Commonwealth Energy Biogas/PV Mini-Grid Renewable Resources Program

Making Renewables Part of an Affordable and Diverse Electric System in California

Contract No. 500-00-036

Monthly Data Report for September 2005 (Draft)

Project 3.1 Co-Digestion of Dairy Manure/Food Processing Wastes and Biosolids /Food Processing Wastes to Energy

Task 3.1.5 Operate and Test Pilot (Demonstration) Plant(s)

Prepared For:
California Energy Commission
Public Interest Energy Research Renewables Program

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Acronyms and Abbreviations

AFT	Applied Filter Technology
AMD	acid manure digester
BFP	belt filter press
Btu/cf	British thermal units per cubic foot
cf/d	cubic feet per day
cf/hr	cubic feet per hour
cf/lb	cubic feet per pound
cfm	cubic feet per minute
CO_2	carbon dioxide
DAF	dissolved air flotation
DAFT	dissolved air flotation thickener
dtpd	dry ton per day
FID	flame ionization detector
FS	fixed solids
g/cm^3	gram per centimeter cubed
gpm	gallon per minute
H_2S	hydrogen sulfide
HRT	hydraulic retention time
IA/PA	volatile acids (VA): Alkalinity ratio (expressed as “IA/PA” in IEUA analytical protocols)
IEUA	Inland Empire Utilities Agency
K cf/d	1,000 cubic feet per day
K cf/hr	1,000 cubic feet per hour
K gal/d	1,000 gallons per day
K gpd	1,000 gallons per day
K lb/d	1,000 pounds per day
lb/d	pound per day
lb/gal	pound per gallon
µg/L	micrograms per liter
MG	million gallon
mgd	million gallon per day
mg/L	milligram per liter

NRW	non-reclaimable waste
PIER	Public Interest Energy Research
ppm	part per million
ppmv	part per million by volume, dry
PS	primary sludge
psig	pound per square inch gauge
SiO_2	silicone dioxide
SLR	solids loading rate
SWD	side water depth
TDS	total dissolved solid
TKN	total Kjeldahl nitrogen
TPS	thickened primary sludge
TS	total solids
TSS	total suspended solid
TWAS	thickened waste activated sludge
VA	volatile acids
VS	volatile solids
VSR	volatile solids reduction
WAS	waste activated sludge
wtpd	wet ton per day

SECTION 1

Introduction

In late September 2005, the California Energy Commission (Energy Commission) authorized the contractor to proceed with Project 3.1—Co-Digestion of Dairy Manure/Food Processing Wastes and Biosolids/Food Processing Wastes to Energy. The goals of this project are to:

- Develop technologies that will address the lack of knowledge of the relationship between various co-digestion feedstocks and gas production. Pilot (demonstration) scale systems will be developed to yield information on the direct relationship between the physical and chemical characteristics of the feedstocks and the operating parameters of the co-digestion system and the increase in gas production associated with their co-digestion.
- Provide information for future users on the development of optimal blends or "cocktails" for co-digestion projects.
- Quantify the potential environmental benefits of dairy waste to energy projects in such a way that their values can be identified as individual projects are being implemented.
- Report the results of studies that led to the establishment of the foregoing goals.

Task 3.1.5 in Project 3.1 calls for (1) operating the plant and conducting co-digestion tests in accordance with the test plan, and (2) preparing monthly plant operating data reports to verify that the pilot (demonstration) plant meets performance requirements (e.g., throughput, environmental requirements, waste processing, and gas production/energy recovery).

Pilot tests for co-digestion of both dairy manure/food processing wastes and biosolids/food processing wastes to energy have been conducted at the Inland Empire Utilities Agency (IEUA) Regional Plant No. 1 (RP-1) since April 2005. This report presents the plant operational and performance data obtained during the month of September 2005.

SECTION 2

Co-Digestion Performance Summary

2.1 Co-Digestion Inputs

Table 2-1 shows inputs to the co-digestion systems for dairy manure, biosolids and food waste. For the biosolids test, flows into Digester 1 are shown, with the effluent amounts (flow, total solids [TS] and volatile solids [VS]) apportioned to digesters 2, 6 and 7.

TABLE 2-1
Inputs to Co-Digestion Systems for Dairy Manure, Biosolids, and Food Waste

Inputs	Flow (GPD)	TS (Lbs/Day)	VS (Lbs/Day)	Avg. % Solids (%TS)
1) Co-digestion of dairy manure/food processing wastes				
Digester 4				
Dairy manure	28,849	34,098	24,766	14.2%
Food processing wastes				
Salad Dressing	490	452	387	11.1%
Lactose	222	261	214	14.1%
Ice Cream	172	137	132	9.6%
Total	**29,733**	**34,950**	**25,500**	**14.1%**
2) Co-digestion of biosolids/ food processing wastes				
Digester 1				
Biosolids	253,697	92,608	70,423	4.4%
Food processing wastes[1]				
Salad Dressing	0	0	0	N/A
Lactose	0	0	0	N/A
Ice Cream	3,345	4,548	4,430	16.3%
Total	**257,040**	**97,160**	**74,850**	**4.5%**
Distribution of Digester 1 Effluent: Feed to Digesters 2, 6, and 7:				
Digester 2	68,714*	20,840	16,084	3.7%
Digester 6, 7	94,482*	28,654	22,116	3.7%

* Food waste was added to Digester 1 from DAFT3. The flow here is the proportioned amount based on the flow distribution ratio from Digester 1 to digesters 2, 6, and 7. Average number includes zeros.

Totals rounded to the nearest 10.

2.2 Digester Performance Data

Table 2-2 shows performance parameters for Digester 4 (manure co-digestion) and digesters 1, 2, 6, and 7 (biosolids co-digestion).

TABLE 2-2
Digester Performance

1) Co-digestion of dairy manure/food processing wastes	**Units**	**Digester 4**			
VS loading rate	lbVS/cf active volume[1]	0.231			
Hydraulic Retention Time	Days	25			
Digester Temperature	^{0}F	98			
pH changes over time	pH (range)	7.4 – 8.0			
Iron Salt Addition	gpd	171			
Volatile Solids (VS) Reduction	%	48%			
Gas Yield[2]	cf/lb VSR	9			
CH_4 in Biogas	%	60%			
CO_2 in Biogas	%	39%			
H_2S in Biogas[3]	ppm	83.1			
2) Co-digestion of biosolids/food processing wastes		**Digester 1**	**Digester 2**	**Digester 6**	**Digester 7**
VS loading rate	lbVS/cf active volume[c]	0.611	0.131	0.098	0.092
Hydraulic Retention Time	Days	2.9	12.6	17	17
Digester Temperature	^{0}F	100	127	98	121
pH changes over time	pH (range)	5.1 – 5.4	7.5 – 7.8	7.3 – 7.5	7.5 – 7.9
Volatile Solids (VS) Reduction	%	18%	49%	44%	43%
Biogas Yield[2]	cf/lb VSR	5.1	38.1	21.8	25
CH_4 in Biogas	%	N/A	62%	64%	63%
CO_2 in Biogas	%	N/A	35%	36%	37%
H_2S in Biogas[3]	ppm	70.1	N/A	N/A	N/A

1 Digester's active volume was calculated based on digester SWD (30 ft) and with cone volume

2 Gas Yield/Biogas Yield based on 15-day running averages for VS in, VS out, and Gas Production. This would be a different value if a different running average period was used.

3 H_2S was not measured specifically for digesters 2, 6, or 7. H_2S in gas from these digesters was measured at the waste gas burner, where it averaged 48 ppm, and at the common feed to the recovery boiler (after iron sponge treatment, where it averaged 9 ppm.

Totals were rounded to the nearest 10.

NA: Not Available or Not Applicable.

The focus of the monthly reporting was on digesters 2 and 6. Detailed graphical data showing trends for the above parameters for digesters 2 and 6 are shown in the body of this report.

2.3 Cost Data

2.3.1 Installation Costs

Total installation costs for the co-digestion equipment at RP-1 used to conduct the field tests are shown in Table 2-3. Costs to install iron sponge modifications, which were indirectly related to the co-digestion project, are shown as well.

TABLE 2-3
Co-Digestion and Iron Sponge Project Installation Costs

	Co-Digestion	Iron Sponge Modifications	Total	Comments
Raw Materials	$562,000	$14,000	$576,000	Includes food-waste tanks, pumps, media for iron sponge
Total installation subcontracts	$226,000	$158,000	$384,000	
Host site (IEUA) General & Administrative	$79,000	$17,000	$96,000	10% of (Raw Materials + Installation costs)
CH2M HILL cost (design and engineering)	$85,000	$31,000	$116,000	
Total	**$952,000**	**$220,000**	**$1,172,000**	

Note: All costs rounded to nearest $1,000.

These costs are one-time costs to the project, and will be recorded again for reference only in subsequent monthly data reports for Task 3.1.5.

In addition, IEUA spent approximately $1.3 million on safety and performance upgrades to the existing gas handling system. These changes had already been identified before the project started. However, the addition of co-digestion increased the urgency of these expenditures. For estimating purposes, approximately one-third of this cost, or about $433,000, could be necessary in addition to the direct costs of the co-digestion project shown in Table 2-3. It is anticipated that similar expenditures could be needed at other facilities in California where co-digestion projects are installed.

2.3.2 Operations and Maintenance Costs

For the month of September, 2005, total operations and maintenance costs were estimated at $30,100, broken out as follows:

- $4,400 host site (IEUA) labor and administrative costs
- $14,300 subcontracted operators and lab costs
- $11,400 costs from CH2M HILL

These costs include laboratory testing costs as well as standard operating costs. For a full-scale system, the laboratory tests would not be included.

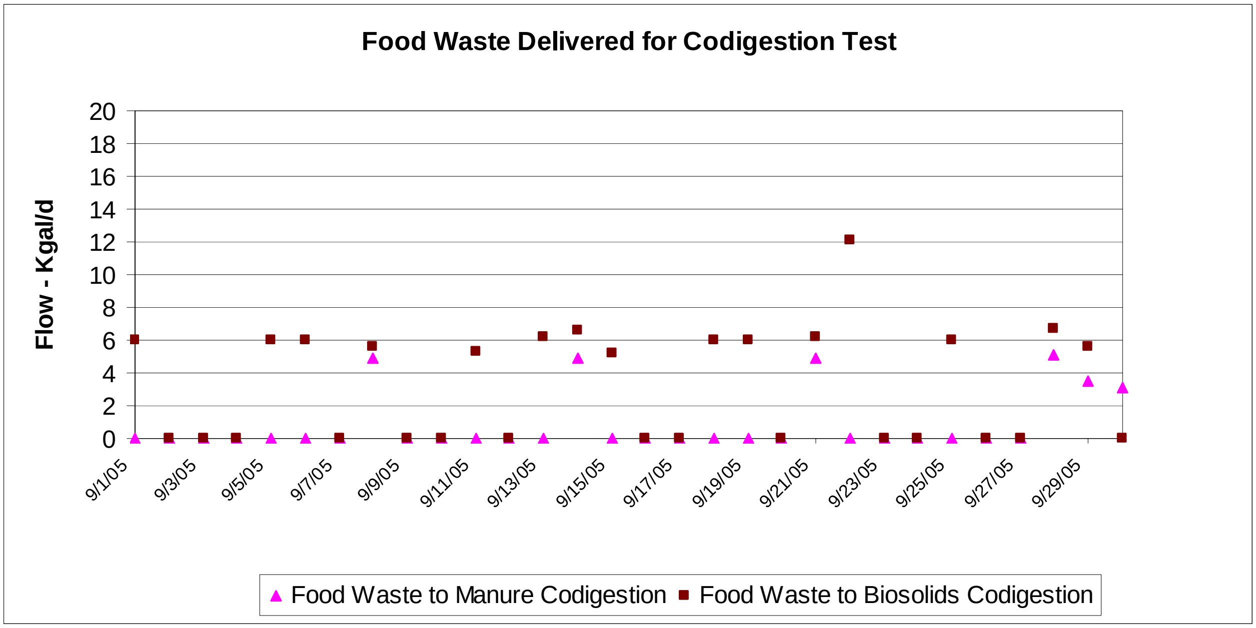
SECTION 3

Food Waste Received for Manure and Biosolids Co-Digestion Test

This section provides a summary of the food waste delivered to the RP-1 plant during the month of September 2005. The food waste delivered was used for manure and biosolids co-digestion tests and included salad dressing waste from GFF, Inc. (normally delivered on Wednesdays), lactose waste from AJ Juice, and ice cream waste from Alta Dena, delivered over the week.

