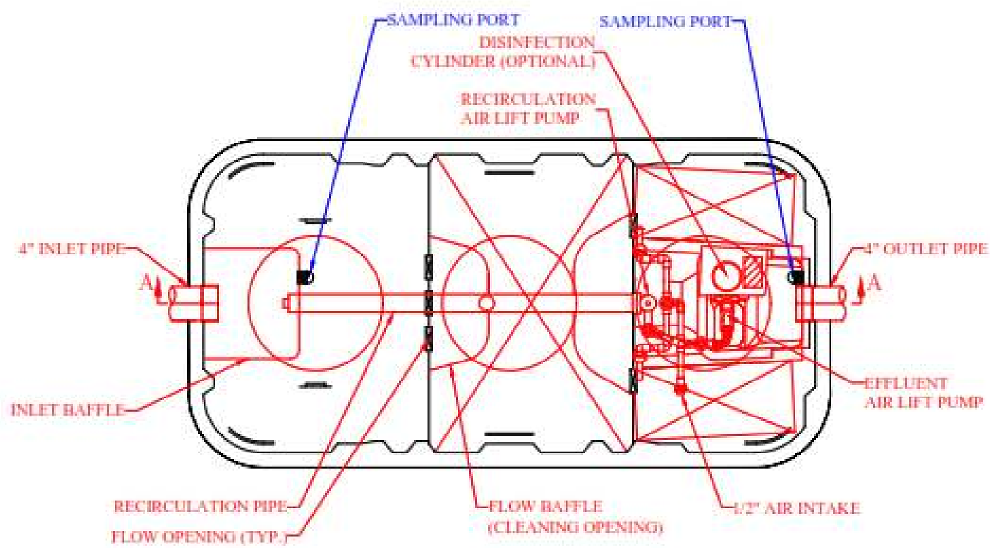
Figure 4—Sampling Location Detail

All sampling was conducted using a standardized method and equipment common to both states. All Fuji Clean CEN-Series models contain both inlet and outlet baffle walls. A 12-inch long sampling tube was connected to the tank side of the baffle and a vacuum drawn to bring the wastewater directly to the sampling container. Regardless of whether the sample was a 24-hour composite or instantaneous grab sample, the composite sampler was used to collect the influent and effluent samples.

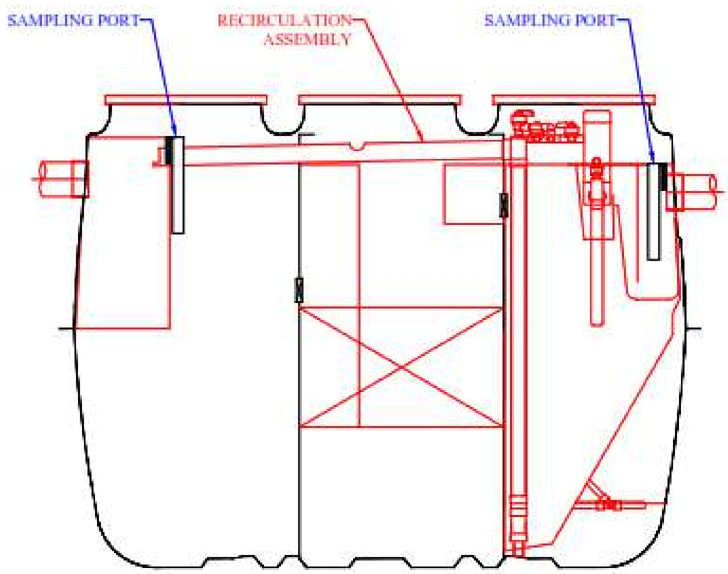
Flow data was unavailable though occupancy information is. Sites are served by wells, and onsite wastewater treatment systems that include pumps either were on demand-dosing or incorporated mechanical timers. Regardless, none of the systems showed signs of excess flow. Occupancy ranged from two-to-five persons, so typical daily flow is estimated to range from 100 gpd at the low side to 250 gpd at the high side. The range yields an average daily flow of 175 gpd. Typical flow for dwellings connected to metered water connections is 190 gpd.

Dwelling size ranged from two-to-four bedrooms, so Fuji Clean CEN5 and CEN7 models were selected. Units were monitored after start-up, and formal sampling began approximately three-to-six months afterword—when normal operation was confirmed. In one case, the contents had to be pumped and the system re-started because someone had added excessive chlorine to the wastewater.

