

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 November 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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# Contents

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| Section   | Page       |
|---|------------|
| <b>Acronyms and Abbreviations</b> .....   | <b>vii</b> |
| <b>1 Introduction</b> .....   | <b>1-1</b> |
| <b>2 Co-Digestion Performance Summary</b> .....                                 | <b>2-1</b> |
| 2.1 Co-Digestion Inputs .....   | 2-1        |
| 2.2 Digester Performance Data .....   | 2-1        |
| 2.3 Cost Data.....  | 2-2        |
| 2.3.1 Installation Costs .....  | 2-2        |
| 2.3.2 Operations and Maintenance Costs .....                                    | 2-3        |
| <b>3 Food Waste Received for Manure and Biosolids Co-Digestion Test</b> .....   | <b>3-1</b> |
| <b>4 Manure and Food Waste Co-Digestion</b> .....                               | <b>4-1</b> |
| 4.1 Manure and Food Waste Co-Digestion Operations with Digester 4 at RP-1 ..... | 4-1        |
| 4.1.1 Manure Digestion at RP-1 .....  | 4-1        |
| 4.1.2 Food Waste and Dairy Manure Co-Digestion at Digester 4 .....              | 4-1        |
| 4.1.3 Co-digestion Facility at RP-1.....  | 4-1        |
| 4.2 Digester 4 Operational Parameters .....                                     | 4-2        |
| 4.2.1 Feed Manure and Food Waste .....  | 4-2        |
| 4.2.2 Solids Loading Rate (SLR).....  | 4-4        |
| 4.2.3 Hydraulic Retention Time (HRT).....                                       | 4-5        |
| 4.3 Digester 4 Performance.....   | 4-5        |
| 4.3.1 Digester 4 pH .....   | 4-5        |
| 4.3.2 Digester 4 IA/PA.....   | 4-6        |
| 4.3.3 Digester 4 Temperature .....  | 4-6        |
| 4.3.4 Digester 4 Biogas Production.....   | 4-7        |
| 4.3.5 VSR .....   | 4-8        |
| 4.3.6 Biogas Yield .....  | 4-8        |
| 4.4 Monthly Operation and Performance Summary .....                             | 4-9        |
| <b>5 Biosolids and Food Waste Co-Digestion</b> .....                            | <b>5-1</b> |
| 5.1 Existing Biosolids Processing Trains at RP-1 .....                          | 5-1        |
| 5.2 Biosolids and Food Waste Co-Digestion at RP-1 .....                         | 5-2        |
| 5.3 Digesters 2 and 6 Operational Parameters.....                               | 5-2        |
| 5.3.1 Feed Biosolids and Food Waste .....                                       | 5-2        |
| 5.3.2 Solids Loading Rate (SLR).....  | 5-4        |
| 5.3.3 Hydraulic Retention Time (HRT).....                                       | 5-5        |
| 5.4 Digesters 2 and 6 Performance .....   | 5-5        |
| 5.4.1 Digester pH .....   | 5-6        |
| 5.4.2 Digester IA/PA.....   | 5-6        |
| 5.4.3 Digester Temperature .....  | 5-7        |
| 5.4.4 Biogas Production.....  | 5-7        |

| Section   | Page |
|---|------|
| 5.4.5 VSR.....                                      | 5-8  |
| 5.4.6 Biogas Yield.....                             | 5-8  |
| 5.5 Monthly Operation and Performance Summary ..... | 5-9  |

## Tables

|  |                              |
|--|------------------------------|
| 2-1 Inputs to Co-Digestion Systems for Dairy Manure, Biosolids, and Food Waste.....                          | 2-1                          |
| 2-2 Digester Performance.....  | 2-2                          |
| 2-3 Co-Digestion and Iron Sponge Project Installation Costs.....   | 2-3                          |
| 4-1 Digester 4 Monthly Average Data for Feed and Feed Characterization for<br>November 2005 .....            | 4-4                          |
| 4-2 Monthly Digester 4 Data Averages for November 2005 .....   | 4-9                          |
| 4-3 Monthly Averages of Dewatering and Recycle Streams Data for Manure<br>Digester 4 for November 2005 ..... | 4-11                         |
| 5-1 Monthly Digesters 2 and 6 Feed Characteristics Averages for November 2005                                | Error! Bookmark not defined. |
| 5-2 Monthly Averages of Digesters 2 and 6 Operational and performance Data for<br>November 2005 .....        | 5-9                          |
| 5-3 Monthly Averages of Dewatering and Recycle Streams Data for Digesters 2 and 6<br>for November 2005 ..... | 5-10                         |

## Figures

|  |     |
|--|-----|
| 3-1 Combined Food Waste Flow Delivered for Co-digestion Test During the Month of<br>November 2005.....   | 3-1 |
| 3-2 TS Concentration and VS Content of the Food Waste Delivered by Type .....                            | 3-2 |
| 4-1 Manure and Food Waste Co-digestion Facility at RP-1 .....  | 4-2 |
| 4-2 Digester 4 Manure and Food Waste Daily Flow .....  | 4-3 |
| 4-3 TS Concentrations and VS Content of the Manure Fed to Digester 4 .....                               | 4-3 |
| 4-4 Digester 4 Volatile Solids Loading Rate (Manure and Food Waste Combined).....                        | 4-4 |
| 4-5 Digester 4 Hydraulic Retention Time .....  | 4-5 |
| 4-6 Digester 4 pH.....   | 4-6 |
| 4-7 Digester 4 IA/PA .....   | 4-6 |
| 4-8 Digester 4 Temperature.....  | 4-7 |
| 4-9 Digester 4 Gas Production .....  | 4-7 |
| 4-10 Digester 4 VS Reduction .....   | 4-8 |
| 4-11 Digester 4 Biogas Yield.....  | 4-9 |
| 5-1 RP-1 Current Biosolids Digester Configuration .....  | 5-1 |
| 5-2 Biosolids and Food Waste Flow to Digesters 2 and 6 .....   | 5-3 |
| 5-3 TS Concentration and VS Content of Digesters 2 and 6 Feed Sludge<br>(i.e., Digester 1 Effluent)..... | 5-4 |
| 5-4 Digesters 2 and 6 Volatile Solids Loading Rate .....   | 5-5 |
| 5-5 Digesters 2 and 6 Hydraulic Retention Times .....  | 5-5 |
| 5-6 Digester pH.....   | 5-6 |
| 5-7 Digester IA/PA .....   | 5-6 |

| <b>Section</b>                   | <b>Page</b> |
|----------------------------------|-------------|
| 5-8 Digester Temperature .....   | 5-7         |
| 5-9 Digester Gas Production..... | 5-7         |
| 5-10 VS Reduction.....           | 5-8         |
| 5-11 Biogas Yield.....           | 5-8         |



# Acronyms and Abbreviations

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|                   |   |
|-------------------|---|
| 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 <sub>2</sub>   | 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 <sup>3</sup> | gram per centimeter cubed   |
| gpm               | gallon per minute   |
| H <sub>2</sub> S  | 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 <sub>2</sub> | 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 November 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 November 2005.



SECTION 2

# Co-Digestion Performance Summary

## 2.1 Co-Digestion Inputs

Table 2-1 below 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) |
|--|---------------------|---------------|---------------|---------------------|
| <b>1) Co-digestion of dairy manure/food processing wastes</b>              |                     |               |               |                     |
| <b>Digester 4</b>  |                     |               |               |                     |
| Dairy manure   | 23,414              | 26,551        | 20,668        | 13.6%               |
| Food processing wastes   |                     |               |               |                     |
| Salad Dressing   | 162                 | 210           | 183           | 15.5%               |
| Lactose  | 0                   | 0             | 0             | NA                  |
| Ice Cream  | 743                 | 1,004         | 983           | 16.2%               |
| <b>Total</b>   | <b>24,320</b>       | <b>27,770</b> | <b>21,830</b> | <b>13.7%</b>        |
| <b>2) Co-digestion of biosolids/ food processing wastes</b>                |                     |               |               |                     |
| <b>Digester 1</b>  |                     |               |               |                     |
| Biosolids  | 253,222             | 89,825        | 72,307        | 4.3%                |
| Food processing wastes <sup>1</sup>  |                     |               |               |                     |
| Salad Dressing   | 187                 | 241           | 217           | 15.5%               |
| Lactose  | 1,651               | 1,641         | 1,368         | 11.9%               |
| Ice Cream  | 936                 | 1,219         | 1,181         | 15.6%               |
| <b>Total</b>   | <b>256,000</b>      | <b>92,930</b> | <b>75,070</b> | <b>4.4%</b>         |
| <b>Distribution of Digester 1 Effluent: Feed to Digesters 2, 6, and 7:</b> |                     |               |               |                     |
| Digester 2   | 68,446 <sup>1</sup> | 20,109        | 15,754        | 3.5%                |
| Digester 6, 7  | 94,113 <sup>1</sup> | 27,650        | 21,661        | 3.5%                |

<sup>1</sup> 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

|   | Units                              | Digester 4 |            |            |            |
|---|------------------------------------|------------|------------|------------|------------|
| <b>1) Co-digestion of dairy manure/food processing wastes</b> |                                    |            |            |            |            |
| VS loading rate   | lbVS/cf active volume <sup>1</sup> | 0.198      |            |            |            |
| Hydraulic Retention Time                                      | Days                               | 31         |            |            |            |
| Digester Temperature  | °F                                 | 98         |            |            |            |
| pH changes over time  | pH (range)                         | 7.4 - 7.6  |            |            |            |
| Iron Salt Addition  | gpd                                | 30         |            |            |            |
| Volatile Solids (VS) Reduction                                | %                                  | 47.3%      |            |            |            |
| Gas Yield <sup>2</sup>  | cf/lb VSR                          | 14.7       |            |            |            |
| CH <sub>4</sub> in Biogas                                     | %                                  | 59%        |            |            |            |
| CO <sub>2</sub> in Biogas                                     | %                                  | 37%        |            |            |            |
| H <sub>2</sub> S in Biogas <sup>3</sup>                       | ppm                                | 343.6      |            |            |            |
|   |                                    | Digester 1 | Digester 2 | Digester 6 | Digester 7 |
| <b>2) Co-digestion of biosolids/food processing wastes</b>    |                                    |            |            |            |            |
| VS loading rate   | lbVS/cf active volume <sup>1</sup> | 0.612      | 0.129      | 0.096      | 0.097      |
| Hydraulic Retention Time                                      | Days                               | 2.9        | 12.3       | 16.9       | 17         |
| Digester Temperature  | °F                                 | 93         | 126        | 98         | 116        |
| pH changes over time  | pH (range)                         | 5.0 – 5.2  | 7.4 – 7.7  | 7.2 – 7.4  | 7.3 – 7.6  |
| Volatile Solids (VS) Reduction                                | %                                  | 21.6%      | 39.5%      | 40.6%      | 42.6%      |
| Biogas Yield <sup>2</sup>                                     | cf/lb VSR                          | 4.6        | 41.8       | 23.9       | 21.9       |
| CH <sub>4</sub> in Biogas                                     | %                                  | NA         | 60%        | 63%        | 63%        |
| CO <sub>2</sub> in Biogas                                     | %                                  | NA         | 35%        | 37%        | 36%        |
| H <sub>2</sub> S in Biogas <sup>3</sup>                       | ppm                                | 22.7       | NA         | NA         | NA         |

<sup>1</sup> Digester's active volume was calculated based on digester SWD (30 ft) and with cone volume.