Figure 3-1 shows the combined food waste flow that has been fed to the manure (Digester 4) and biosolids train for co-digestion tests.

Figure 3-2 presents the TS concentration and VS content of the TS of the food waste, by type, that has been fed to the manure (Digester 4) and biosolids train for co-digestion tests.



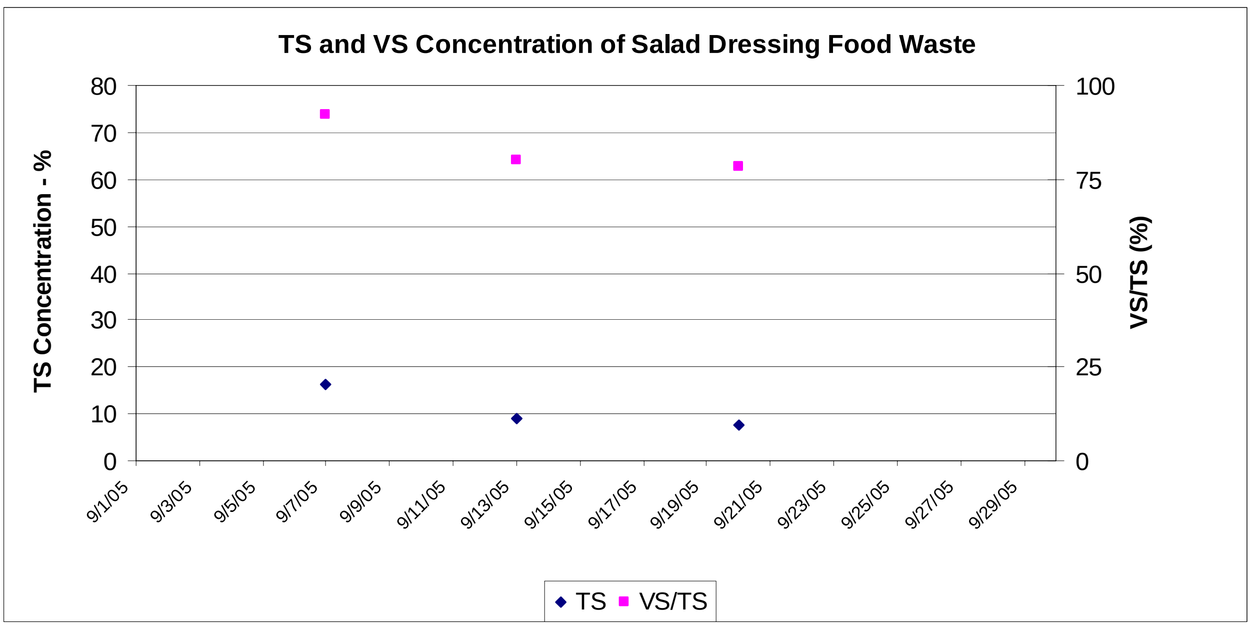
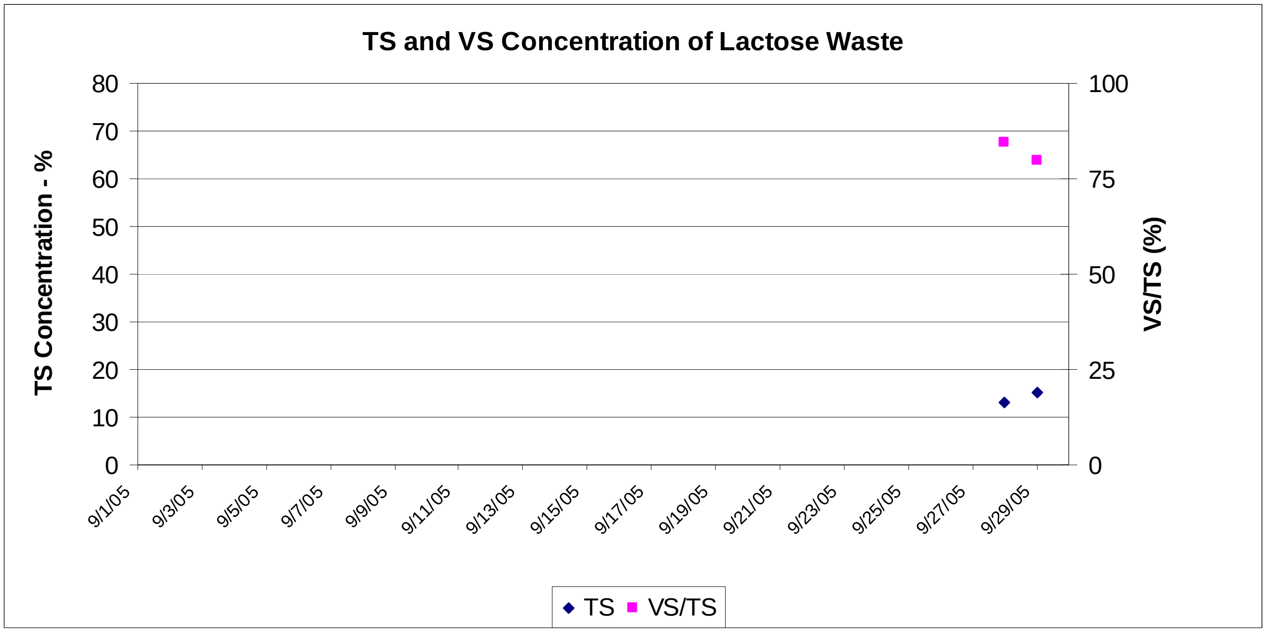


FIGURE 3-1
Combined Food Waste Flow Delivered for Co-Digestion Test During September 2005



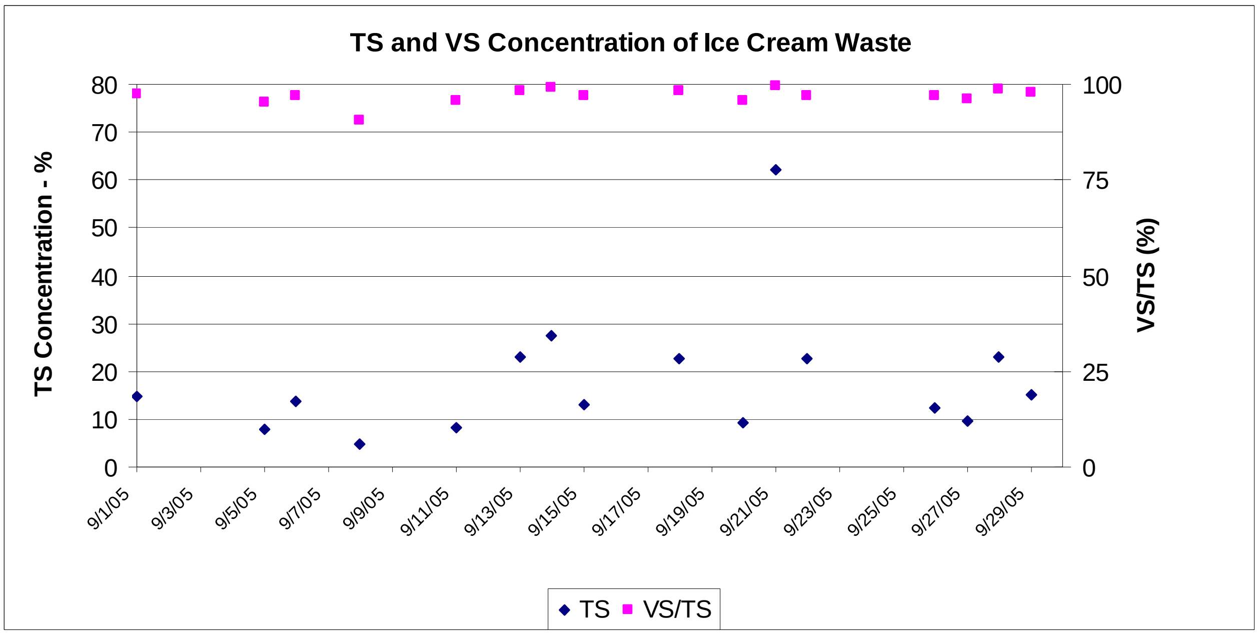


FIGURE 3-2
TS Concentration and VS Content of the Food Waste Delivered by Type

SECTION 4

Manure and Food Waste Co-Digestion

This section provides operational and performance data obtained from manure and food waste co-digestion tests during the month of September 2005.

4.1 Manure and Food Waste Co-Digestion Operations with Digester 4 at RP-1

4.1.1 Manure Digestion at RP-1

In 2002, IEUA retrofitted an existing digester (Digester 4) located within the Agency RP-1 facility to accept dairy manure. RP-1 currently serves a cluster of seven dairies within 5 miles, which makes it an ideal location for a centralized dairy manure digestion facility. Manure is collected daily from the dairies' feed lanes by means of a vacuum tanker truck called the "honey-vac" and is transported daily to the RP-1 digester in a nurse tanker. The vacuum nurse tanker has a holding capacity of 5,500 gallons, and roams from dairy to dairy picking up manure slurry that has been temporarily stored in a holding tank and delivers it to the manure digestion facility at RP-1. These units provide efficient, clean transportation of manure from the dairies to the manure digester at RP-1. Under normal operations, the plant receives five to seven loads per day of dairy manure. Before July 2005, the trucked manure was fed to an acid manure digester (AMD) first; from there, it was fed to Digester 4. Since July, the trucked manure has been fed directly to Digester 4.

4.1.2 Food Waste and Dairy Manure Co-Digestion at Digester 4

Beginning in early April 2005, the RP-1 plant initiated a co-digestion project by adding food waste to the dairy manure fed to Digester 4. The food wastes are trucked to the plant on a daily basis, stored temporarily in the four food waste storage tanks, and fed to the manure digester and biosolids digestion trains from there. Prior to the full-scale pilot project, bench-scale testing of manure and food waste co-digestion was conducted at mesophilic and thermophilic conditions. Bench-scale testing showed that the microbial population in the digester can be stressed much more easily and rapidly at thermophilic temperatures; therefore, the full-scale testing of manure and food waste was conducted at mesophilic temperatures.