SECTION 4—DIAGRAM OF FUJI CLEAN CEN-SERIES UNITS WITH SAMPLING LOCATIONS

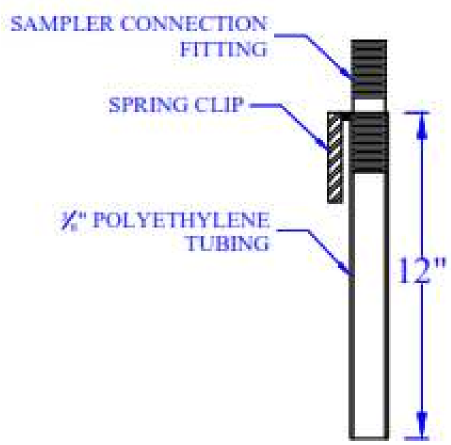


PLAN VIEW



SECTION A-A VIEW

INFLUENT AND EFFLUENT SAMPLING PORT WILL ATTACH TO ALL UNITS AS SHOWN. A CONNECTION FITTING SHALL BE USED TO ATTACH THE COMPOSITE SAMPLER. THE PORT MUST BE INSPECTED AND CLEANED PRIOR TO AND AFTER EACH SAMPLING EVENT.



SAMPLING PORT DETAIL (NTS)

SECTION 4—THIRD PARTY PERFORMANCE VERIFICATION

Introduction. The sampling results presented in this verification were originally conducted to fulfill requirements of the State of Maryland, the consortium of state regulators whose states are within the Chesapeake Bay ("Chesapeake Bay States"), and the Commonwealth of Virginia. All jurisdictions required that properly credentialed/certified third parties collect and analyze samples and submit all reports. 3-Engineering, LLC, of Richmond, VA, managed the program. The firm selected Microbac Laboratories, Inc., which has offices in Baltimore, MD, and Richmond, VA, and is fully-certified in both states, to collect and analyze samples from the field sites. Bennette D. Burks, P.E, received and analyzed the results, confirming their validity and otherwise addressed routine issues related to schedules, errors, and other activities related to the program. Fuji Clean provided its own witness, Yosuke Tabata, for each sampling event. The results demonstrate that the average effluent Total Nitrogen (TN) concentration is 13.4 mg/L.

Please note that many results were reported as "<X" where X is the resultant value. In the "Raw Data" columns, the "<" sign was removed but the value unchanged. In the "Clean Data" columns the values having a "<" sign were reduced by half the reported value.

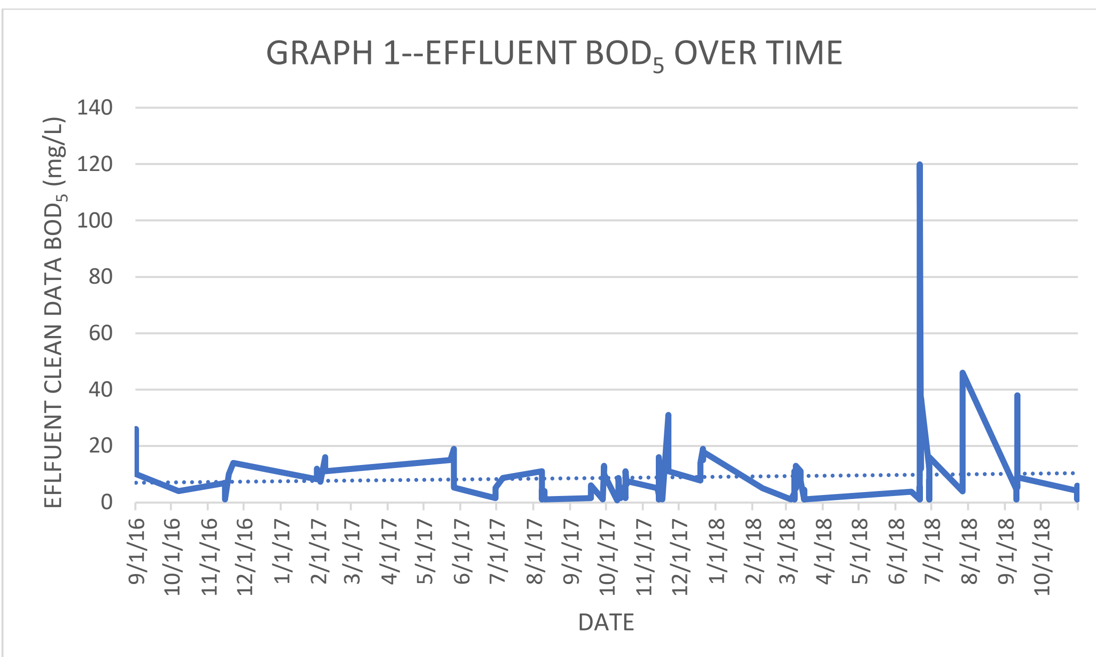
BOD_5 and TSS Removal. Table 4 provides BOD_5 and TSS removal prepared in accordance with the Virginia MOU, which allows for the use of "Clean Data" tables. The data is based on a total of 105 samples taken from 22 sites. Each site has a minimum of four samples. Several sites have five or more samples; one site has seven samples. All data was included including a couple of samples that appeared to be erroneous. The erroneous data resulted in higher averages but not sufficiently high to affect the outcome. An effluent BOD_5 result of 120 mg/L was traced to owner abuse the day before sampling. The owner is involved in dog rescue efforts and cares for a number of dogs. He had cleaned up after the dogs just prior to sampling.