<sup>2</sup> Gas yield/Biogas yield are based on 15-day running averages for VS in, VS out, and Gas Production. This value would be different if a different period for running averages was chosen.

<sup>3</sup> H<sub>2</sub>S was not measured specifically for digesters 2, 6, or 7. H<sub>2</sub>S gas from these digesters was measured at the waste gas burner, where it averaged 0.3 ppm, and at the common feed to the recovery boiler (after iron sponge treatment), where it averaged 2.6 ppm.

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 for conducting these 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          |   |
| <b>Total</b>                              | <b>\$952,000</b> | <b>\$220,000</b>          | <b>\$1,172,000</b> |   |

NOTE: All costs rounded to nearest \$1,000.

These 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 this project. 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 November, 2005, total operations and maintenance costs were estimated at \$28,800, as follows:

- \$ 3,100 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 November 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.

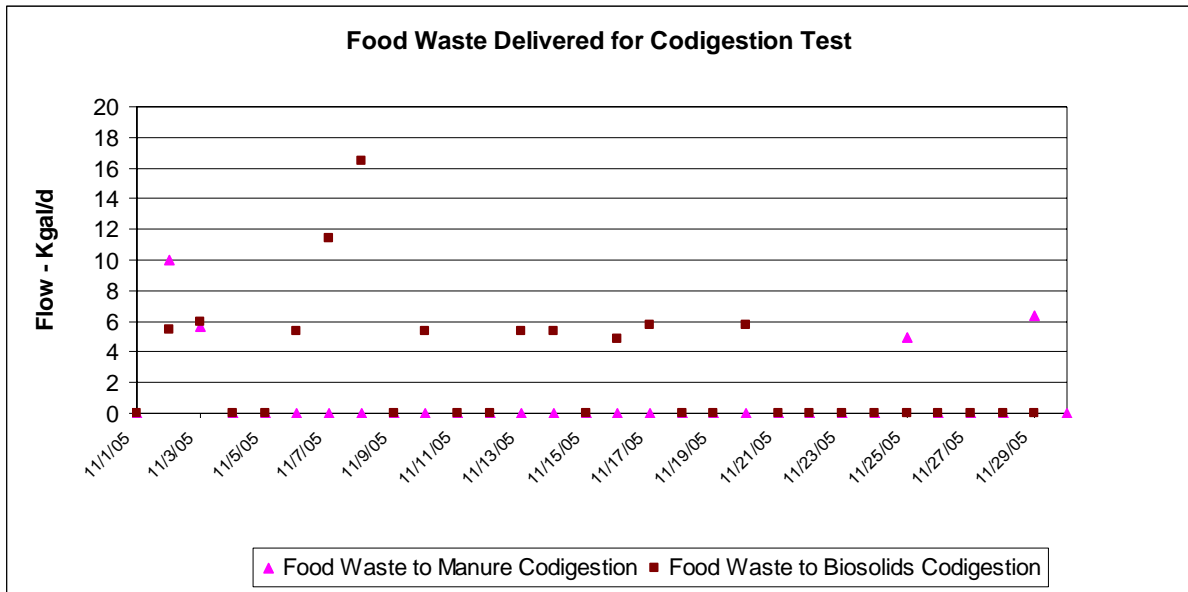


FIGURE 3-1  
Combined Food Waste Flow Delivered for Co-Digestion Test During the Month of November 2005

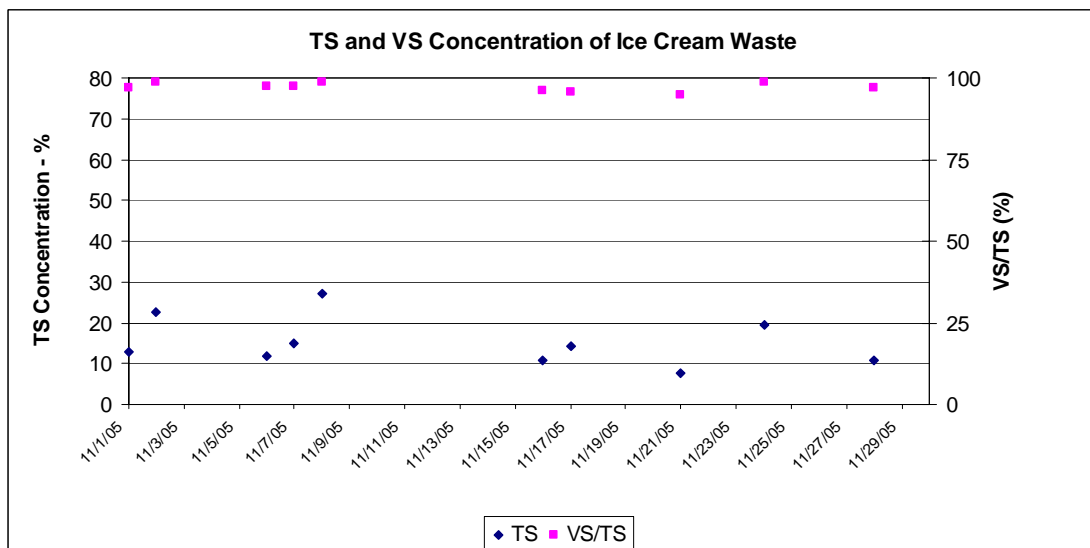
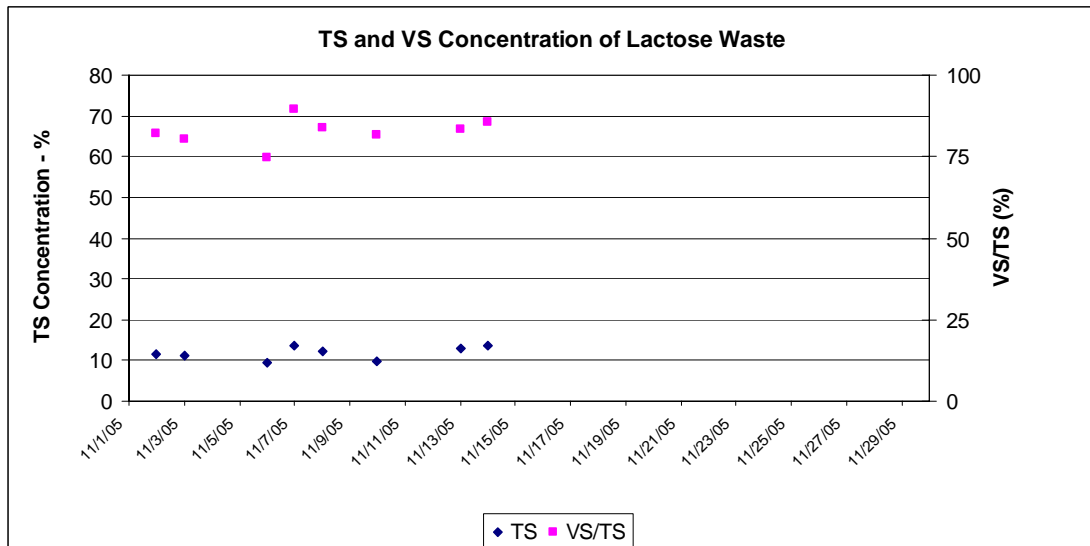
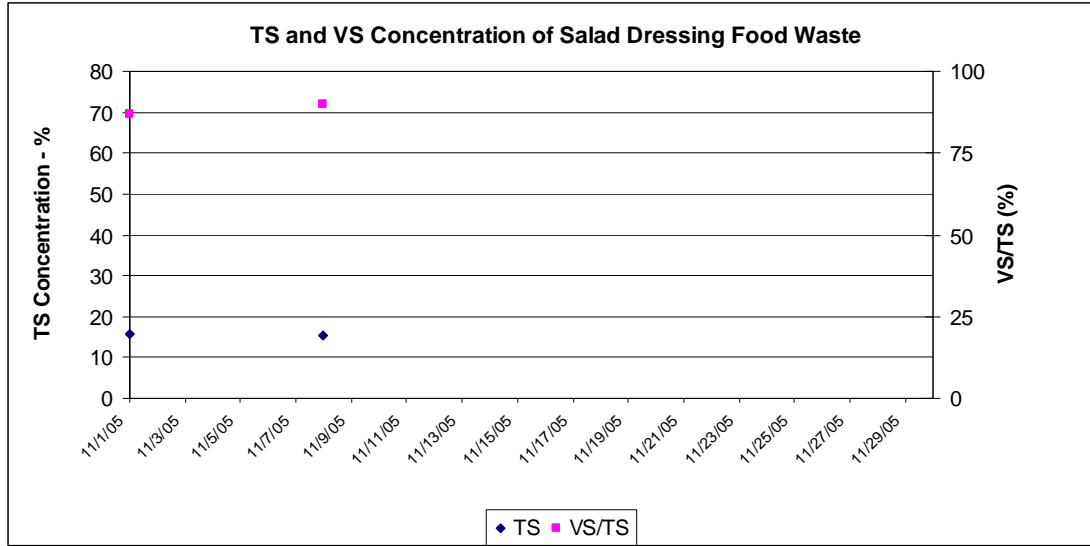