4.1.3 Co-digestion Facility at RP-1

Figure 4-1 shows the manure and food waste co-digestion facility at RP-1.

FIGURE 4-1
Manure and Food Waste Co-Digestion Facility at RP-1

4.2 Digester 4 Operational Parameters

Because digester operational parameters affect digester performance, it is necessary to monitor these parameters in relation to digester performance. For this full-scale test, digester operational parameters that are monitored include feed characteristics (e.g., flow and solids concentrations of the dairy manure and food waste), VS loading rate, hydraulic retention time, pH, alkalinity, and digester operational temperatures. Figures 4-2 to 4-5 present the digester feed flow and solids concentrations, VS loading rate, and hydraulic retention time. Monthly averages for operational parameters are discussed in Section 4.4.

4.2.1 Feed Manure and Food Waste

Figure 4-2 shows the manure and food waste flow added to Digester 4 during the month of September 2005. The food waste flow is the combined amount of the salad dressing, lactose, and ice cream wastes received in the plant and fed to the manure digester the same day.

Figure 4-3 presents the TS concentration and VS content of the manure that has been fed to Digester 4.

Table 4-1 presents Digester 4 monthly average data for feed and feed characterization for September 2005.

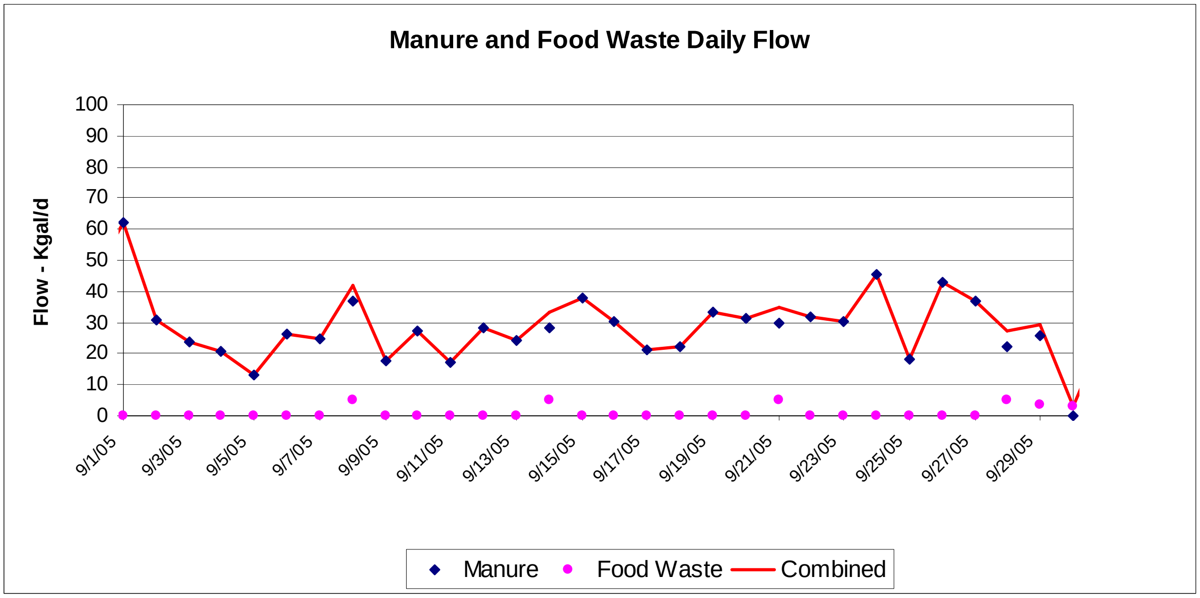


FIGURE 4-2
Digester 4 Manure and Food Waste Daily Flow

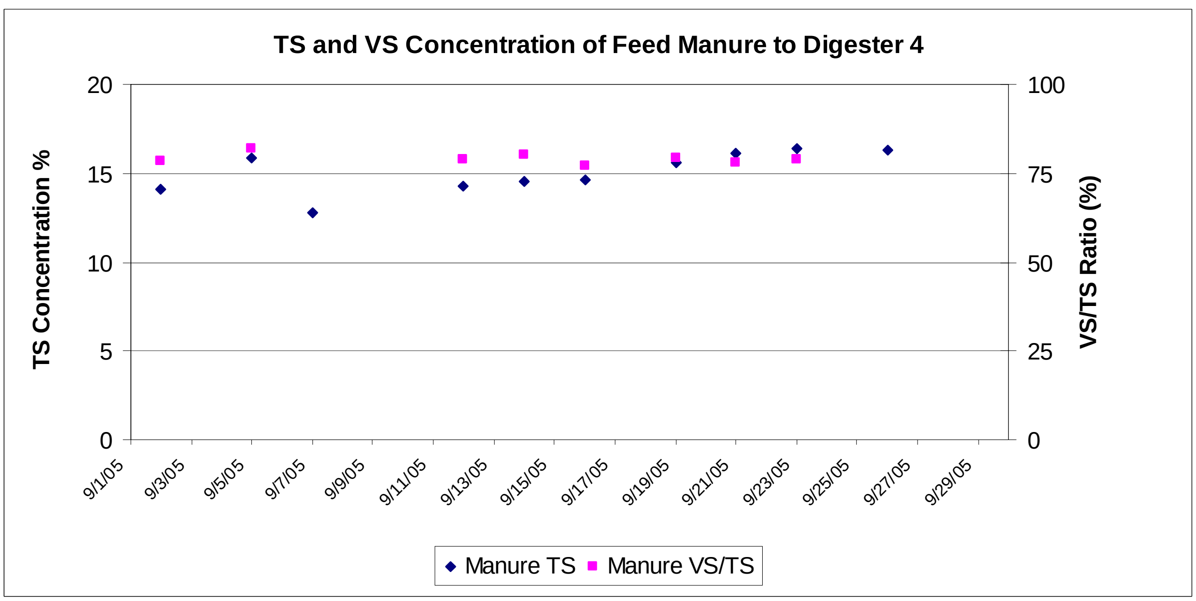


FIGURE 4-3
TS Concentrations and VS Content of the Manure Fed to Digester 4

TABLE 4-1
Monthly Averages of Digester 4 Feed and Feed Characterization Data for September 2005

			Food Waste		
Parameter	**Units**	**Manure Feed**	**Salad Dressing**	**Lactose**	**Ice Cream**
Flow[1]	gpd	28,850	490	220	170
TS	%	14	11[b]	14[2]	10[2]
VS	% of TS	73	86[b]	82[2]	96[2]
pH		NA	NA	NA	NA
Alkalinity	mg/L	NA	NA	NA	NA
Temperature	^{0}F	NA	NA	NA	NA
Volatile Acids	mg/L	NA	NA	NA	NA
Total Organic Carbon	mg/L	NA	NA	NA	NA
COD, mg/L	mg/L	NA	NA	NA	NA
NH_4-N	mg/L	NA	NA	NA	NA
TKN	mg/L	NA	NA	NA	NA
Proximate Analysis		NA	NA	NA	NA

1 Average flow includes zero values. Numbers were rounded to the nearest 10.

2 Missing values were filled with previous or adjacent days' test results.

NA = Not Applicable or Not Available.

4.2.2 Solids Loading Rate (SLR)

Figure 4-4 shows the VS loading rate for Digester 4 during the month of September.

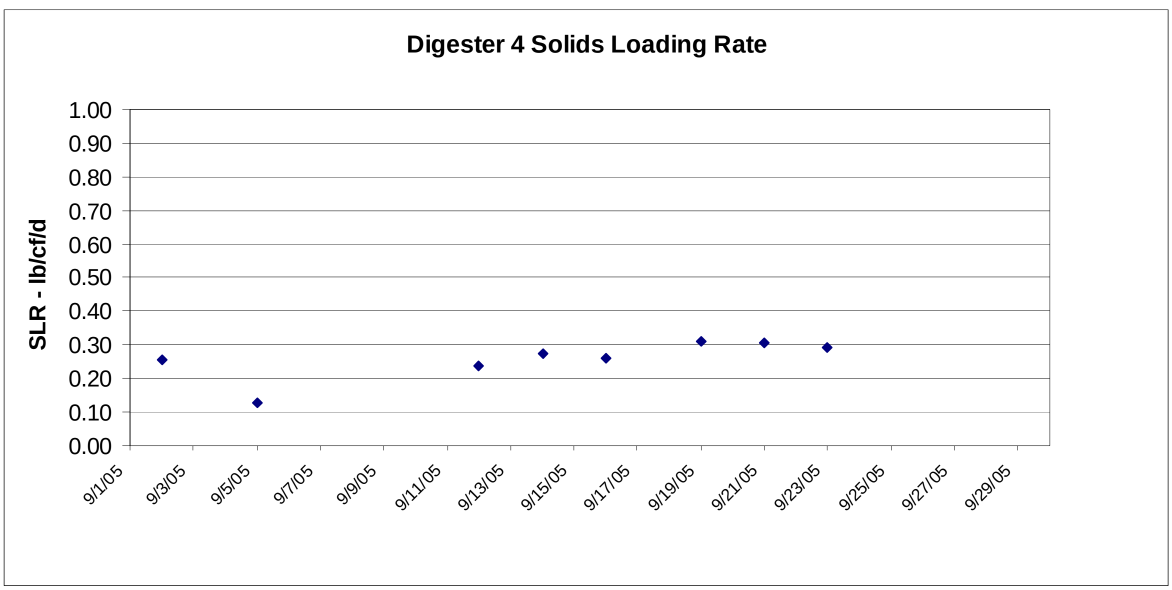


FIGURE 4-4
Digester 4 Volatile Solids Loading Rate (Manure and Food Waste Combined)

4.2.3 Hydraulic Retention Time (HRT)

Figure 4-5 shows the hydraulic retention time in Digester 4.

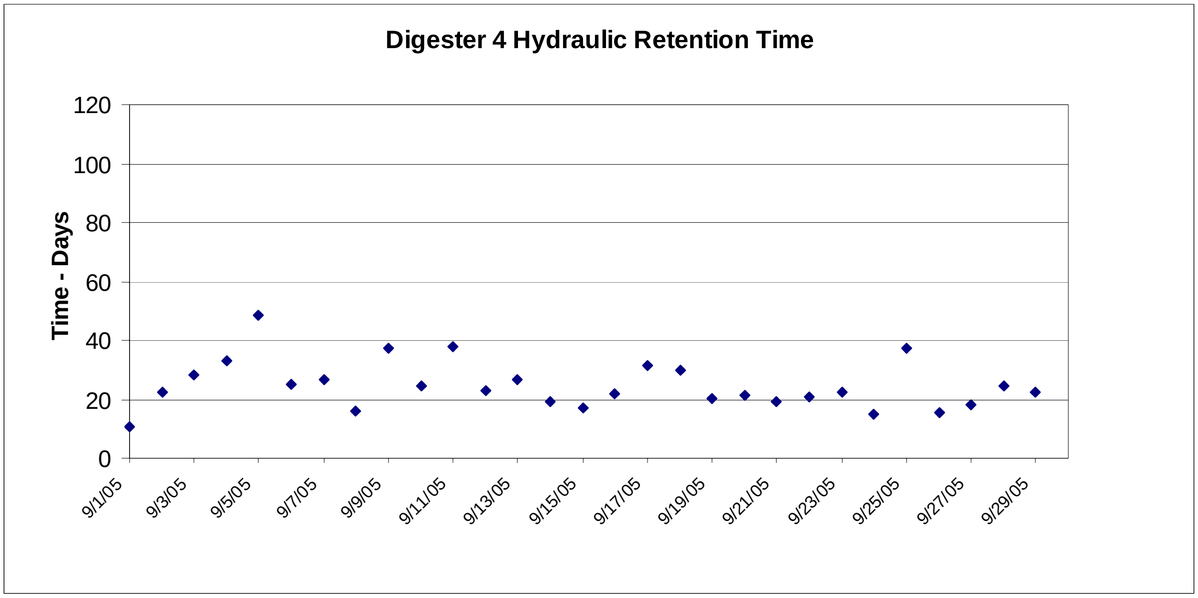


FIGURE 4-5
Digester 4 Hydraulic Retention Time

4.3 Digester 4 Performance

The digester stability indication parameters of pH and IA/PA, and the digester performance parameters of biogas production, VSR, and biogas yield are presented in Figures 4-6 through 4-10.