As noted previously, Table 4 is significant because it represents the Upper 99 percent confidence interval using the Student T-Test. Denitrification is closely associated with high BOD and TSS removal, so low effluent BOD_5 and TSS values indicate that conditions are favorable for high denitrification.

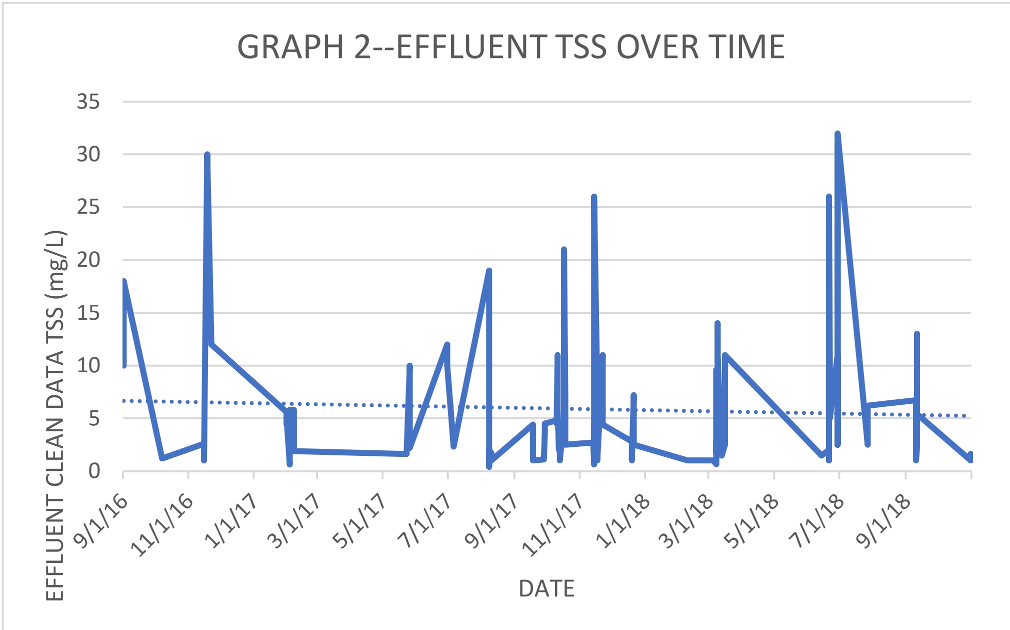
The VDH takes the position that BOD and TSS removals are not linear functions; therefore, the values are converted to log values for manipulation and then re-converted back to exponentials. The result of this manipulation are results that vary from expectations based strictly on arithmetic manipulation of the results. The consequence of this action is that the VDH results are more conservative than averages based on the raw data itself.

Graphs of the data visualize the performance. Graph 1 displays effluent BOD_5 chronologically for all 105 samples. The graph includes a trendline of performance. The data reflects consistent performance documented by the trendline. The lone high value resulted from the owner washing large amounts of dog wastes the day before sampling; the data is sufficiently robust to absorb the high value. The Upper 99 Percent confidence value is 7.1 mg/L.