FIGURE 3-2  
TS Concentration and VS Content of the Food Waste Delivered by Type

# Manure and Food Waste Co-Digestion

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

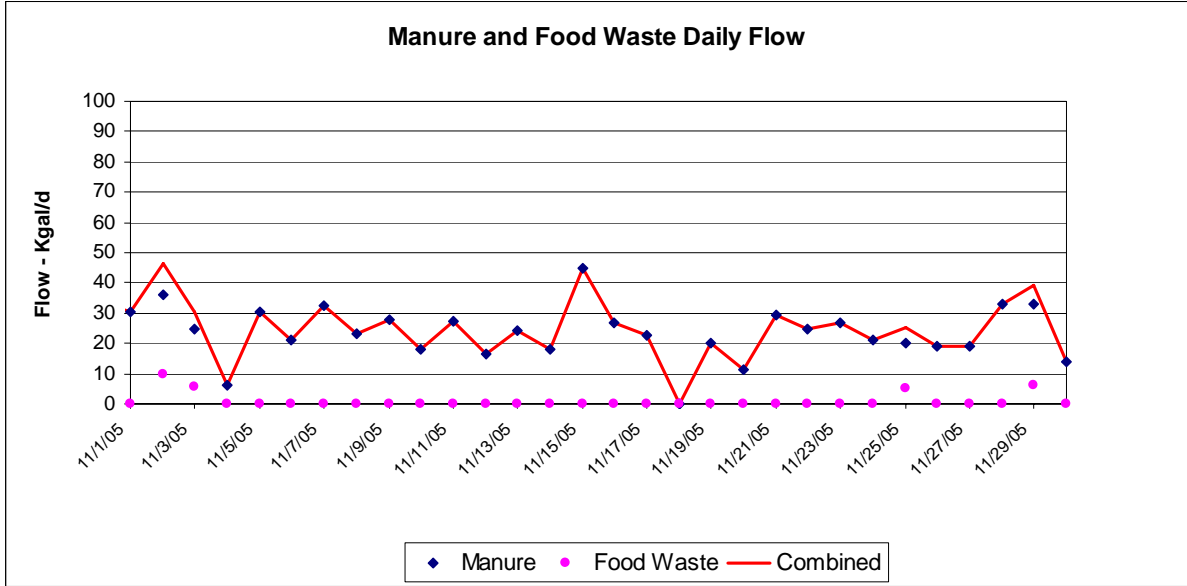


FIGURE 4-2  
Digester 4 Manure and Food Waste Daily Flow

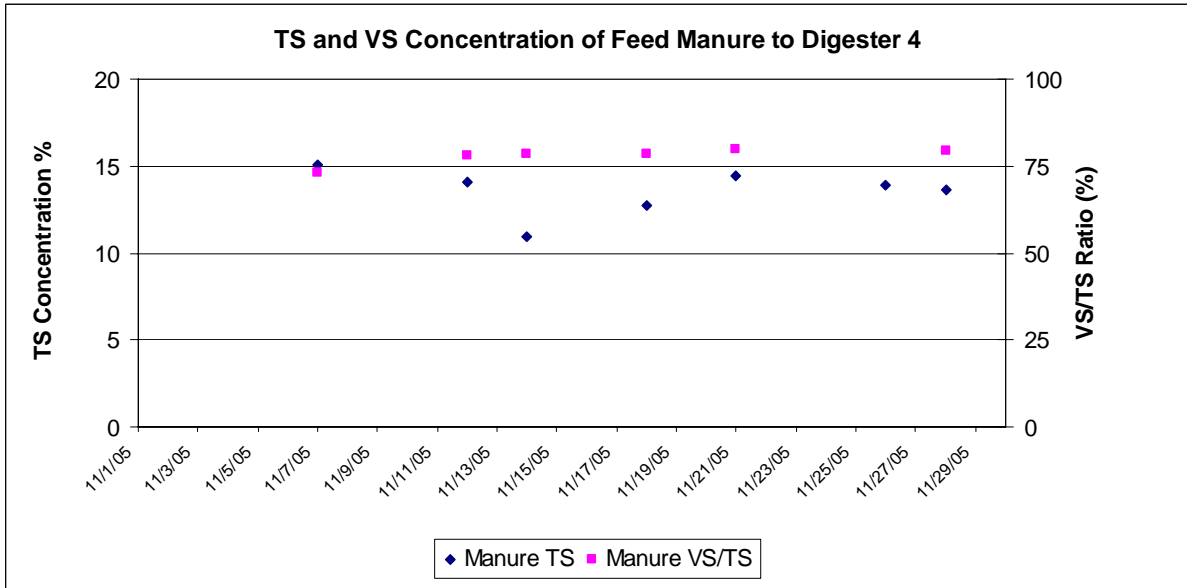


FIGURE 4-3  
TS Concentrations and VS Content of the Manure Fed to Digester 4

TABLE 4-1  
Digester 4 Monthly Average Data for Feed and Feed Characterization for November 2005

| Parameter            | Units   | Manure Feed | Food Waste      |         |                 |
|----------------------|---------|-------------|-----------------|---------|-----------------|
|                      |         |             | Salad Dressing  | Lactose | Ice Cream       |
| Flow <sup>1</sup>    | gpd     | 23,410      | 160             | 0       | 740             |
| TS                   | %       | 14          | 16 <sup>2</sup> | NA      | 16 <sup>2</sup> |
| VS                   | % of TS | 78          | 87 <sup>2</sup> | NA      | 98 <sup>2</sup> |
| pH                   |         | NA          | NA              | NA      | NA              |
| Alkalinity           | mg/L    | NA          | NA              | NA      | NA              |
| Temperature          | °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 <sub>4</sub> -N   | mg/L    | NA          | NA              | NA      | NA              |
| TKN                  | mg/L    | NA          | NA              | NA      | NA              |
| Proximate Analysis   |         | NA          | NA              | NA      | NA              |

Notes:

<sup>1</sup> Average flow includes zero values. Numbers were rounded to the nearest 10.

<sup>2</sup> Missing values were filled with previous or adjacent days' test results.

NA = Not Available or Not Applicable.

## 4.2.2 Solids Loading Rate

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

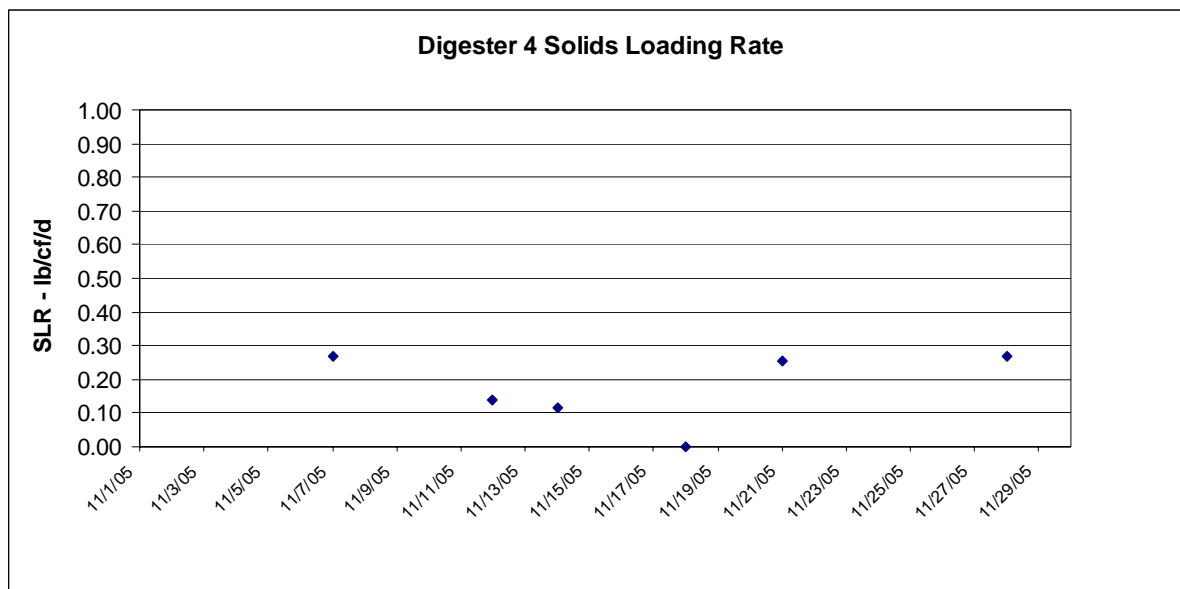


FIGURE 4-4  
Digester 4 Volatile Solids Loading Rate (Manure and Food Waste Combined)

