TREATING AND HANDLING MANURE ON DAIRY FARMS TO PROTECT THE ENVIRONMENT

Part 1: Anaerobic Digestion of Dairy Cow Manure

Prepared for

WATERSHED AGRICULTURAL COUNCIL FOR THE NYC WATERSHEDS, INC.
Walton, NY

Co-sponsors

THE NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY
Albany, NY

Tom Fiesinger, Project Manager

NEW YORK STATE ELECTRIC & GAS, INC.
Ithaca, NY

John Zabliski, Manager
Agricultural Sales & Marketing

NIAGARA MOHAWK POWER CORPORATION
Syracuse, NY

Edward Neuhauser, Environmental Analyst

CORNELL UNIVERSITY, PRO-DAIRY
Ithaca, NY

Peter Wright, Manure Management Specialist

Prepared by

DLTECH, INC.
PO Box 3910
Ithaca, NY 14852

David C. Ludington, Ph.D., Project Coordinator

479-99 9 March, 2006

NOTICE

This report was prepared by DLtech, Inc. in the course of performing work contracted for and sponsored by the New York State Energy Research and Development Authority and by the Watershed Agricultural Council for the NYC Watersheds, Inc., New York State Electric and Gas, Inc., Niagara Mohawk Power Corp., and Cornell University, PRO-DAIRY (hereafter the "Sponsors"). The opinions expressed in this report do not necessarily reflect those of the Sponsors or the State of New York, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it. Further, the Sponsors and the State of New York make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods, or other information contained, described, disclosed, or referred to in this report. The Sponsors, the State of New York, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

ACKNOWLEDGEMENTS

The following people are recognized for their assistance in the Project.

Advisory Committee

*Dana Chapman, ACS
Project&Construction Mgr
7723 Weedsport-Sennett Rd.
Auburn, NY 13021
716-314-5312

Lilly Mathisen, WAC
Watershed Agricultural Council
33195 State Highway 10
Walton, NY 13856

*Stan Weeks
4 Ashlor Drive
Middle Grove, NY 12850
413-775-1562

*Curt Gooch, Cornell
Sr. Ext. Assoc.
334 Riley Robb Hall
Cornell University
Ithaca, NY 14853
607-255-2088

Ed Neuhauser, NMPC
National Grid
300 Erie Blvd. West
Syracuse, NY 13202-4250
315-428-3355

*Peter Wright, Cornell
Sr. Ext. Assoc.
328 Riley Robb Hall
Cornell University
Ithaca, NY 14853
607-255-2803

Tom Fiesinger, NYSERDA
Project Manager
17 Columbia Circle
Albany, NY 12203-6399
518-862-1090 x3218

Tom O'Brien, WAC
Director
Watershed Agricultural Council
33195 State Highway 10
Walton, NY 13856

John Zabliski, NYSEG
Mgr, Ag. Sales & Marketing
79 Clark St.
Canandaigua, NY14424
585-771-2660, ext. 2609

*Scott Inglis, Cornell
330 Riley Robb Hall
Cornell University
Ithaca, NY 14853
607-255-8578

Dick Peterson, NATC
Box 1002
95 Brown Rd.
Ithaca, NY 14852
607-266-9007

*David Ludington, DLtech, Inc.
Project Coordinator
Box 3910
Ithaca, NY 14852
607-266-6401

Kim Scamman, WAC
Watershed Agricultural Council
33195 State Highway 10
Walton, NY 13856
607-865-7090

* Project Working Group

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

EXECUTIVE SUMMARY
Part 1: Anaerobic Digestion of Dairy Manure

Dairy farmers are coming under increasing pressure to control the release of contaminants from their establishments to air and water. Comprehensive Nutrient Management Plans (CNMP) to protect water quality often prescribed long-term manure storage as the Best Management Practices (BMP). Unfortunately, objectionable odors were produced during storage and then released to the atmosphere during mixing of the storage and during spreading. Thus a conflict existed between BMP for water quality and air contamination by the release of odors. Alternative manure treatment and handling systems were needed. Two systems were assembled and demonstrated at two dairy farms in the New York City Watershed. The first system treated the separated liquid in an anaerobic digester while the solids would be composted and sold. The initial digester used a fixed film and was designated as "Fixed-film AD". This system is reported on in Final Report, Part I. The second system treated the manure aerobically as a solid. The system was designated as "Biodrying". This system is reported on in Final Report, Part 2.

Anaerobic digestion will control odors, reduce pathogens and produce methane for heating the digester. Conventional digesters, used for treating animal wastes, generally have a HRT (hydraulic retention time) of 15 to 21 days. A fixed film digester utilizes increased surface area in the digester to retain bacteria allowing it to operate with HRT as low as 2 days. This reduces the cost of the digester. Corrugated black plastic drain pipe served as the fixed film. This type digester was built at the Farber Farm in Green County to treat the separated liquid. One half of the separated solids were to be composted/dried in a skid mounted mixer as a possible source of bedding and the other half were to be stored for sale or land application.