4.3.1 Digester 4 pH

Figure 4-6 shows Digester 4 pH during the month of September 2005.

4.3.2 Digester 4 IA/PA

Figure 4-7 shows Digester 4 IA/PA during the month of September 2005.

4.3.3 Digester 4 Temperature

Figure 4-8 shows Digester 4 temperature during the month of September 2005.

4.3.4 Digester 4 Biogas Production

Figure 4-9 shows the daily biogas production by Digester 4 during the month of September 2005.

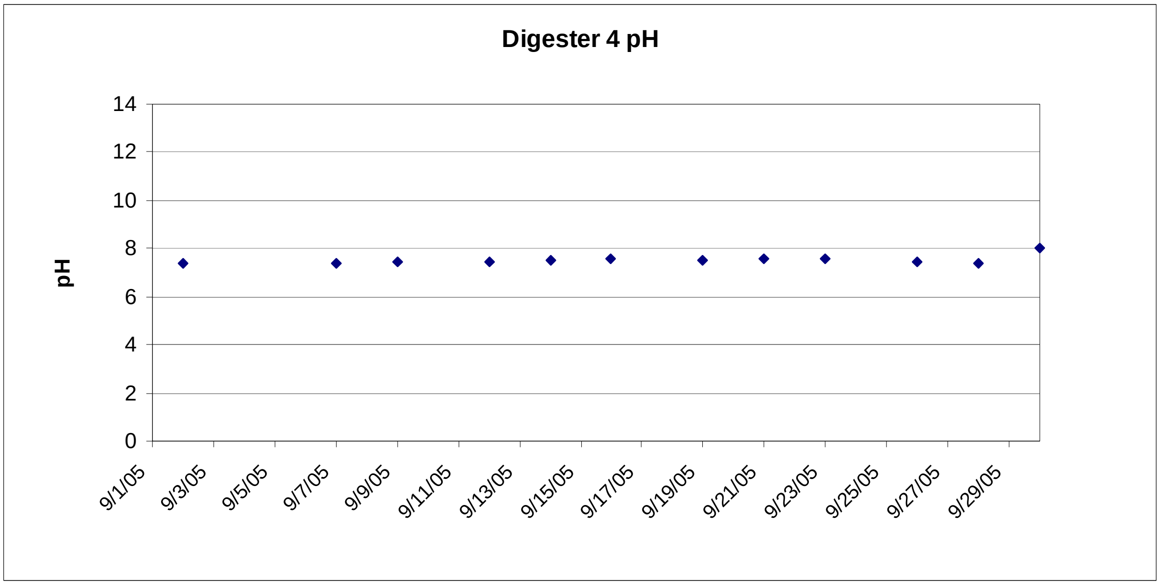


FIGURE 4-6
Digester 4 Ph

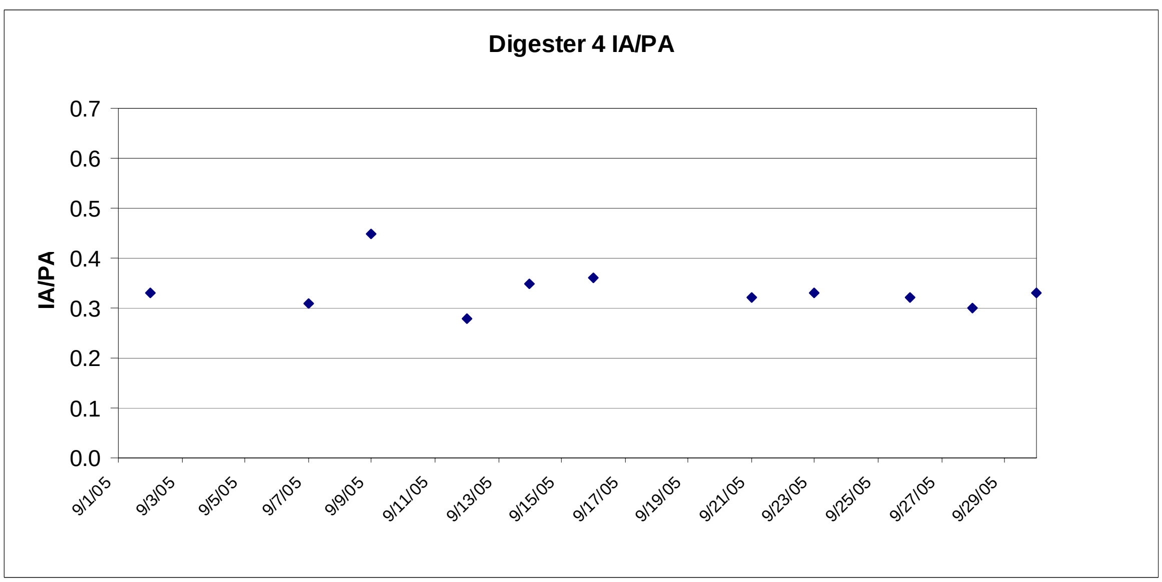


FIGURE 4-7
Digester 4 IA/PA

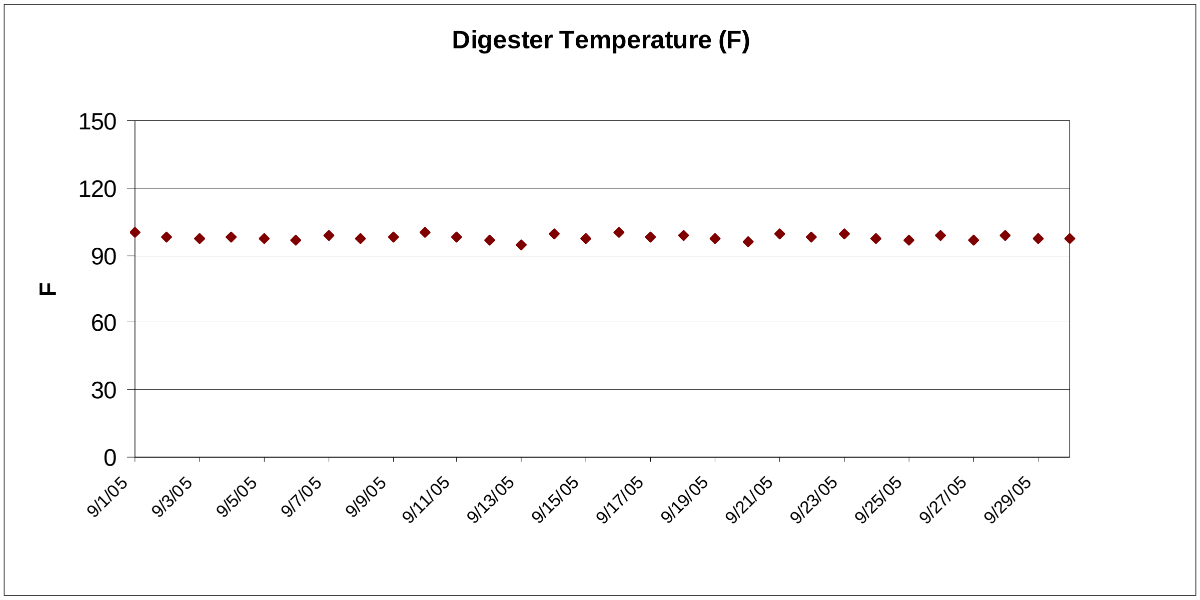


FIGURE 4-8
Digester 4 Temperature

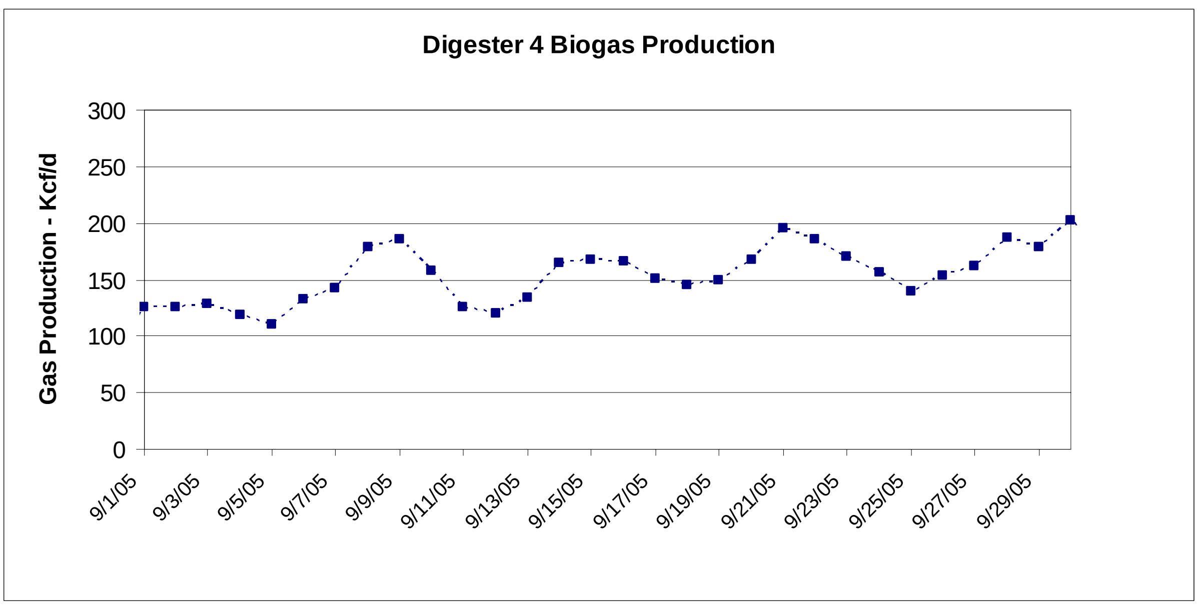


FIGURE 4-9
Digester 4 Gas Production

4.3.5 VSR

Figure 4-10 shows the percentage of VS reduction (VSR) in Digester 4 during the month of September 2005. VSR was calculated by using both the approximate mass balance and Van Kleek methods, however, the approximate mass balance was considered more appropriate for this case and the result is presented here.