### 4.2.3 Hydraulic Retention Time

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

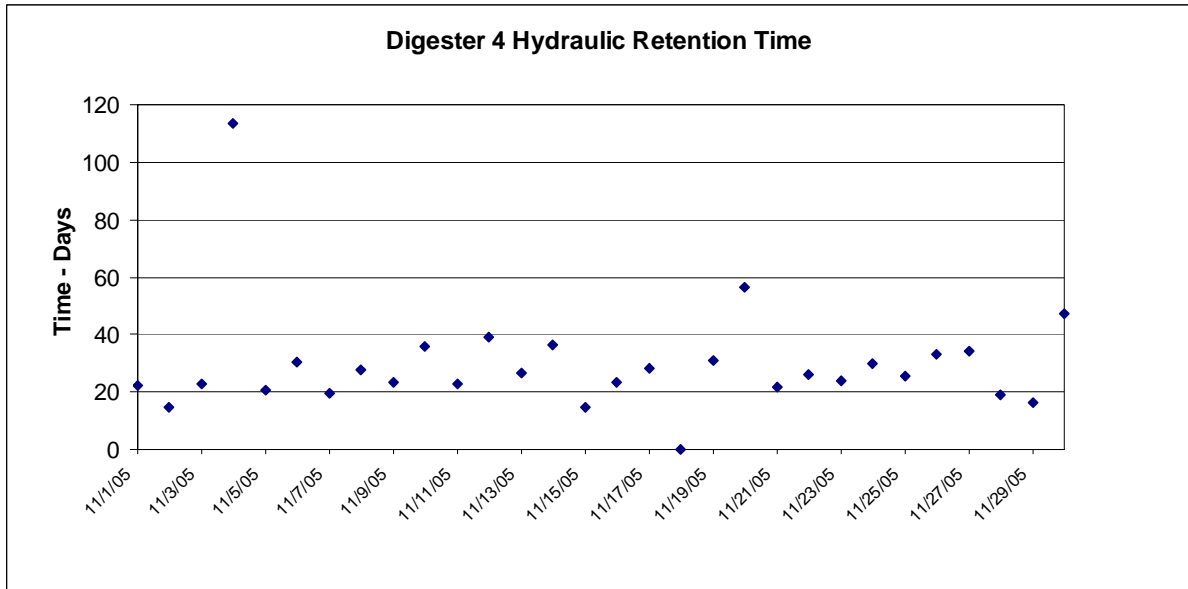


FIGURE 4-5  
Digester 4 Hydraulic Retention Time

## 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 November 2005.

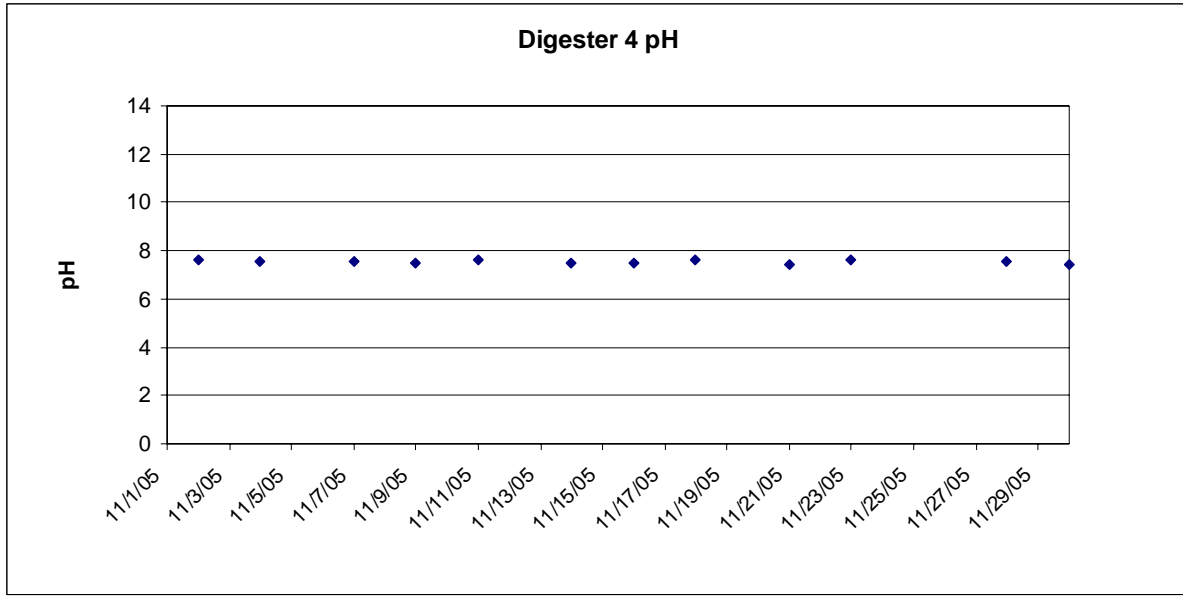


FIGURE 4-6  
Digester 4 pH

### 4.3.2 Digester 4 IA/PA

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

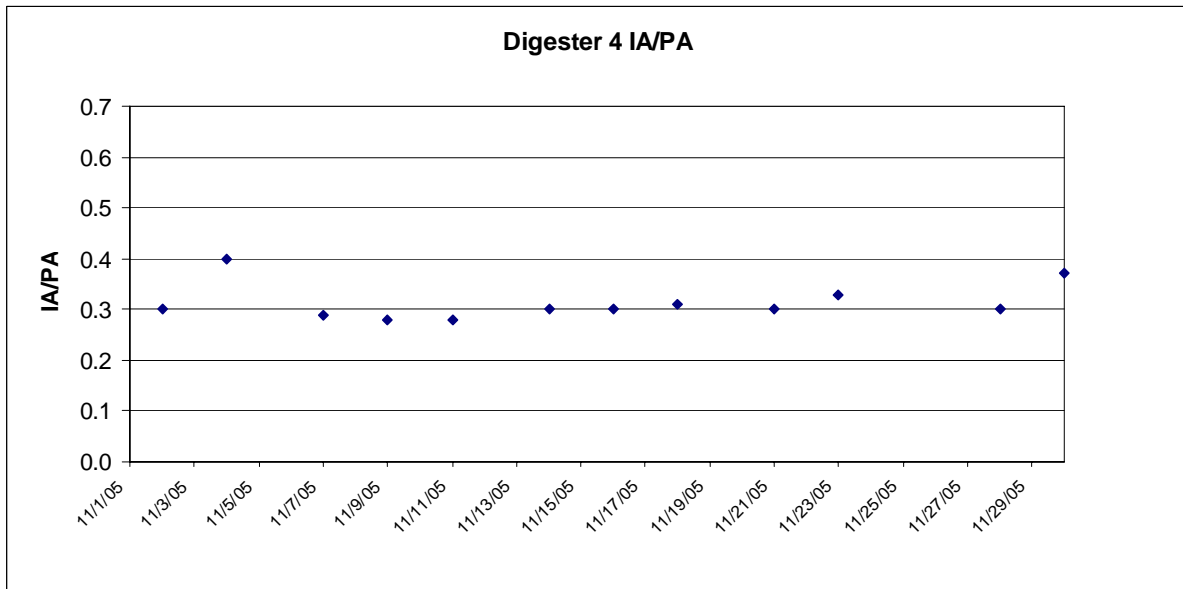


FIGURE 4-7  
Digester 4 IA/PA

### 4.3.3 Digester 4 Temperature

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

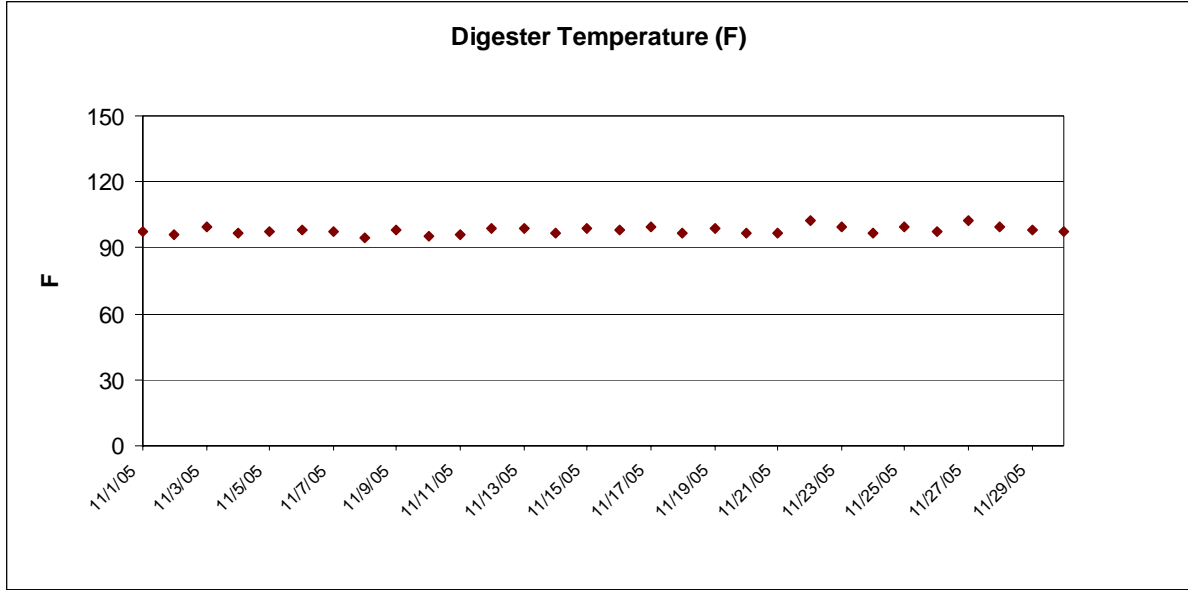


FIGURE 4-8  
Digester 4 Temperature

### 4.3.4 Digester 4 Biogas Production

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

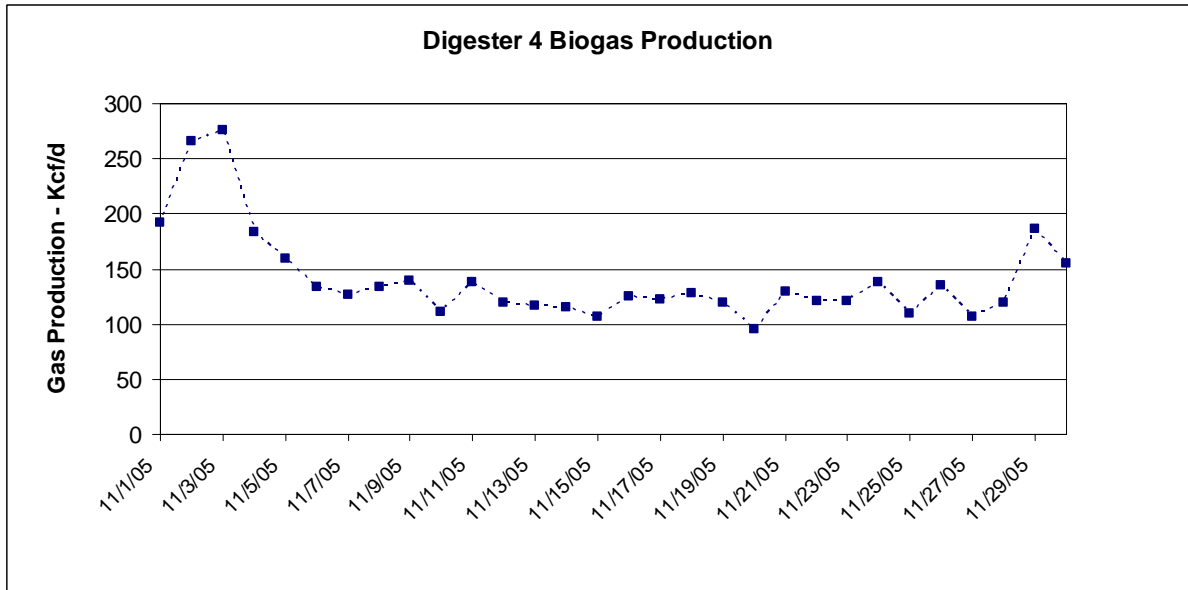


FIGURE 4-9  
Digester 4 Gas Production

### 4.3.5 VSR

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

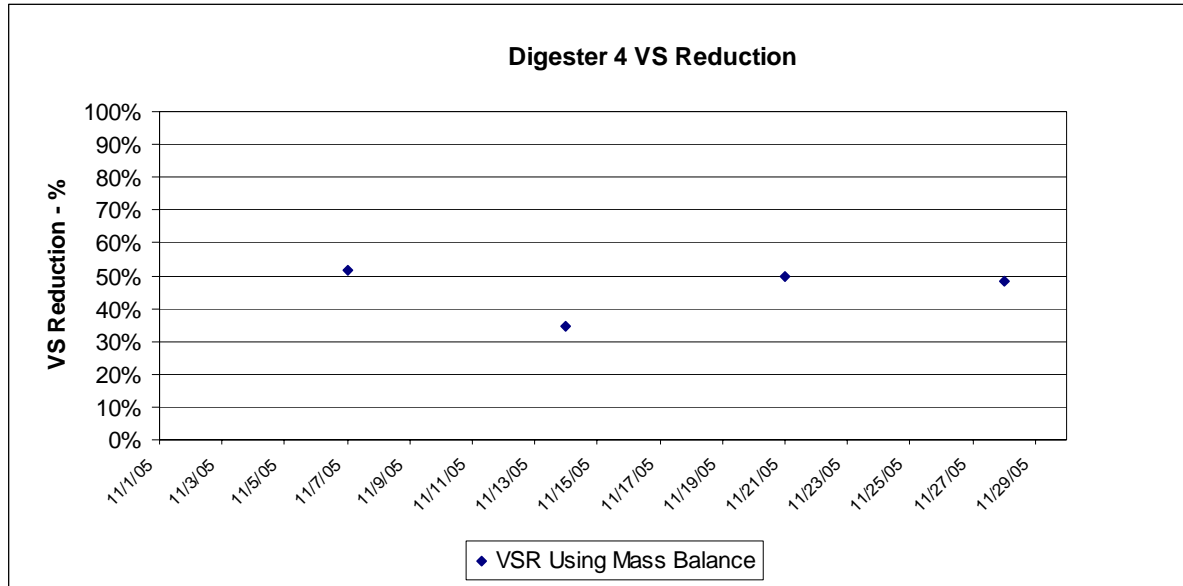


FIGURE 4-10  
Digester 4 VS Reduction

### 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 November 2005 (15-day running averages were not used for this graph).