The digester was operated with a fixed film in the mesophilic range (approximately 100 ^{o}F) for 18 months. The digester was fed separated liquid via a grinder pump (1/4 inch) every 30 minutes. The average (weighted) HRT was 4.8 days, average production of biogas was 24 ft^3/cow-day with an average methane concentration of 63%. During this time a scale formed on most of the surfaces inside the digester including the fixed film. Analysis showed that the scale was calcium carbonate. The farm manager uses about 150 pounds of calcite per day in cow walkways. Near the end of the 18 months the HRT may have been close to 3 days.

Foam did develop in the digester. There were several major foaming incidents during this time. All seemed to be related to a change in feed ration, perhaps an increase in fat content of the total mixed ration. An antifoam emulsion with 5% active silicone was purchased. A concentration of 75 ppm (2 gallons per 1,340 gal of separated liquid) controlled the foam. The cost of the antifoam was $13.60 for each day there was a foam incidence. A water spray will also reduce the foam near the biogas pipe. This water spray controlled by a time clock is currently being used.

All the biogas was burned in a boiler to produce hot water that was used to heat the digester. Biogas production averaged 20 ft^3 per lb of volatile solids "destroyed". In one year the digester produced nearly 739,000 ft^3 of biogas with a heating value of 436,000,000 Btu. Heat not need for the digester was transferred to the outside air via a heat dump radiator. The digester temperature is controlled with a temperature-microprocessor feedback control to an adjustable frequency drive on the heat dump radiator motor.

Digestion of the separated liquid certainly controlled odors allowing the farm manager to spread manure on land that was "off limits" before. Without the solids, the digested liquid was much easier to handle – emptying the long term storage with no prior mixing. Some of the separated solids were sold with the remaining spread on land low in organic matter. Yields were definitely increased. The sampling and analysis for F. Coli was too erratic to determine the effectiveness of the digester to kill pathogens.

The digester was emptied and the fixed film, supporting structures and settled solids were removed. The digester was restarted and operated in a standard mode for 368 days in the same manner as with fixed film, fed separated liquid via the grinder pump 24 times per day and maintained at approximately 100 ^oF.

The average number of cows during the operation of the digester in standard mode was 80, 11 less than with the fixed film digester. With fewer cows and no volume reduction due to the fixed film and supporting structure, the average HRT was 8.0 days. Production of biogas averaged 21 ft^3/cow-day, about 10% less than the fixed film digester even with nearly twice the HRT. However, the production of biogas was28 ft^3/lb VS "destroyed". The average concentration of methane was 67%. There appeared to be a greater reduction in F. Coli (by a factor of 10^+) and COD while operating in the standard mode compared to fixed film. All other parameters were similar for both digesters.

Some of the solids were sold directly from the separator. The moisture content of these solids ranged from 70 to 80 percent, too high for direct composting. The mixer wagon was unable to stir these wet solids and warm air from the heat dump radiator could not be blown through the dense material. The effort to compost the solids was discontinued.

The total annual cost of the original liquid system including the storage costs was estimated to be about $350 per cow-yr. With the anaerobic digester and the storage cost, the total annual cost was $510 per cow-yr. Odor control, easier handling of the liquid manure and solids for land application cost about $160 per cow-yr.

SECTION 1
BACKGROUND

Dairy farmers are coming under increasing pressure to control the release of contaminants from their establishments. Comprehensive Nutrient Management Plans (CNMP) as described by EPA and USDA to protect water quality will often prescribe long-term manure storage. Unfortunately, stored manure will produce significant amounts of objectionable odors that will be released when the storage is mixed prior to spreading and during spreading. Thus a conflict arises between Best Management Practice (storage) to reduce the potential for water pollution and practices (daily spreading) that would reduce odor development. There was a need for alternative manure treatment and handling systems that address both the water quality and quality of life (odor) issues simultaneously.

The New York City Watershed wanted to investigate alternative manure treatment and handling systems that will reduce odors and the population of viable pathogenic organism and develop a product that would allow exporting nutrients out of a watershed. Two alternative manure treatment and handling system were assembled and demonstrated. The first system will treat the separated liquid in an anaerobic fixed film digester. The separated solid would be composted or sold directly. This system will be designated as "FIXED-FILM AD". The second system will treat the manure as a solid with aerobic biodrying. This system will be designated as "Biodrying".

SECTION 2
ANAEROBIC DIGESTION OF DAIRY COW MANURE

INTRODUCTION

The Anaerobic Fixed Film Digester (FIXED-FILM AD) system was intended to control odors, reduce pathogens, produce methane for digester heating and drying solids, and produce manure solids for bedding and soil amendment.

Conventional anaerobic digesters used for treating animal waste are generally built for an HRT (hydraulic retention time) of 21 days. One reason for this retention time is to give the bacteria time to multiply, seeing that every time a digester is fed (influent) an equal volume is discharged (effluent). There is a high concentration of bacteria in the effluent and these bacteria are lost.