Table 4—BOD_5 and TSS Results for Log-Transformed Data		
	BOD_5 (mg/L	TSS (mg/L)
Count (N) =	22	22
Degrees of Freedom (N-1) =	21	21
Mean =	1.59	1.22
Std Dev =	0.70	0.57
Std Err =	0.15	0.12
Upper 99% T (1-tailed) =	2.52	2.52
Upper 99% T Conf Int =	1.96	1.53
Upper 99% T Conf Int =	7.1	4.6
NOTE: Background Color Indicates Value Type	Native Values	
	Log-Transformed Values	



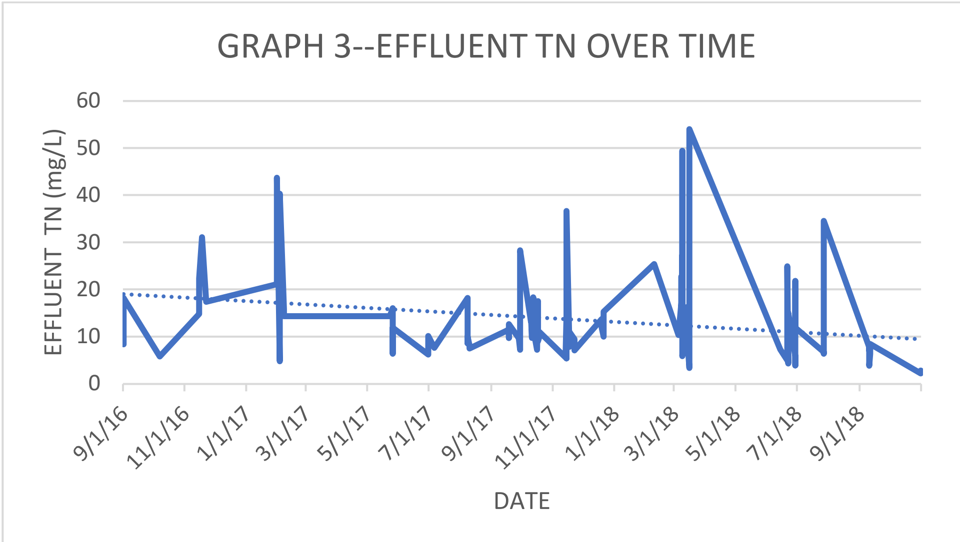
Graph 2 displays the effluent TSS chronologically for all 105 samples. The graph also reflects consistent results with a consistent trendline. The Upper 99 Percent confidence value is 4.6 mg/L.



TN Removal. Table 5 provides Effluent nitrogen species performance. The average Effluent TN is 14.2mg/L, which is 5.8 mg/L below the City of Austin's limit. This removal is significant because the NSF/ANSI Standard 245 standard is a 50 percent removal based on influent TN, which may exceed 60 mg/L.

Table 5—Average Effluent Nitrogen Species (mg/L)					
Constituent	**TKN**	**NH_4-N**	**NO_2-N**	**NO_3-N**	**TN**
Average	5.6	3.1	0.43	7.5	13.4

Graph 3 is the Effluent TN (Total Nitrogen) for all samples. The average Effluent TN is 13.4 mg/L for 105 samples. The standard deviation is 9.6 mg/L. TN sampling is not required for TL-3 listing; Virginia accepts NSF/ANSI Standard 245 for nitrogen reduction, and the Fuji Clean CEN-Series already has certification under NSF/ANSI Standard 245. Regardless, some jurisdictions such as North Carolina, Austin, Texas, and Florida accept data from other jurisdictions as a part of their approval processes.