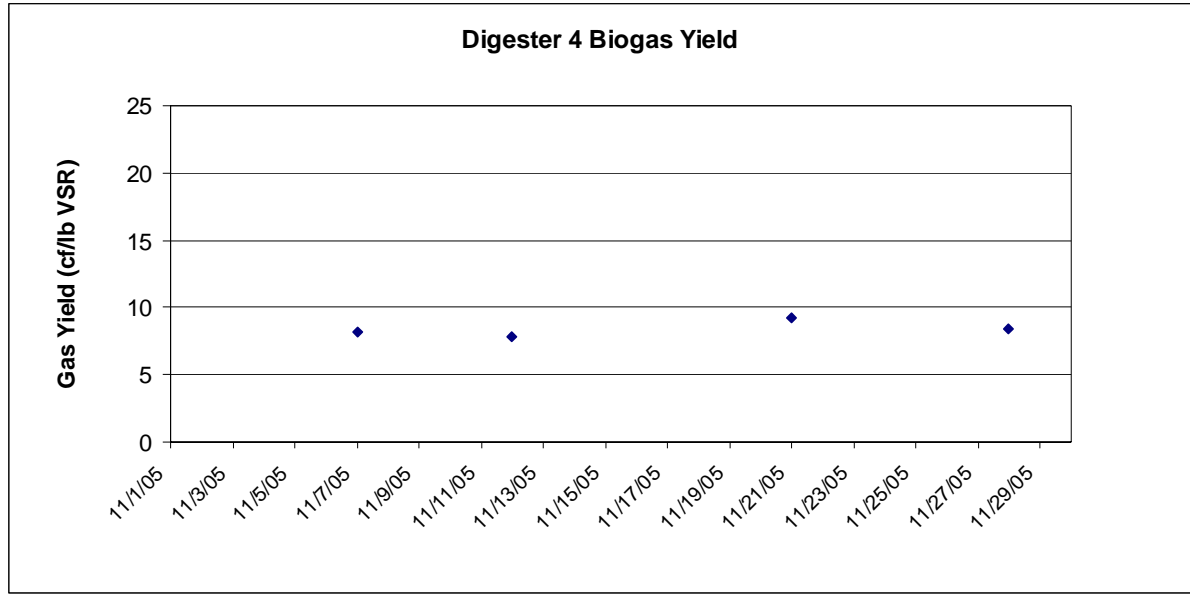


FIGURE 4-11  
Digester 4 Biogas Yield

## 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<sub>2</sub>S formation. The digester gas data are also presented, including total gas produced and gas yield. Gas quality parameters include methane content and H<sub>2</sub>S concentrations.

TABLE 4-2  
Monthly Digester 4 Data Averages for November 2005

| Parameter  | Units | November 2005 |
|--|-------|---------------|
| <b>Digester Feed Characteristics</b>                                   |       |               |
| Manure Flow  | gpd   | 23,414        |
| Food Waste Flow <sup>1</sup>   | gpd   | 905           |
| Combined Flow  | gpd   | 24,319        |
| Manure TS  | lb/d  | 26,551        |
| Manure VS  | lb/d  | 20,668        |
| Food Waste TS  | lb/d  | 1,214         |
| Food Waste VS  | lb/d  | 1,166         |
| Combined TS  | lb/d  | 27,765        |
| Combined VS  | lb/d  | 21,834        |
| <b>Digester Effluent (i.e. Digested Manure and Food Waste Mixture)</b> |       |               |
| Digester TS  | TS%   | 7.6           |

TABLE 4-2  
Monthly Digester 4 Data Averages for November 2005

| Parameter                              | Units                              | November 2005 |
|--|------------------------------------|---------------|
| Digester VS                            | VS%                                | 74            |
| Digested TS                            | lb/d                               | 15,495        |
| Digested VS                            | lb/d                               | 11,506        |
| VSR                                    | lb/d                               | 10,328        |
| VSR                                    | %                                  | 47.3          |
| pH                                     | SU                                 | 7.5           |
| Alkalinity                             | mg/L                               | 9,755         |
| VA                                     | mg/L                               | 1,660         |
| VA:Alk (IA/PA)                         | -                                  | 0.31          |
| Total Organic Carbon                   | mg/L                               | NA            |
| COD                                    | mg/L                               | NA            |
| NH <sub>4</sub> -N                     | mg/L                               | NA            |
| TKN                                    | mg/L                               | NA            |
| Phosphate-P                            | mg/L                               | NA            |
| Dissolved Sulfide                      | mg/L                               | NA            |
| Total Sulfide                          | mg/L                               | NA            |
| Total Sulfur                           | mg/L                               | NA            |
| Total Sulfate                          | mg/L                               | NA            |
| Proximate Analysis <sup>2</sup>        |                                    | NA            |
| <b>Digester Gas</b>                    |                                    |               |
| Gas                                    | K cf/d                             | 141           |
| Gas Production                         | cf/lb VS in                        | 5.9           |
| Gas Yield <sup>3</sup>                 | cf/lb VSR                          | 14.7          |
| CH <sub>4</sub>                        | %                                  | 59            |
| CO <sub>2</sub>                        | %                                  | 37            |
| H <sub>2</sub> S                       | ppm                                | 343.6         |
| Volatile Sulfur Compounds              | ppb                                | NA            |
| <b>Digester Operations</b>             |                                    |               |
| Digester Temperature                   | °F                                 | 98            |
| Digester Free Board Level <sup>4</sup> | ft                                 | 6.6           |
| Digester Active Vol <sup>5</sup>       | gal                                | 826,840       |
| HRT by SWD Vol <sup>5</sup>            | days                               | 31            |
| VS Load Rate                           | lbVS/cf active volume <sup>5</sup> | 0.198         |
| Iron Salt Addition                     | gpd                                | 30            |

<sup>1</sup> Average food waste flow is the monthly average that includes the days without food waste delivery.

<sup>2</sup> Proximate Analysis.

<sup>3</sup> Gas yield/Biogas yield are based on 15-day running averages for VS in, VS out, and Gas Production. This value would be different if a different period for running averages was chosen.

<sup>4</sup> Digester Free Board Level is the actual operational level measured. Digester 4 sidewall depth (SWD) is 30 feet.

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

NA = Not Available or Not Applicable.

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

|                           | Unit   | November 2005 |
|---------------------------|--------|---------------|
| <b>Feed to Dewatering</b> |        |               |
| pH                        | -      | 7.5           |
| Alkalinity                | mg/L   | 9,755         |
| Temperature               | °F     | 98            |
| Flow                      | kgal/d | 24            |
| TS %                      | %      | 7.6           |
| VS %                      | %      | 74            |
| VA by IA/PA method        | mg/L   | 1,660         |
| NH <sub>4</sub> -N        | mg/L   | NA            |
| COD                       | mg/L   | NA            |
| Magnesium                 | mg/L   | NA            |
| Ortho-phosphorus          | mg/L   | NA            |
| Dissolved Sulfide         | mg/L   | NA            |
| Total Sulfide             | mg/L   | NA            |
| <b>Dewatered Cake</b>     |        |               |
| TS %                      | %      | 28            |
| Polymer usage             | lb/ton | 11.1          |
| <b>Filtrate</b>           |        |               |
| pH                        | -      | NA            |
| Alkalinity                | mg/L   | NA            |
| Flow                      | kgal/d | 22            |
| TDS                       | mg/L   | 1,450         |
| TSS                       | mg/L   | 116           |
| Dissolved Sulfide         | mg/L   | NA            |
| NH <sub>4</sub> -N        | mg/L   | 153           |
| COD                       | mg/L   | 802           |
| Magnesium                 | mg/L   | NA            |
| Ortho-phosphorus          | mg/L   | NA            |

NA = Not Available or Not Applicable.