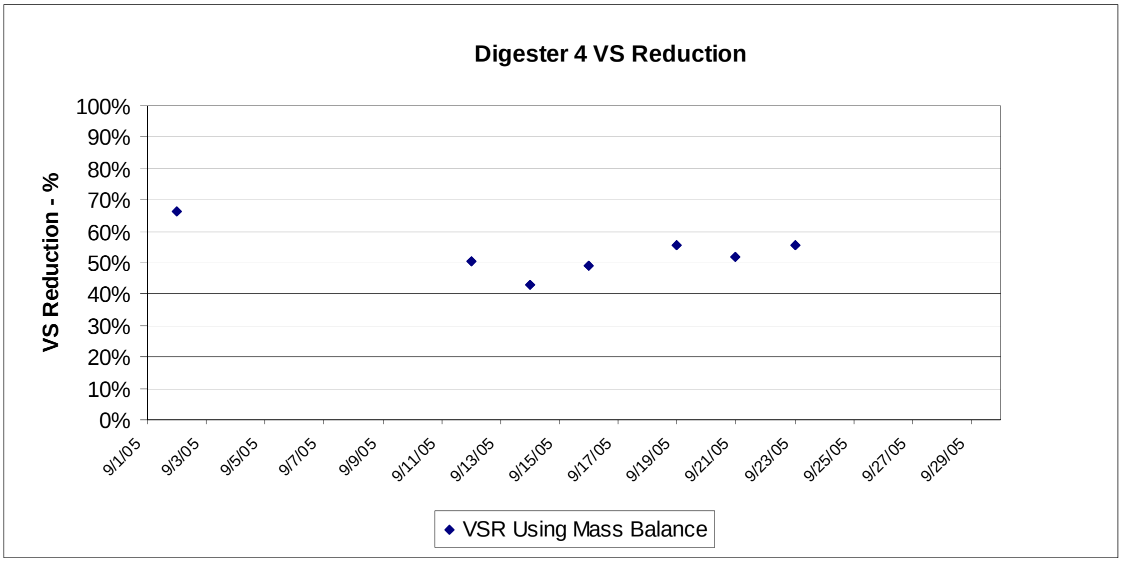


FIGURE 4-10
Digester 4 VS Reduction

4.3.6 Biogas Yield

Biogas yield is calculated as a ratio of biogas production to volatile solids reduction. Figure 4-11 shows the biogas yield obtained by Digester 4 during the month of September 2005.

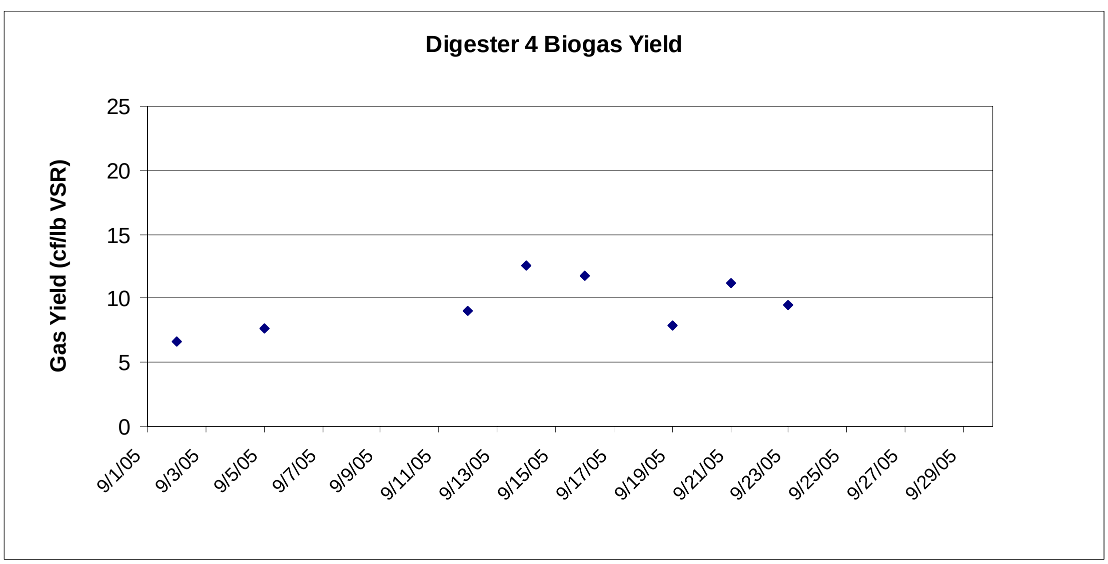


FIGURE 4-11
Digester 4 Biogas Yield

4.4 Monthly Operation and Performance Summary

Tables 4-2 and 4-3 provide the monthly averages for digester operational, performance, and dewatering data. Digester effluent characteristics such as solids concentrations and chemical data (e.g., alkalinity, ammonia and volatile acids) are also included. The flow and solids data were used to determine the mass balance and solids reduction in the digester. The chemical data are measures of digester stability (alkalinity, pH, VAs, ammonia). Ammonia and total Kjeldahl nitrogen (TKN) also have implications for the cost of filtrate treatment, and the fertilizer value of the biosolids product and sulfate concentrations can affect gas quality through H_2S formation. The digester gas data are also presented, including total gas produced and gas yield. Gas quality parameters include methane content and H_2S concentrations.

TABLE 4-2
Monthly Averages of Digester 4 Data for September 2005

Parameter	Units	September 2005
Digester Feed Characteristics		
Manure Flow	gpd	28,849
Food Waste Flow[1]	gpd	884
Combined Flow	gpd	29,733
Manure TS	lb/d	34,098
Manure VS	lb/d	24,766
Food Waste TS	lb/d	850
Food Waste VS	lb/d	733
Combined TS	lb/d	34,948
Combined VS	lb/d	25,499
Digester Effluent (i.e. Digested Manure and Food Waste Mixture)		
Digester TS	TS%	7.4
Digester VS	VS%	72
Digested TS	lb/d	18,313
Digested VS	lb/d	13,267
VSR	lb/d	12,232
VSR	%	48
pH	SU	7.5
Alkalinity	mg/L	7,985
VA	mg/L	1,560
VA:Alk (IA/PA)	-	0.34
Total Organic Carbon	mg/L	NA
COD	mg/L	NA
NH_4-N	mg/L	1,260
TKN	mg/L	3,190
Phosphate-P	mg/L	NA

TABLE 4-2
Monthly Averages of Digester 4 Data for September 2005

Parameter	Units	September 2005
Dissolved Sulfide	mg/L	NA
Total Sulfide	mg/L	NA
Total Sulfur	mg/L	NA
Total Sulfate	mg/L	NA
Proximate Analysis[2]		NA
Digester Gas		
Gas	K cf/d	154
Gas Production	cf/lb VS in	6.1
Gas Yield[c]	cf/lb VSR	9
CH_4	%	60
CO_2	%	39
H_2S	ppm	NA
Volatile Sulfur Compounds	ppb	NA
Digester Operations		
Digester Temperature	^{0}F	98
Digester Free Board Level[4]	ft	6.6
Digester Active Vol[5]	gal	826,840
HRT by SWD Vol[5]	days	25
VS Load Rate	lbVS/cf active volume[5]	0.231
Iron Salt Addition	gpd	171

1 Average food waste flow is the monthly average that includes the days without food waste delivery.

2 Proximate Analysis

3 Gas Yield/Biogas Yield based on 15-day running averages for VS in, VS out, and Gas Production. This would be a different value if a different running average period was used.

4 Digester Free Board Level is the actual operational level measured. Digester 4 side wall depth is 30 ft.

5 Digester's active volume (110,533 cf or 826,844 gal) was calculated based on digester SWD (30 ft) and with cone volume.

NA: Not Available or Not Applicable

TABLE 4-3
Monthly Averages of Digester 4 Dewatering and Recycle Streams Manure Data for September 2005

	Unit	September 2005
Feed to Dewatering		
pH	-	7.5
Alkalinity	mg/L	7,985
Temperature	ºF	98
Flow	kgal/d	30
TS %	%	7.4
VS %	%	72
VA by IA/PA method	mg/L	1,560
NH_4-N	mg/L	1,260
COD	mg/L	NA
Magnesium	mg/L	NA
Ortho-phosphorus	mg/L	NA
Dissolved Sulfide	mg/L	NA
Total Sulfide	mg/L	NA
Dewatered Cake		
TS %	%	28
Polymer usage	lb/ton	8.6
Filtrate		
pH	-	NA
Alkalinity	mg/L	NA
Flow	kgal/d	18
TDS	mg/L	7,260
TSS	mg/L	778
Dissolved Sulfide	mg/L	NA
NH_4-N	mg/L	890
COD	mg/L	4,856
Magnesium	mg/L	NA
Ortho-phosphorus	mg/L	NA

NA = Not Available or Not Applicable.

SECTION 5

Biosolids and Food Waste Co-Digestion

5.1 Existing Biosolids Processing Trains at RP-1

RP-1 has six digesters for wastewater biosolids treatment. The solids from the primary clarifiers, or primary sludge, are thickened in a gravity thickener and the solids from the secondary clarifier, or waste activated sludge (WAS), are thickened with dissolved air flotation (DAF). The thickened primary sludge (TPS) and thickened WAS (TWAS) are then digested in a three-phase anaerobic digestion process: mesophilic acid phase digestion, followed by mesophilic and thermophilic gas phase digestion, then further digestion in an unheated gas phase. As shown in Figure 5-1, Digester 1 was used for the first acid phase, feeding Digester 2 (thermophilic), Digester 6 (mesophilic), and Digester 7 (thermophilic) as the second phase gas digesters. Digester 2 fed Digester 3 as the unheated gas digester. Digesters 6 and 7 fed Digester 5. Digester 5 was offline during the month of September for cleaning.

The digested biosolids are then dewatered by belt filter presses and hauled to the Agency's co-composting plant in Chino, operated by Synagro. Filtrate from the belt presses is sent to the non-reclaimable waste (NRW) line operated by the Los Angeles County Sanitation District. The digester gas is used in three Waukesha spark ignition lean burn engines and eight microturbines to generate electricity, and occasionally is used in two hot water boilers.