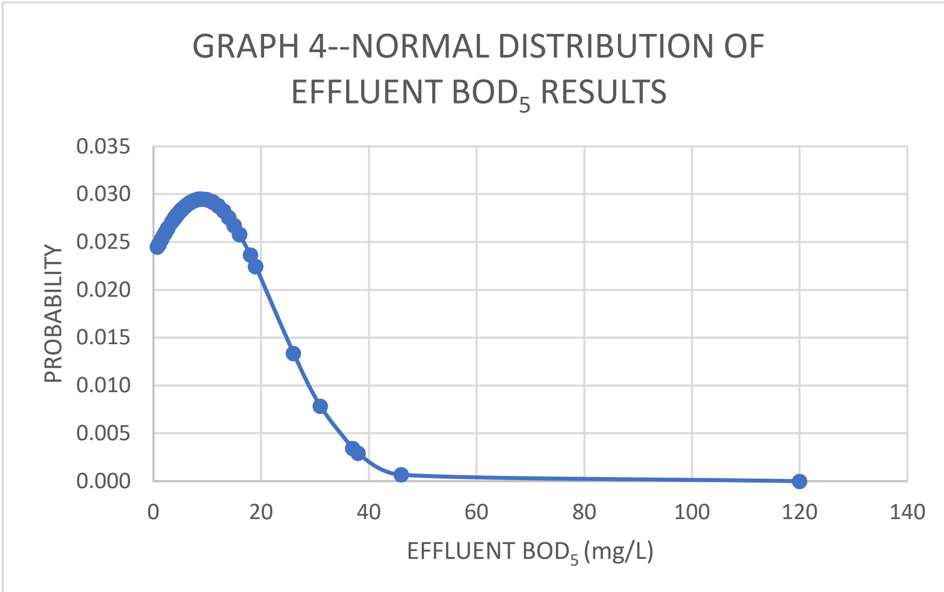


The data was re-sorted and the associated probability with each data point calculated to develop normal distribution graphs. The graphs visualize the data to allow its consistency to be observed rather than inferred. Shown in Table 6 are the averages and standard deviations calculated to develop Graphs 4 through 6. Recall that "Clean Data" refers to data transformed as a result of a "<-sign" (less than) in front a data point. Under the Virginia reporting requirements, the value itself can be divided in half when the <-sign appears in the report. None of the TN data points has <-signs before them, but the data is presented in Table 6 for ease of comparison.

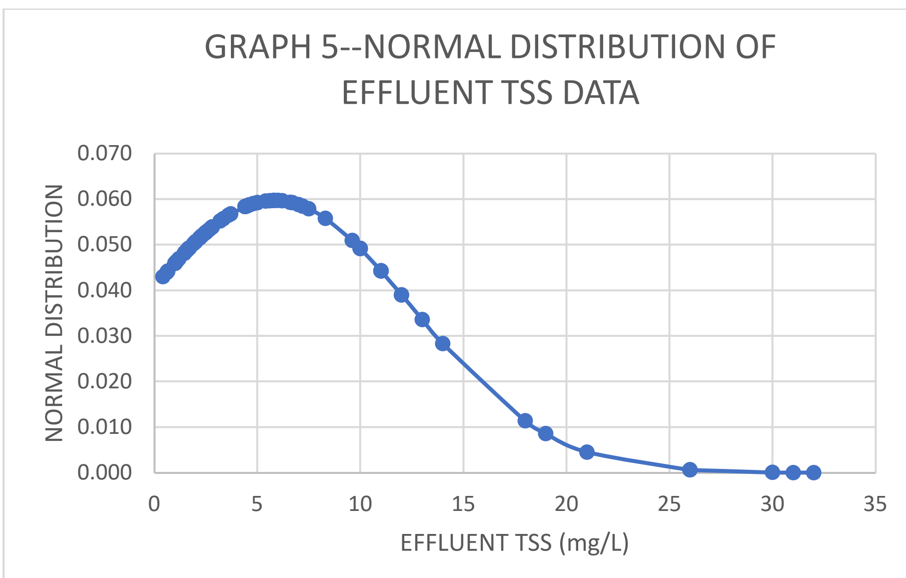
TABLE 6—CALCULATIONS BASED ON CLEAN DATA EFFLUENT VALUES (mg/L)			
ITEM	TN	BOD_5	TSS
AVERAGE	13.4	9.0	5.8
STD DEV	9.6	13.5	6.7
COUNT	105	105	105

The graphs are necessarily one-sided because values cannot be below 0; the typical lower limit for these tests is 2 mg/L unless special procedures are in place. An Excel spreadsheet is provided for the calculations and resulting graphs. Also note that the values include a time-dependent element. Improved performance is expected as system mature. This improved performance is a result of mixed liquor maturation. Intended performance can be observed