# 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 November 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.

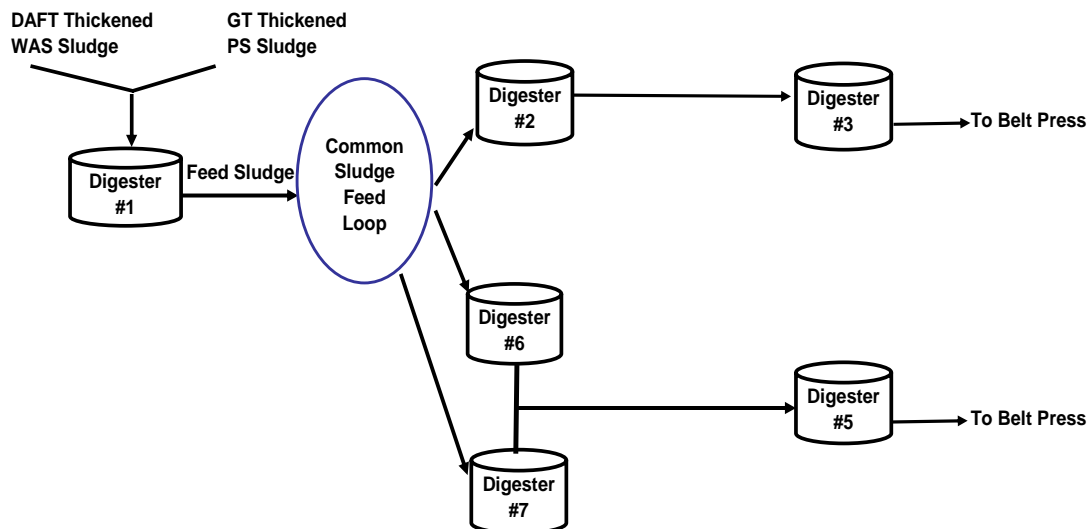


FIGURE 5-1  
RP-1 Current Biosolids Digester Configuration

## 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 November 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.

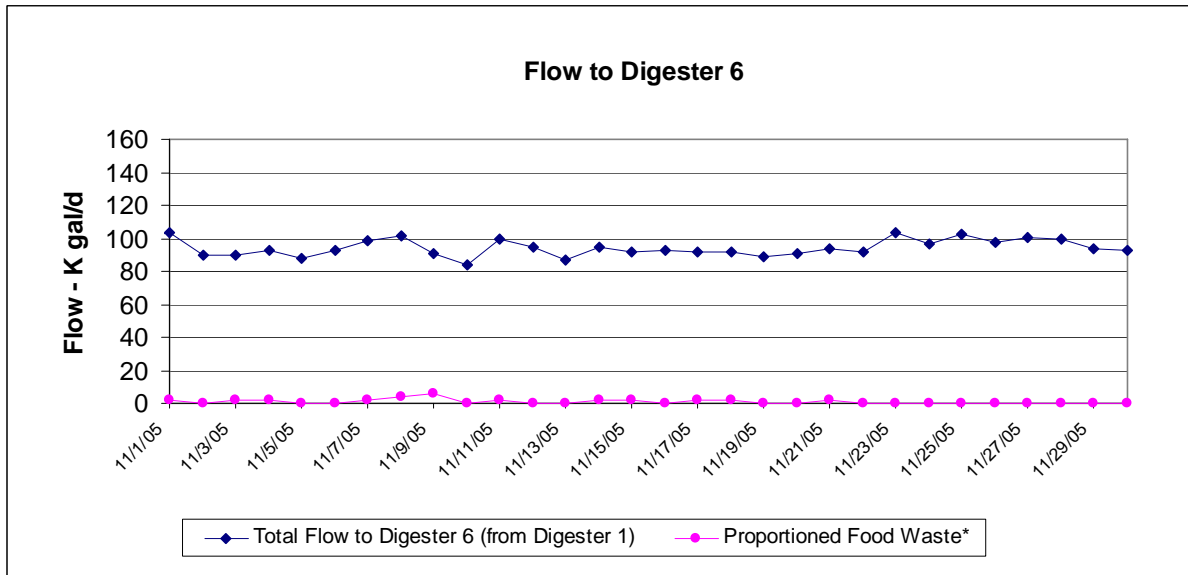
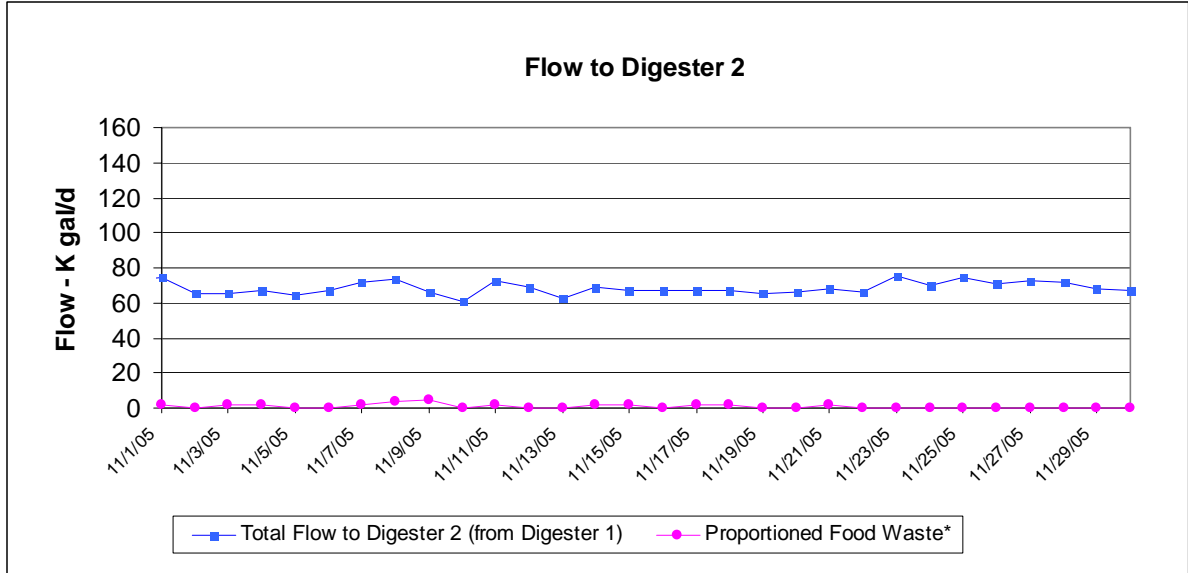
## 5.3 Digesters 2 and 6 Operational Parameters

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



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

\* The food waste flow to digesters 2 and 6 was the proportioned amount based on the total food waste fed to DAFT3, then Digester 1 for the food waste and biosolids co-digestion test. This proportioned amount is included in the total flow fed to the digester, as shown in Figures 5-2 and 5-3.

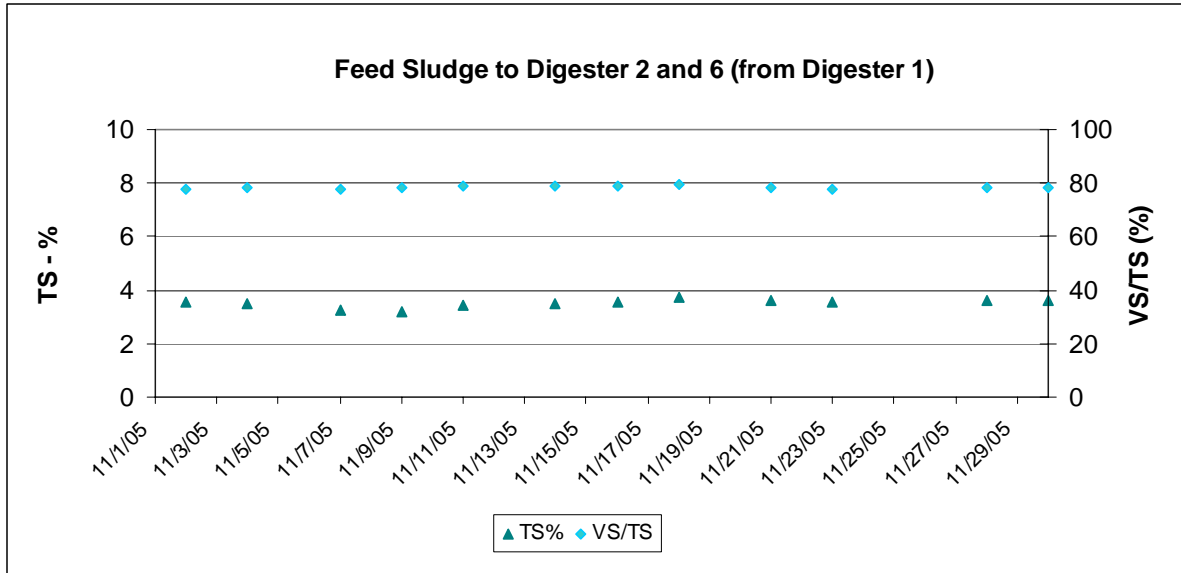


FIGURE 5-3  
TS Concentration and VS Content of Digesters 2 and 6 Feed Sludge (Digester 1 Effluent)

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

| Parameter            | Units | Biosolids and Food Waste Mixture Fed to Digesters 2 and 6 (from Digester 1) |
|----------------------|-------|---|
| TS                   | %     | 3.5   |
| VS                   | %     | 78  |
| pH                   |       | 5.1   |
| Alkalinity           | mg/L  | 2,434   |
| Temperature          | °F    | 93  |
| Volatile acids, mg/L | mg/L  | 5,389   |
| Total Organic Carbon | mg/L  | NA  |
| COD                  | mg/L  | NA  |
| NH <sub>4</sub> -N   | mg/L  | 630   |
| TKN                  | mg/L  | 2,644   |
| Proximate Analysis   |       | NA  |

### 5.3.2 Solids Loading Rate

Figure 5-4 shows the SLR in digesters 2 and 6.