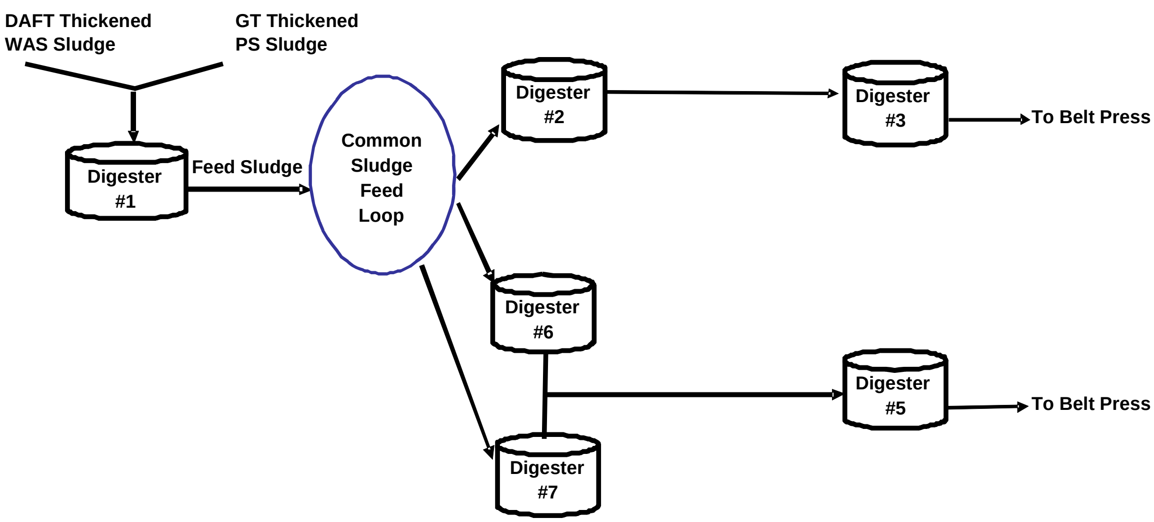


FIGURE 5-1
RP-1 Current Biosolids Digester Configuration

5.2 Biosolids and Food Waste Co-Digestion at RP-1

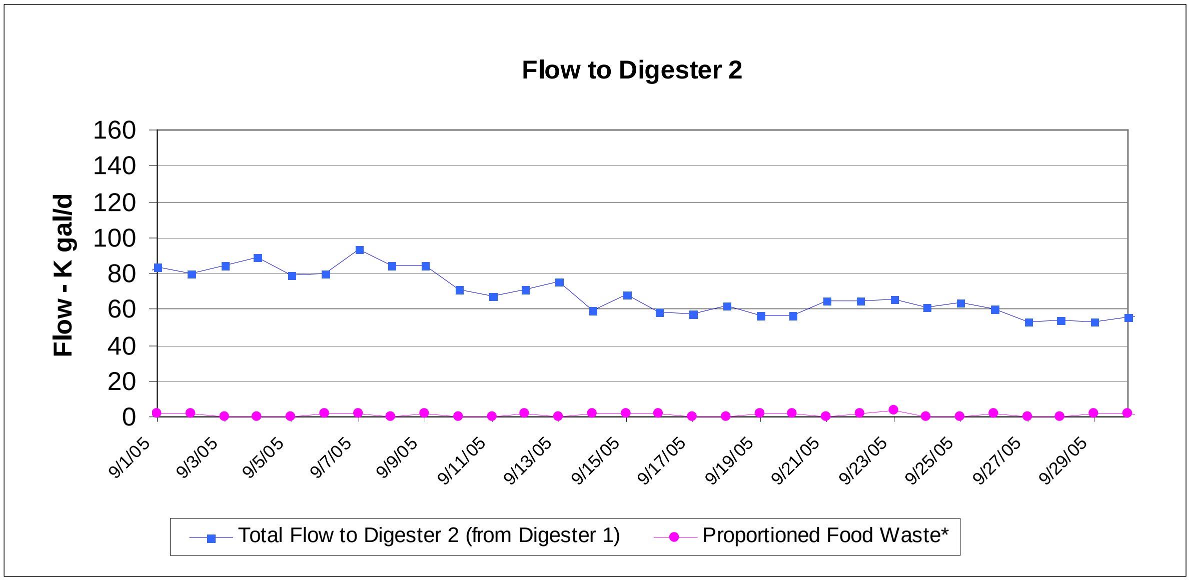
Beginning in early April 2005, the RP-1 plant initiated a co-digestion project. Food wastes are trucked to the plant on a daily basis and fed to DAFT 3, then to Digester 1, and on to the biosolids digestion trains. This section provides operational and performance data for the biosolids and food waste co-digestion obtained during the month of September 2005. The main focus is on digesters 2 and 6, based on the co-digestion test plan, because these two digesters are operated at the thermophilic and mesophilic temperatures, respectively.

5.3 Digesters 2 and 6 Operational Parameters

Digester operational parameters, including feed characteristics, such as flow and solids concentrations to each digester, VS loading rate, and hydraulic retention time, are presented in Figures 5-2 through 5-5. Digester operational parameters affect digester performance; thus it is necessary to monitor these parameters in relation to digester performance.

5.3.1 Feed Biosolids and Food Waste

Figure 5-2 present the daily flow rate to Digester 2 (top) and Digester 6 (bottom). The flow represents the combined flow of the biosolids and food waste transferred to these digesters from the acid digester, Digester 1.



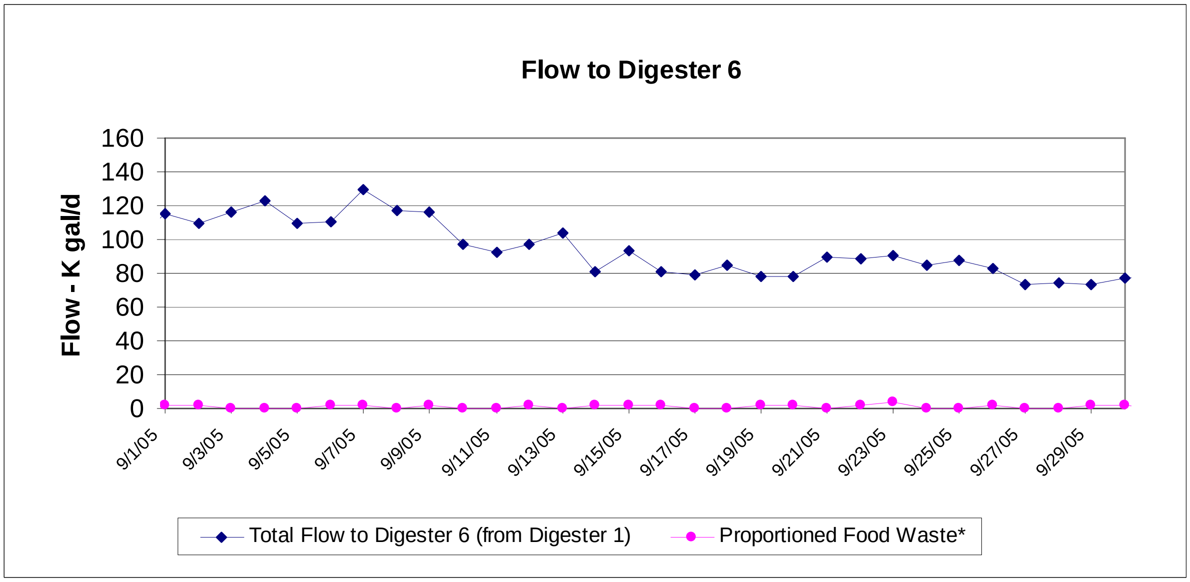


FIGURE 5-2
Biosolids and Food Waste Flow to Digesters 2 and 6

* *The food wastes flow to Digesters 2 and 6 was the proportioned amount based on the total food waste fed to DAFT3 then Digester 1 for food waste and biosolids co-digestion test. This proportioned amount is included in the total flow fed to the digester as shown in the figures.*

Figure 5-3 shows the feed TS concentration and VS content to digesters 2 and 6 (i.e., Digester 1 effluent).

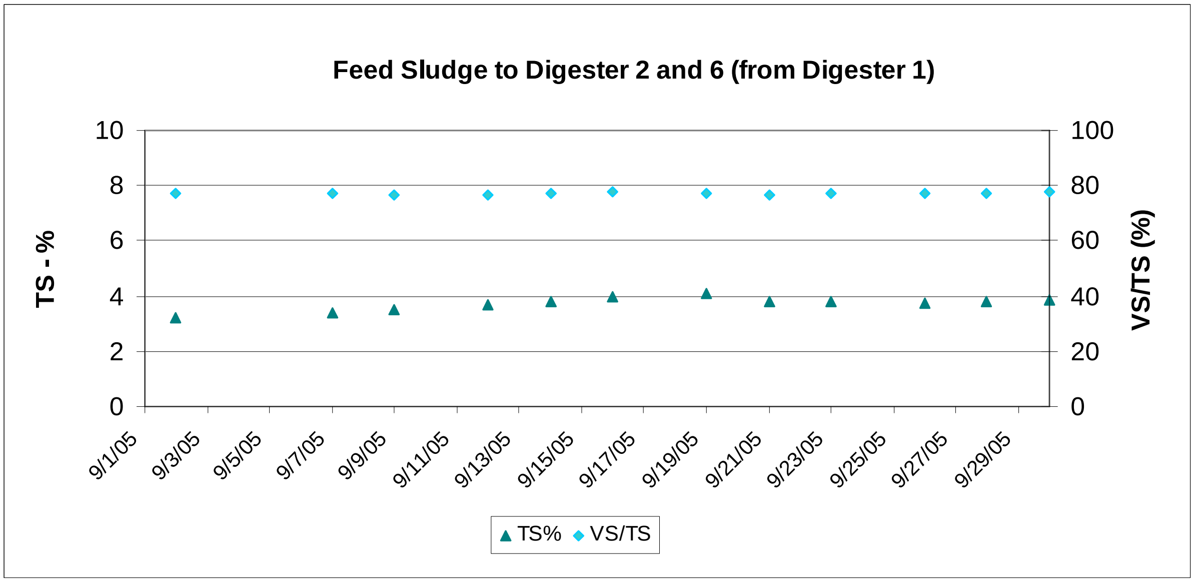


FIGURE 5-3
TS Concentration and VS Content of Digesters 2 and 6 Feed Sludge (Digester 1 Effluent)

Table 5-1 shows the monthly feed characteristics averages for digesters 2 and 6 for September 2005.

Parameter	Units	Biosolids and Food Waste Mixture Fed to Digesters 2 and 6 (from Digester 1)
TS	%	3.7
VS	%	77
pH		5.1
Alkalinity	mg/L	2,424
Temperature	ºF	98
Volatile acids, mg/L	mg/L	5,007
Total Organic Carbon	mg/L	NA
COD	mg/L	NA
NH_4-N	mg/L	387
TKN	mg/L	2,150
Proximate Analysis		NA

5.3.2 Solids Loading Rate (SLR)

Figure 5-4 shows the solids loading rate in digesters 2 and 6.

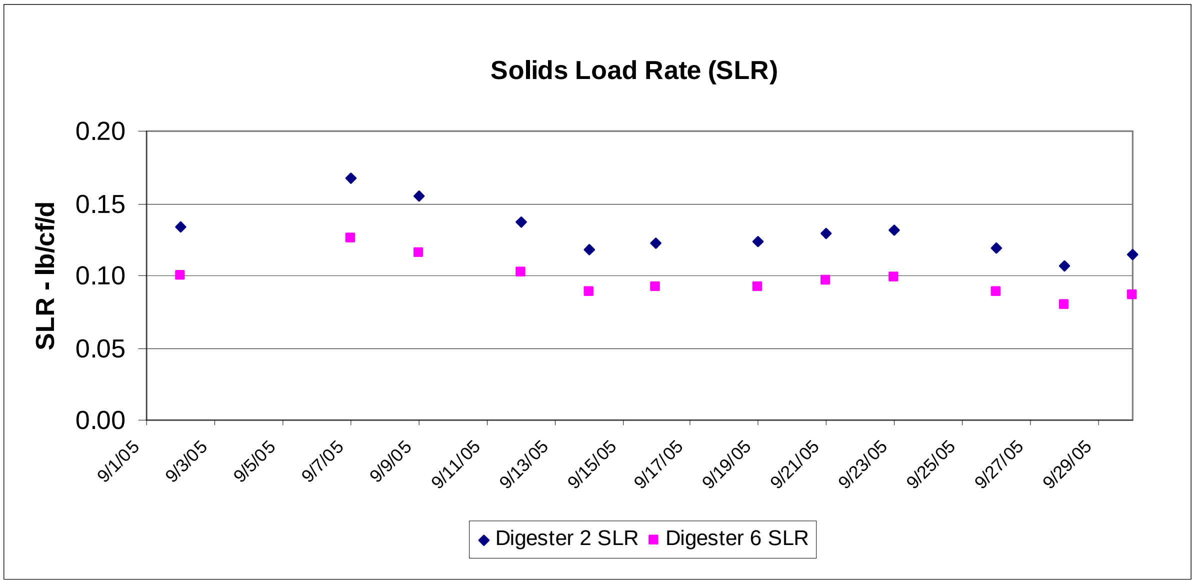


FIGURE 5-4
Digesters 2 and 6 Volatile Solids Loading Rate

5.3.3 Hydraulic Retention Time (HRT)

Hydraulic retention times for both digesters 2 and 6 are shown in Figure 5-5.