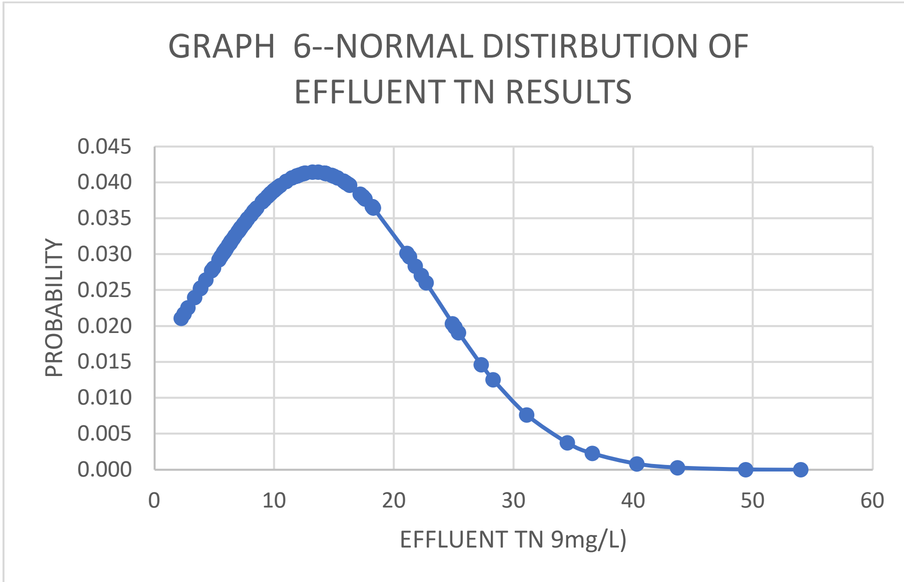
The Clean Data Effluent BOD_5 shows a tight distribution with just a few trailing values. So many values below 9 mg/L are present so as to preclude the observation of any single value. As noted, the 120 mg/L value was a result of owner abuse the day prior to sampling.



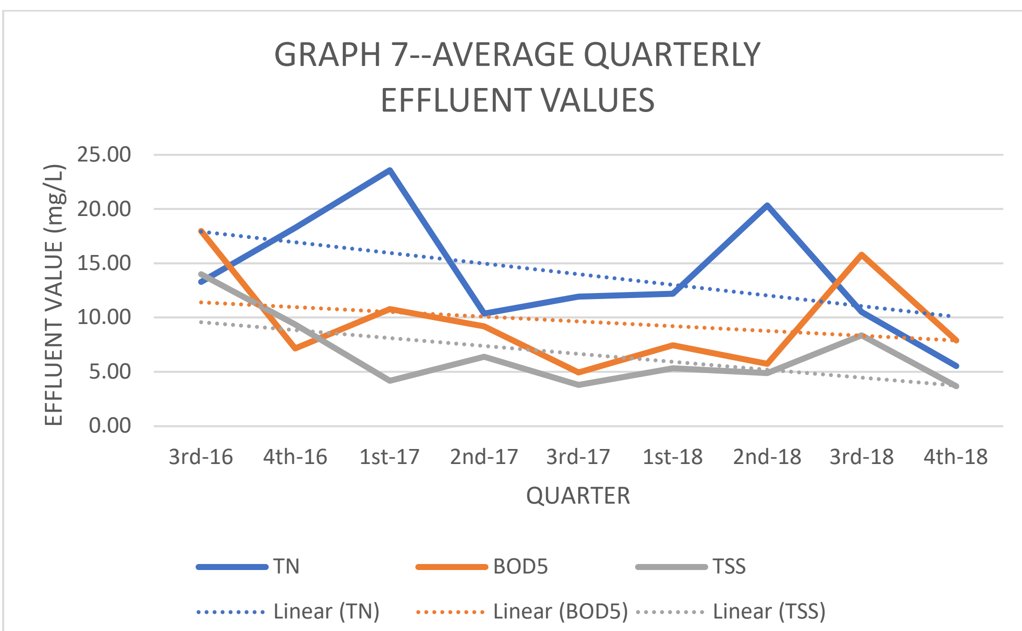
The effluent TSS exhibits a similar distribution over a smaller range. Again, the prevalence of values below the mean makes observation of individual points impossible.



Graph 6, which is a distribution of Effluent TN values, is not required and provided to demonstrate the robustness of the nitrogen-removal capabilities of the models.