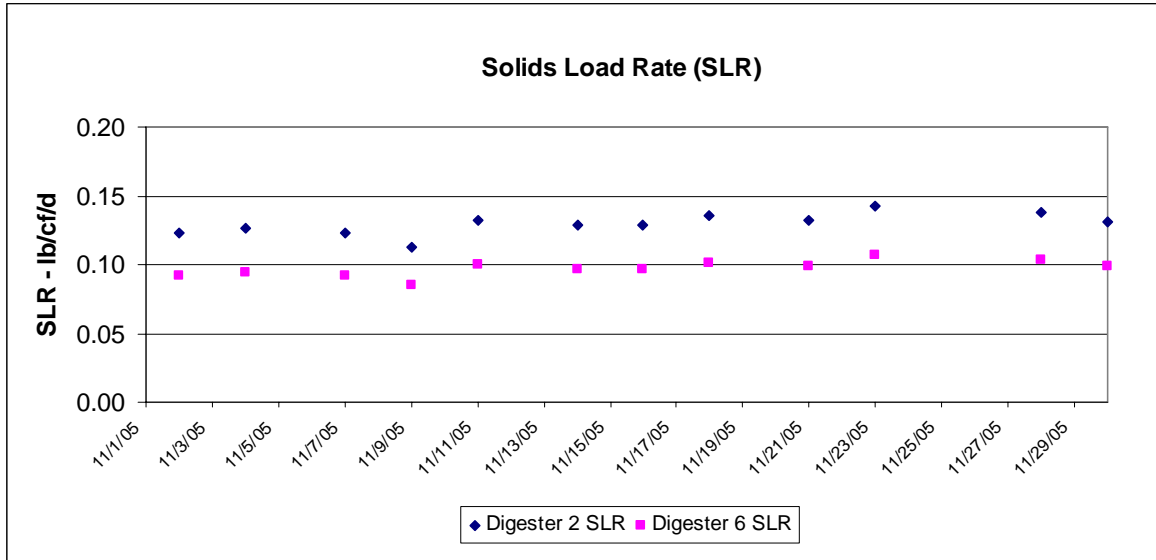


FIGURE 5-4  
 Digesters 2 and 6 Volatile Solids Loading Rate

### 5.3.3 Hydraulic Retention Time

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

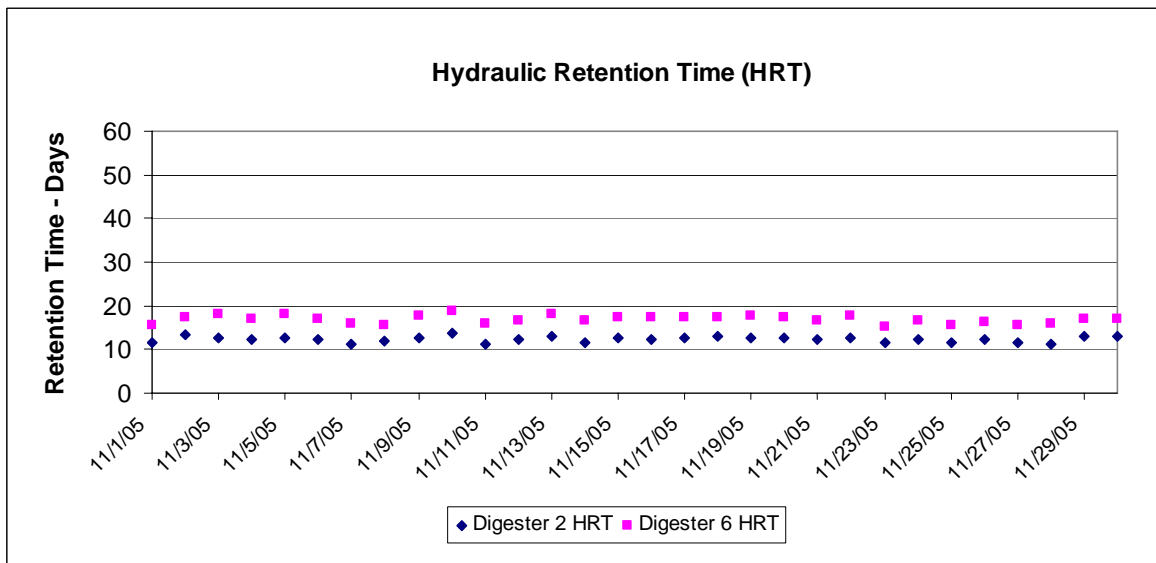


FIGURE 5-5  
 Digesters 2 and 6 Hydraulic Retention Times

## 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.

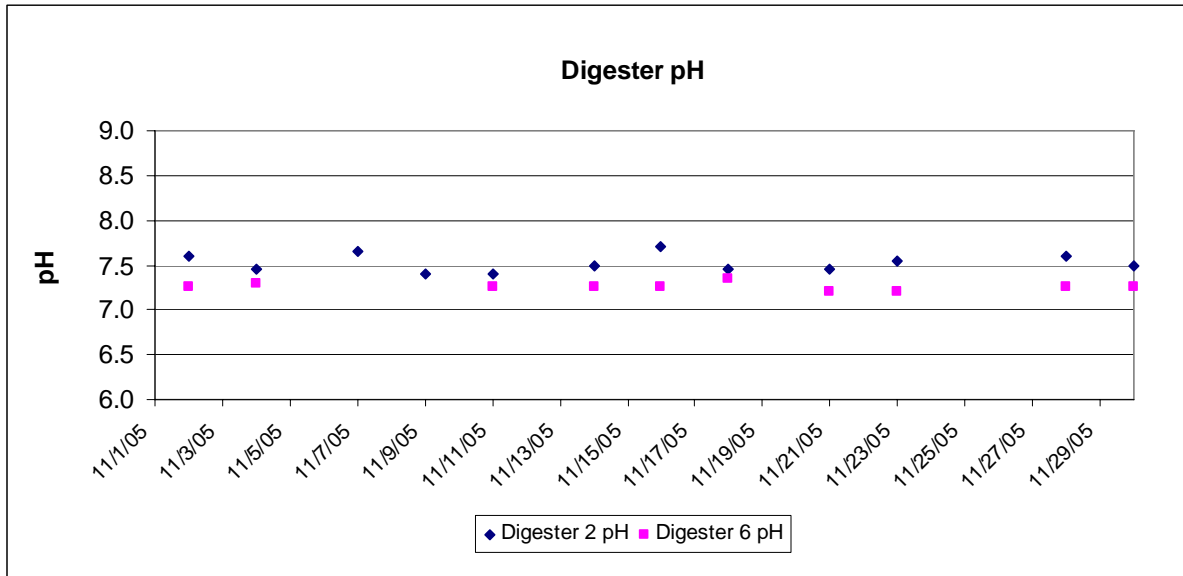


FIGURE 5-6  
Digesters 2 and 6 pH

### 5.4.2 Digester IA/PA

The IA/PA of digesters 2 and 6 is presented in Figure 5-7.

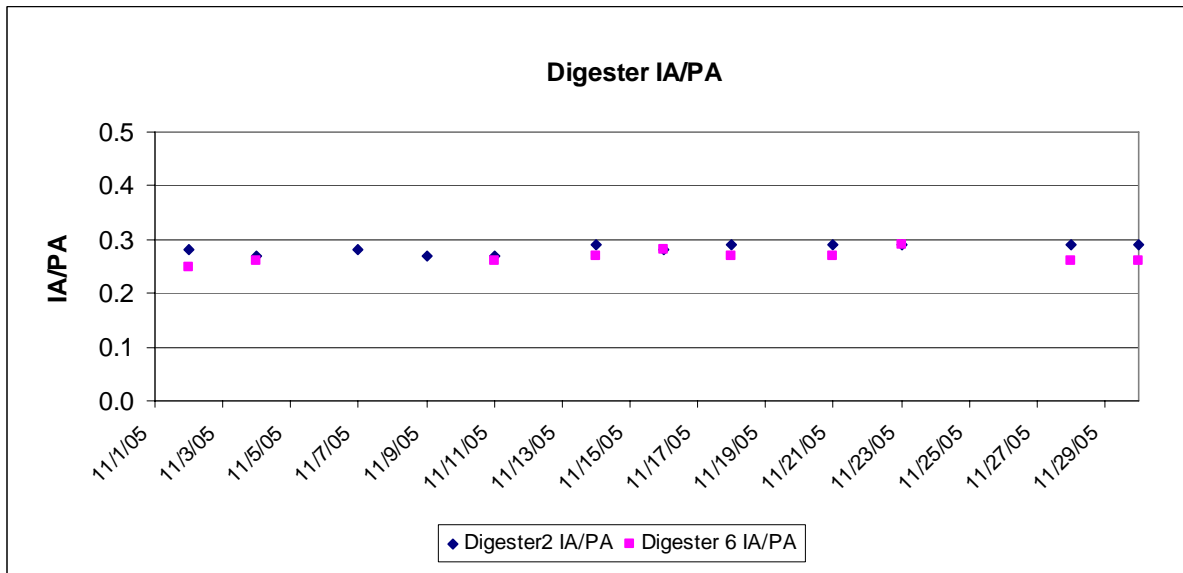


FIGURE 5-7  
Digesters 2 and 6 IA/PA

### 5.4.3 Digester Temperature

The temperature of digesters 2 and 6 is presented in Figure 5-8.

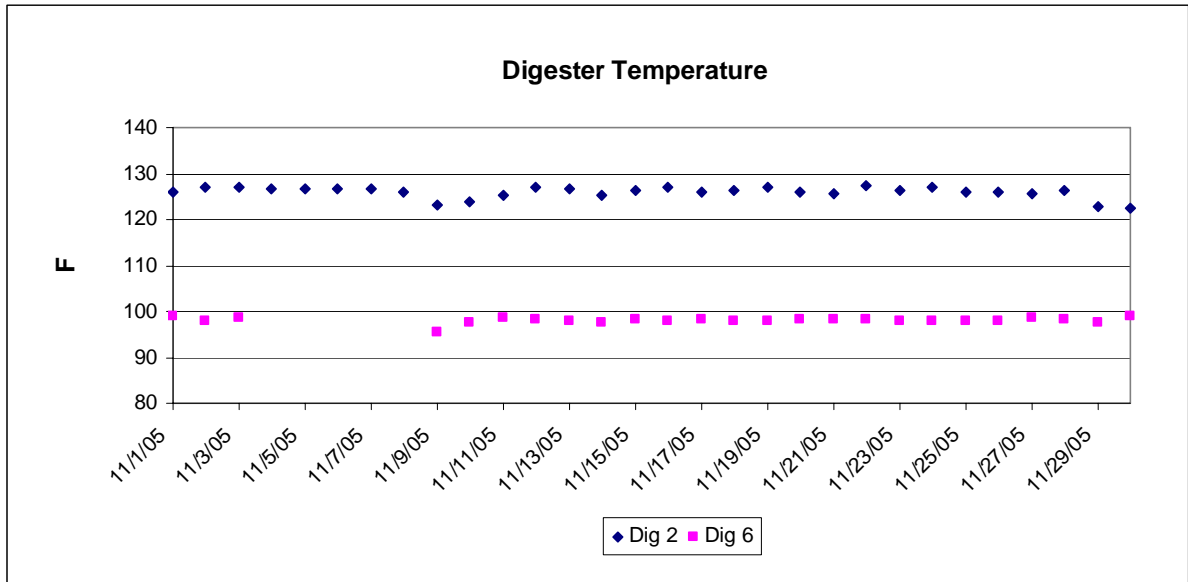


FIGURE 5-8  
Digesters 2 and 6 Temperature

### 5.4.4 Biogas Production

The daily gas production of digesters 2 and 6 is shown in Figure 5-9.

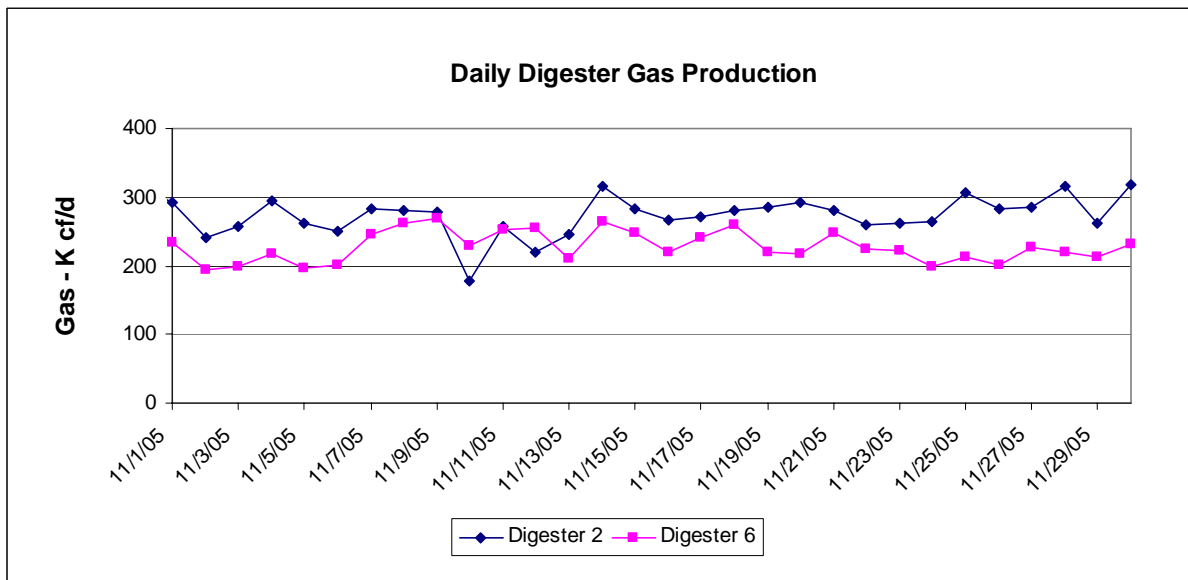


FIGURE 5-9  
Digesters 2 and 6 Gas Production

### 5.4.5 VSR

The VS reduction in digesters 2 and 6 is shown in Figure 5-10. An approximate mass balance method was used for calculating the VSR.