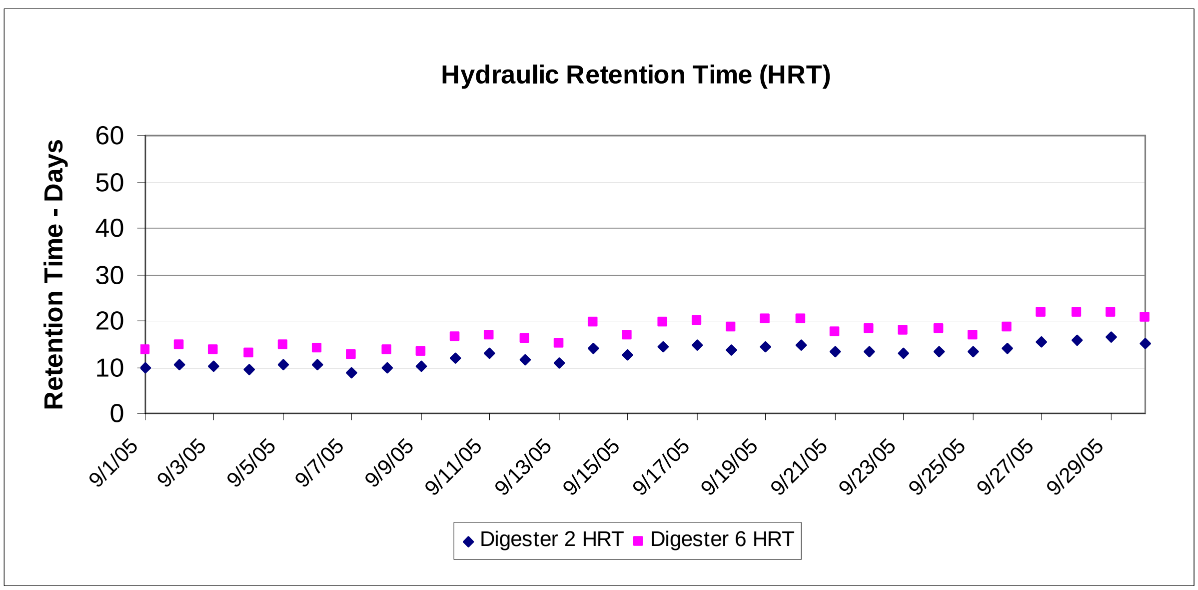


FIGURE 5-5
Digesters 2 and 6 Hydraulic Retention Times

5.4 Digesters 2 and 6 Performance

Digester stability indication parameters (pH and IA/PA) and digester performance parameters (biogas production, VSR, and biogas yield) are presented in Figures 5-6 through

5-11. The monthly averages of these data, along with digester feed, digested biosolids, and food waste mixture characteristics are discussed in Section 5.5.

5.4.1 Digester pH

The pH of digesters 2 and 6 is shown in Figure 5-6.

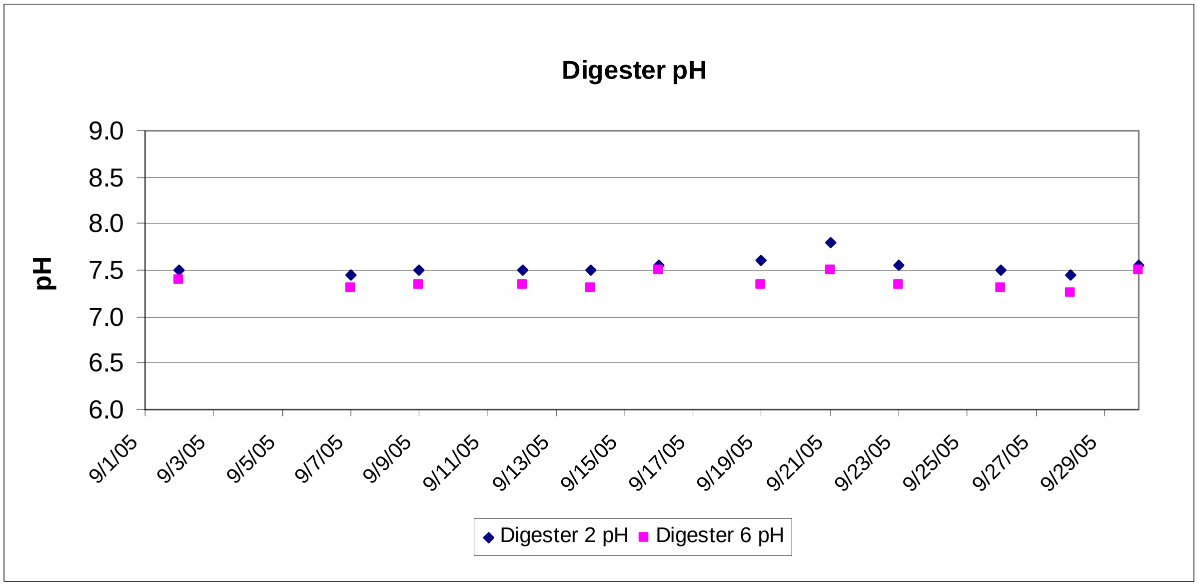


FIGURE 5-6
Digester pH

5.4.2 Digester IA/PA

Digesters 2 and 6 IA/PA is presented in Figure 5-7.

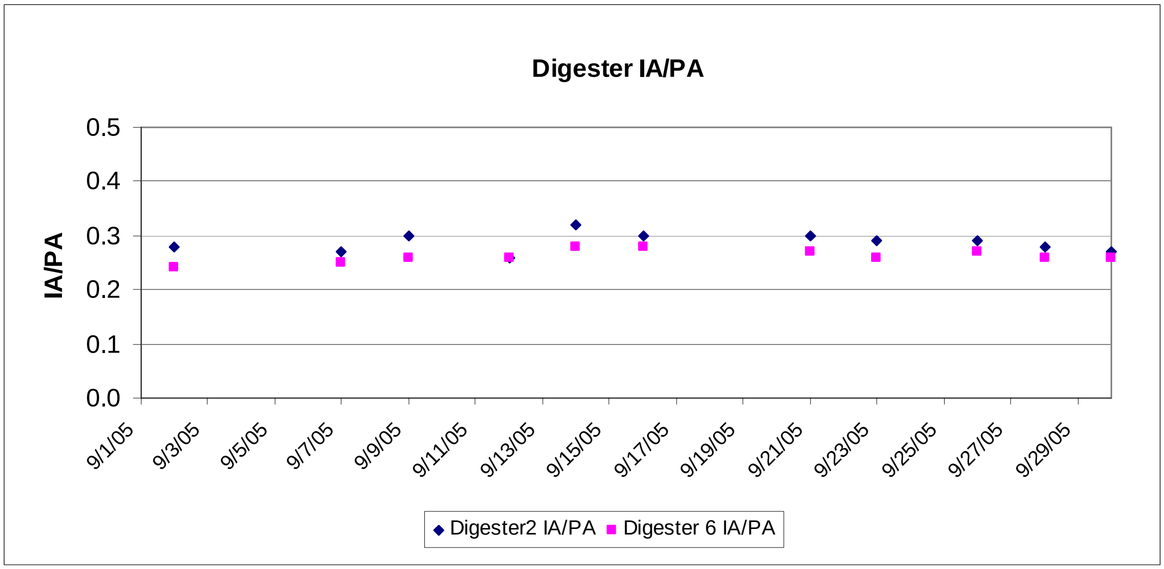


FIGURE 5-7
Digester IA/PA

5.4.3 Digester Temperature

Digesters 2 and 6 temperature is presented in Figure 5-8.

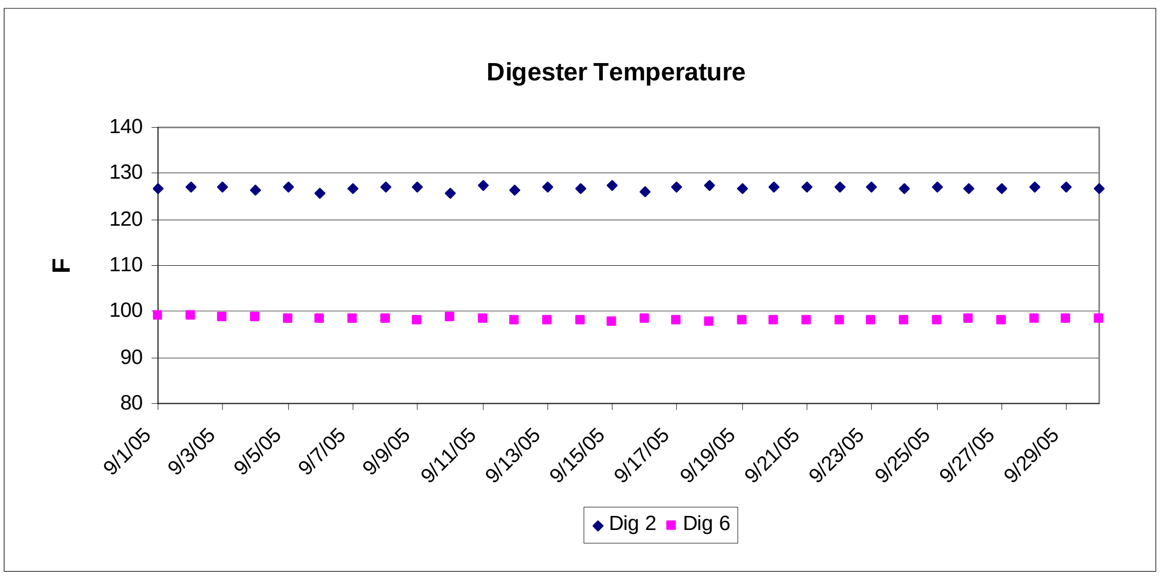


FIGURE 5-8
Digester Temperature

5.4.4 Biogas Production

Figure 5-9 shows the daily gas production by digesters 2 and 6.