Graph 7 is presented to examine performance through the year. Again, two trends are observed. First, the Effluent BOD_5 and TSS demonstrate improvement except during the third quarter of 2018. This unexpected result is the result of owner abuse, as noted. This result does not affect the outcome with regard to over performance. BOD_5 and TSS performance increases as systems age.



The second trend are the higher Effluent TN results during colder months. Higher values are expected because of cooler tank temperatures. Higher TN values can be addressed by providing insulation or heating to raise water temperature. Overall, the TN performance is increasing as the systems age.

Influent TKN Consideration. The average Influent TN is 14.3 mg/L. More important, the average Influent TKN is 8.2 mg/L, which is well-below the minimum value of 36 mg/L required by the City of Austin. The City of Austin, as noted, should not consider this a discrepancy or violation of its policy. As noted previously, Fuji Clean systems incorporate the practice of influent conditioning through recirculation to facilitate denitrification. The result is that no “pure” influent samples can be obtained. The influent TN and TKN can be inferred from the effluent results. In this case, the effluent TN is approximately 72 mg/L, and Influent TKN is a minimum of 58 mg/L.

Table 7—Average Influent Nitrogen Species (mg/L)

Constituent	TKN	NH_4-N	NO_2-N	NO_3-N	TN
Average	8.2	3.8	0.69	5.6	14.3

The Influent TKN and TN can be estimated by noting that a Fuji Clean unit is set at the factory to have an approximate 4:1 recirculation. The recirculation ratio can be adjusted to fit the unique wastewater regime at each dwelling. The simple estimation comes about by assuming a 100 percent TN removal. Knowing that the recirculation ratio results in an internal flow of five times the daily flow, the Influent TN is calculated to be five times the resultant of influent concentration and four times the recirculated effluent were the TN completely removed, which is shown below and within the range of typical influent TN from onsite wastewater treatment systems.

$$\frac{Daily\ Flow}{(Daily\ Flow + 4 * Daily\ Flow)} = 14.3\ mg/L$$

Of course, the actual biochemical mechanisms are more complicated, and each installation is unique, but two factors are clear. The first is that the Fuji Clean CEN-Series units can provide a consistent low Effluent TN regardless of occupancy and estimated flow, and Fuji Clean CEN-unit owners are not special; their wastewater will not be different than wastewater from owners of other wastewater treatment systems.

Maintenance

Typical operational issues were observed during the sampling. Re-sampling was conducted if the issue resulted in unrepresentative results or delayed if the matter was temporary. For example, an air hose was observed to have broken and resulted in impeded operation. The airline was repaired and the unit resampled. Occasionally, high oil and grease was encountered. A couple of analyses seemed incorrect and were questioned. Notes were made of unusual conditions and results.

SECTION 5—FUJI CLEAN OPERATION AND MAINTENANCE MANUAL

The Fuji Clean Operation and Maintenance Manual is attached. This manual is applicable to the CEN-Series. The Fuji Clean Installation and Owner's Manuals are also attached to provide additional information.

SECTION 6—FUJI CLEAN PERFORMANCE REPORTS

Performance reports submitted to Maryland and Virginia regulators are attached.

SECTION 7—FUJI CLEAN NSF AND TCEQ CERTIFICATIONS

The NSF International Standards 40 and 245 reports are attached. Reports have been amended by NSF over the years, so the current reports may be different from reports originally submitted. The attachment also includes a separate TCEQ letter addressing the CE7A and CEN7A. Certifications listed on the NSF website and provided, too.

SECTION 8--ASSESSMENT

City of Austin staff should expect that Fuji Clean CEN-Series perform consistent with the test sites. Staff should expect that Fuji Clean units will produce an effluent having a BOD_5 and TSS less than or equal to 10 mg/L. Staff should also expect an effluent TN in the range of 14 mg/L. All three values represent superior performance.

City of Austin staff should expect that Fuji Clean CEN-Series units can be maintained easily and need little maintenance effort when the units are installed, operated, and maintained in accordance with the manufacturer's design, installation, operation, and maintenance requirements, recommendations, limits, and prohibitions. Maintenance events were infrequent and required little effort to repair. One system was found to have been poisoned before sampling began. This unit was pumped and put back into service. The resultant sampling has been successful.

Respectfully Submitted,

Bennette D. Burks

Bennette D. Burks, P.E., Principal
3-Engineering, LLC
1605 Hanover Ave
Richmond, VA 23220
804-873-5000
www.3-eng.com