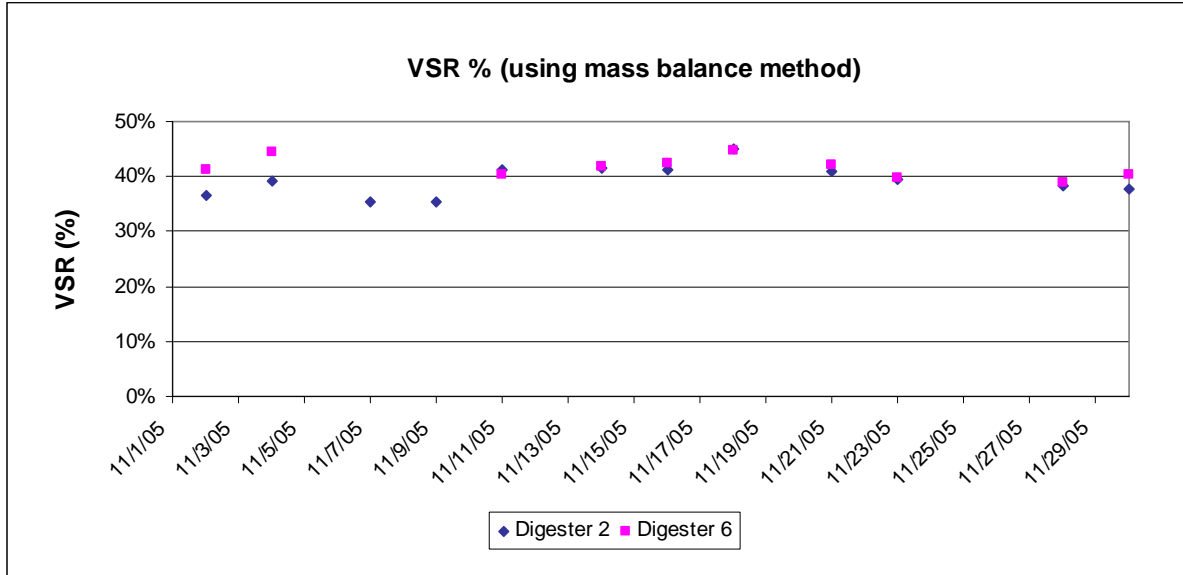


FIGURE 5-10  
Digesters 2 and 6 VS Reduction

### 5.4.6 Biogas Yield

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

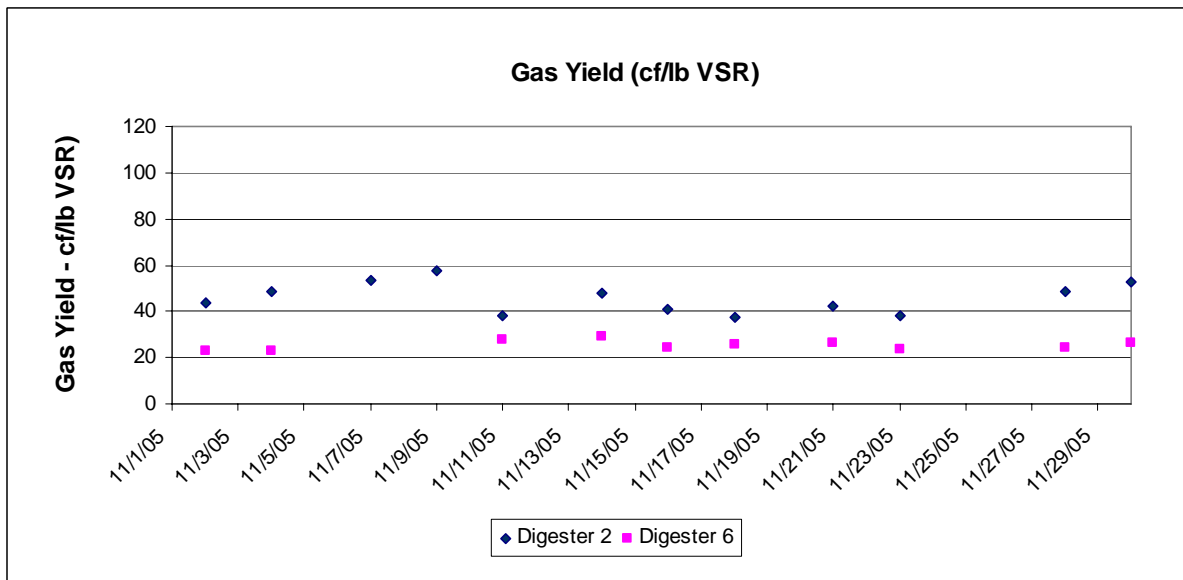


FIGURE 5-11  
Digesters 2 and 6 Biogas Yield

## 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<sub>2</sub>S. The digester gas data are also presented, including total gas produced and gas yield. Gas quality parameters include methane content and H<sub>2</sub>S 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 November 2005

| Parameter   | Units | Digester 2 | Digester 6 |
|---|-------|------------|------------|
| <b>Digester Feed Characteristics</b>                              |       |            |            |
| Mixture of Combined Biosolids and Food Waste Flow from Digester 1 | gpd   | 68,446     | 94,113     |
| Proportioned Food Waste Flow <sup>1</sup>                         | gpd   | 832        | 971        |
| Combined TS   | lb/d  | 20,109     | 27,650     |
| Combined VS   | lb/d  | 15,754     | 21,661     |
| <b>Digested Sludge</b>  |       |            |            |
| Dig Sludge TS   | TS%   | 2.5        | 2.5        |
| Dig Sludge VS   | VS%   | 68         | 67         |
| Dig Sludge TS   | lb/d  | 14,119     | 19,325     |
| Dig Sludge VS   | lb/d  | 9,536      | 12,863     |
| VSR   | lb/d  | 6,218      | 8,798      |
| VSR   | %     | 39         | 41         |
| pH  | SU    | 7.5        | 7.3        |
| Alkalinity  | mg/L  | 4,252      | 4,002      |
| VA  | mg/L  | 525        | 368        |
| VA:Alk (IA/PA)  | -     | 0.28       | 0.27       |
| Total Organic Carbon  | mg/L  | NA         | NA         |
| COD   | mg/L  | NA         | NA         |
| NH <sub>4</sub> -N  | mg/L  | 1,175      | 1,720      |
| TKN   | mg/L  | 2,316      | 2,466      |
| 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         |

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

| Parameter                              | Units                              | Digester 2 | Digester 6 |
|--|------------------------------------|------------|------------|
| <b>Digester Gas</b>                    |                                    |            |            |
| Gas                                    | kcf/d                              | 273        | 228        |
| Gas Yield <sup>2</sup>                 | cf/lb VSR                          | 44         | 25         |
| CH <sub>4</sub>                        | %                                  | 60         | 63         |
| CO <sub>2</sub>                        | %                                  | 35         | 37         |
| H <sub>2</sub> S                       | ppm                                | NA         | NA         |
| Volatile Sulfur Compounds              | ppb                                | NA         | NA         |
| <b>Digester Operations</b>             |                                    |            |            |
| Digester Temperature                   | °F                                 | 126        | 98         |
| Digester Free Board Level <sup>3</sup> | ft                                 | 2.6        | 2.1        |
| Digester Active Volume <sup>4</sup>    | gal                                | 916,270    | 1,680,630  |
| HRT by SWD vol                         | days                               | 12         | 17         |
| VS load rate                           | lbVS/cf active volume <sup>4</sup> | 0.129      | 0.096      |

<sup>1</sup> 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.

<sup>2</sup> Gas yield/Biogas yield are based on 15-day running averages for VS in, VS out, and Gas Production. This value would be different if a different period for running averages was chosen.

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

<sup>4</sup> 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 Dewatering and Recycle Streams Data for Digesters 2 and 6 for November 2005

|                           | Unit    | Digester 2 | Digester 6 |
|---------------------------|---------|------------|------------|
| <b>Feed to Dewatering</b> |         |            |            |
| pH                        | -       | 7.5        | 7.3        |
| Alkalinity                | mg/L    | 4,252      | 4,002      |
| Temperature               | °F      | 126        | 98         |
| TS %                      | %       | 2.5        | 2.5        |
| VS %                      | % of TS | 68         | 67         |
| VA by IA/PA method        | mg/L    | 525        | 368        |
| NH <sub>4</sub> -N        | mg/L    | 1,175      | 1,720      |
| 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         |

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

|                            | Unit   | Digester 2 | Digester 6 |
|----------------------------|--------|------------|------------|
| <b>Dewatered Cake</b>      |        |            |            |
| TS %                       | %      | 17.53      | 16.4       |
| Polymer usage <sup>1</sup> | lb/ton |            | 15.5       |
| <b>Filtrate</b>            |        |            |            |
| pH                         | -      | 8.1        | 7.9        |
| Alkalinity                 | mg/L   | NA         | NA         |
| TDS                        | mg/L   | 1,400      | 1,780      |
| TSS                        | mg/L   | 368        | 144        |
| Dissolved Sulfide          | mg/L   | 0          | 0          |
| NH <sub>4</sub> -N         | mg/L   | NA         | NA         |
| COD                        | mg/L   | 1,850      | 337        |
| Magnesium                  | mg/L   | 1.75       | 1.3        |
| Ortho-phosphorus           | mg/L   | 91         | 88         |

<sup>1</sup> The numbers are tracked for the combined filtrate from dewatering of the biosolids digesters.

NA = Not Available or Not Applicable.