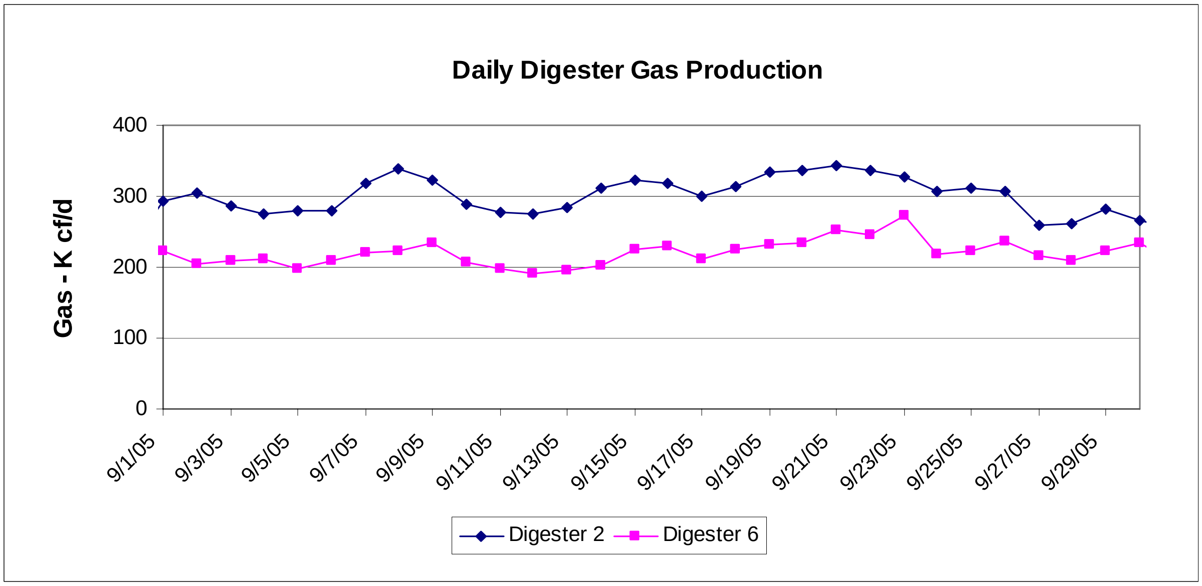


FIGURE 5-9
Digester Gas Production

5.4.5 VSR

Figure 5-10 shows VS reduction in digesters 2 and 6. Approximate mass balance method was used for calculating the VSR.

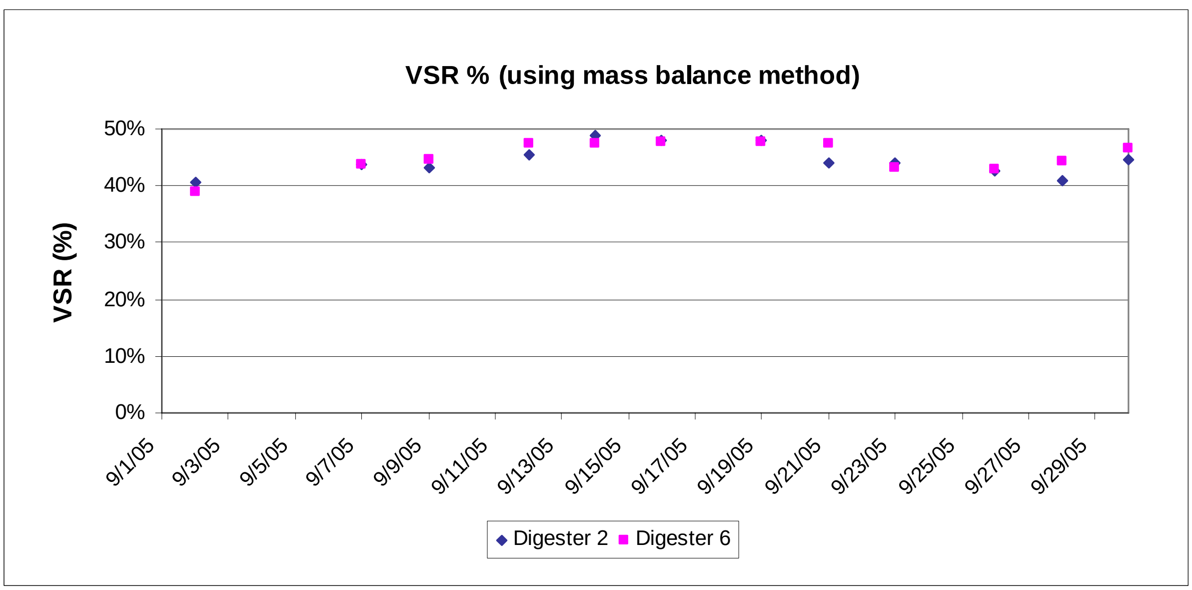


FIGURE 5-10
VS Reduction

5.4.6 Biogas Yield

Figure 5-11 shows the biogas yield by digesters 2 and 6.

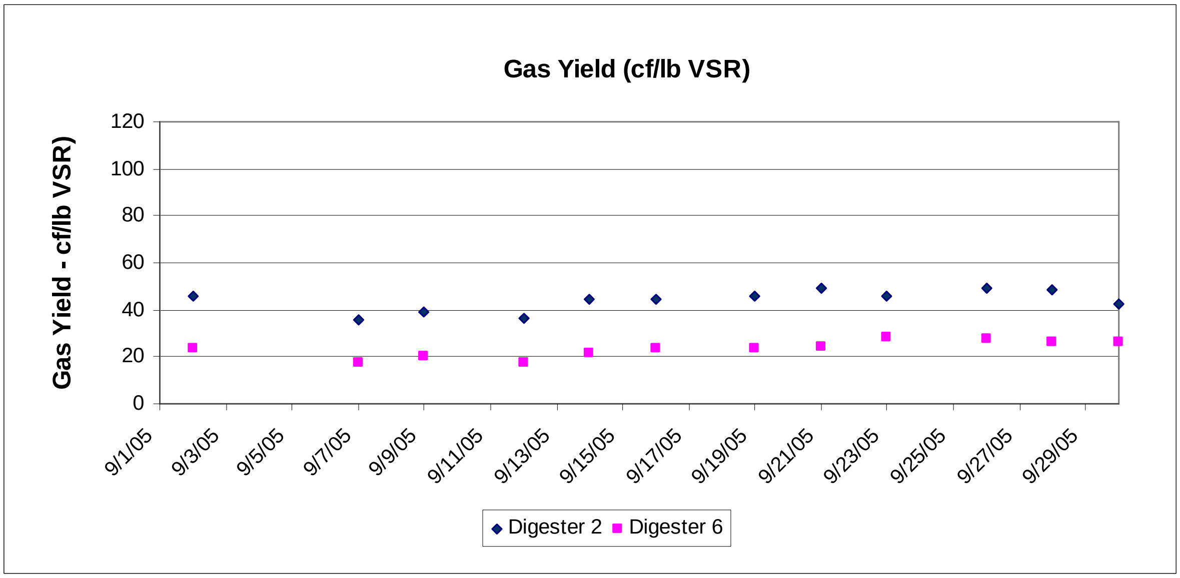


FIGURE 5-11
Biogas Yield

5.5 Monthly Operation and Performance Summary

Tables 5-2 and 5-3 provide the monthly average data for digester operation, performance, and dewatering. Digester effluent characteristics, such as solids concentrations and chemical data (e.g., alkalinity, ammonia and volatile acids), are also included. The flow and solids data were used to determine the mass balance and solids reduction in the digester. The chemical data are measures of digester stability (alkalinity, pH, VA, ammonia). Ammonia and TKN also have implications for the cost of filtrate treatment. In addition, the fertilizer value of the biosolids product and sulfate concentrations can affect gas quality through formation of H_2S. The digester gas data are also presented, including total gas produced and gas yield. Gas quality parameters include methane content and H_2S concentrations. The methane content was calculated based on carbon dioxide content measured in the gas.

TABLE 5-2
Monthly Averages of Digesters 2 and 6 Operational and Performance Data for September 2005

Parameter	Units	Digester 2	Digester 6
Digester Feed Characteristics			
Mixture of Combined Biosolids and Food Waste Flow from Digester 1	gpd	68,714	94,482
Proportioned Food Waste Flow[1]	gpd	1,000	1,171
Combined TS	lb/d	20,840	28,654
Combined VS	lb/d	16,084	22,116
Digested Sludge			
Dig Sludge TS	TS%	2.3	2.4

TABLE 5-2
Monthly Averages of Digesters 2 and 6 Operational and Performance Data for September 2005

Parameter	Units	Digester 2	Digester 6
Dig Sludge VS	VS%	60	64
Dig Sludge TS	lb/d	13,293	19,207
Dig Sludge VS	lb/d	8,266	12,353
VSR	lb/d	7,818	9,763
VSR	%	49	44
pH	SU	7.5	7.4
Alkalinity	mg/L	4,074	3,630
VA	mg/L	431	279
VA:Alk (IA/PA)	-	0.29	0.26
Total Organic Carbon	mg/L	NA	NA
COD	mg/L	NA	NA
NH_4-N	mg/L	1,060	1,100
TKN	mg/L	2,110	2,220
Phosphate-P	mg/L	NA	NA
Dissolved Sulfide	mg/L	NA	NA
Total Sulfide	mg/L	NA	NA
Total Sulfur	mg/L	NA	NA
Total Sulfate	mg/L	NA	NA
Proximate Analysis		NA	NA
Digester Gas			
Gas	kcf/d	302	220
Gas Yield[2]	cf/lb VSR	38.1	21.8
CH_4	%	62	64
CO_2	%	35	36
H_2S	ppm	NA	NA
Volatile Sulfur Compounds	ppb	NA	NA
Digester Operations			
Digester Temperature	^{0}F	127	98
Digester Free Board Level[3]	ft	2.6	2.1
Digester active vol[4]	gal	916,270	1,680,630
HRT by SWD vol	days	13	17
VS load rate	lbVS/cf active volume[4]	0.131	0.098

[1] Food waste was added to Digester 1 from DAFT3. The flow here is the proportioned amount based on the flow distribution ratio from Digester 1 to digesters 2, 6 and 7. Average number includes zeros.

[2] Gas Yield/Biogas Yield based on 15-day running averages for VS in, VS out, and Gas Production. This would be a different value if a different running average period was used.

[3] Digester Free Board Level is the actual operational level measured. Digesters 2 and 6 sidewall depths (SWD) are 30 feet.

[4] Digester's active volume was calculated based on digester SWD (30 feet) and with cone volume.

NA = Not Available or Not Applicable

TABLE 5-3
Monthly Averages of Digesters 2 and 6 Dewatering and Recycle Streams Data for September 2005

	Unit	Digester 2	Digester 6
Feed to Dewatering			
pH	-	7.5	7.4
Alkalinity	mg/L	4,074	3,630
Temperature	ºF	127	98
TS %	%	2.3	2.4
VS %	% of TS	62	64
VA by IA/PA method	mg/L	431	279
NH_4-N	mg/L	1,060	1,100
COD	mg/L	NA	NA
Magnesium	mg/L	NA	NA
Ortho-phosphorus	mg/L	NA	NA
Dissolved Sulfide	mg/L	NA	NA
Total Sulfide	mg/L	NA	NA
Dewatered Cake			
TS %	%	19*	
Polymer usage	lb/ton	12*	
Filtrate			
pH	-	NA*	
Alkalinity	mg/L	NA*	
TDS	mg/L	1,100*	
TSS	mg/L	132*	
Dissolved Sulfide	mg/L	NA*	
NH_4-N	mg/L	840*	
COD	mg/L	821*	
Magnesium	mg/L	NA*	
Ortho-phosphorus	mg/L	NA*	

* The numbers are tracked for the combined filtrate from dewatering of the biosolids digesters currently.

NA = Not Available or Not Applicable.