Recent designs of digesters have utilized the fact that bacteria cling to surfaces within the digester and by increasing the area in the digester (fixed film) the bacteria population is increased. As a result, the bacteria lost in the effluent are a much lower percentage of the total population in the digester. The bacteria are retained within the digester on the fixed film media. As a result, the hydraulic retention time can be reduced. A digester with this increased surface area is termed a fixed film digester.

System Operation

The original intent was to study the operation of a fixed film digester. This digester was operated from April 2, 2002 to June 17, 2003. The average HRT (hydraulic retention time) was 4.3 days (range 4-6 days). However, after one and one-half years the fixed film had to be removed because of a buildup of scale on the fixed film. The digester was emptied and the fixed film removed on June 24, 2003. The digester was refilled and operated as a standard digester with an average HRT of 8.3 days (range 6-13 days) from September 5, 2003 to September 7, 2004. The results of this project will be reported in two sections. Table 2-1 summarizes the activity for this operation.

Table 2-1. Summary of Activity for Anaerobic Digestion Operation at Farber Farm.

Date (period)	Activity
August 2, 2001	Separator installed
August 21, 2001	Digester full
Sept 9, 2001	Digester top hatches sealed
Sept 12, 2001	Manual heat exchanger backflush system installed
October 19, 2001	Biogas boiler started (methane concentration was high enough to burn in the boiler)
April 2, 2002 - June 17, 2003	**Fixed film digester operation**
May 17, 2002	Automatic heat exchanger backflush system installed
June 7, 2002	Grinder pump installed
May 19, 2003	Second Btu meter installed, measured heat for digester
August 23, 2003	Fixed film material and supporting framework removed
Sept 5, 2003 - Sept 7, 2004	**Standard digester operation**
December 16, 2003	Changed screen from 0.750mm to 1.000mm
December 17, 2003	Digester temperature control installed
Sept 8, 2004	Digester cleaned out

The Farber Farm

The JJ Farber Farm was selected to be the farm for the anaerobic fixed film digester. This farm is located west of East Jewett, NY on County Road 23C in Greene County in the New York City watershed. The farm is managed by Jack and John Verhoeven. The tiestall barn houses 100 milking cows and the 60 replacement herd are housed in a bedded pack barn.

The previous manure handling system consisted of an in-ground reception pit at the end of the milking herd tiestall barn. The gutter cleaner emptied directly into this pit that was large enough to hold 5 weeks manure production. Manure was pumped from the reception pit to a poured concrete above ground storage using a PTO driven pump/agitator. The concrete tank provides a 6-month storage. An over-the-wall agitator/pump and one vacuum spreader and one box spreader were used to spreading the stored manure on the farm and leased land. Storage was emptied twice each year – approximately 300 loads annually. Manure from the heifer barn is either spread daily or stacked in winter months for subsequent spreading.

The farm managers were receiving complaints about the odor from the spread liquid manure. There was land that the owners were willing to lease, but the managers could not spread manure on that land. The major concern was odor control.

System Layout

A layout of the fixed film digester, associated structures, and equipment is shown in Figure A-1. The following is a list and description of the structures and equipment.

After the existing reception pit was cleaned out, three precast tanks were placed in the pit and fastened to the floor. The new raw manure reception tank was placed under the gutter cleaner discharge. Two smaller precast tanks were also placed in the old reception pit, one to receive freshly separated liquids and one to receive digested liquids. All three tanks would overflow into the original reception tank - the space between the new tanks. The digested effluent and the other material that overflowed would be pumped to the large long term storage tank for spreading. Milkhouse wastewater was piped to the gutter in the tiestall barn thus eliminating the need for a separate milkhouse wastewater treatment/disposal system. The wastewater is used to dilute the dairy manure.

Equipment specifications:

1. **Raw manure reception pit** - precast tank, 7 ft x 12 ft x 7 ft, [580 ft^3, 4,410 gal] - a two day holding capacity.
2. **Separated liquid pit** – precast tank, 6 ft x 12 ft x 7 ft, [504 ft^3, 3,780 gal] would receive the separated liquid from the separator and serve as the feed tank for the digester.
3. **Digested effluent pit** – precast tank, 6 ft x 10 ft x 7 ft, [420 ft^3, 3,150 gal] receives the digested effluent from the digester.

   All three tanks were connected to the separator and the digester with PVC pipes installed underground. All electric supply wires and control wires were drawn through other buried PVC pipe.

4. **Raw manure pump** – 5 hp motor, pumps manure to separator, *HOMA Pump*, Model AM434/1-140/SN [5 gpm fresh water had to be introduced at the bottom of the impeller to reduce clogging.]

5. **Raw manure mixer** – 7.5 hp motor, *Houle Electromix Agitator*
6. **Centrifugal feed pump** –replaced with a 2 hp grinder pump on 6/7/02, [¼ inch], *Zoeller* Model 6840
7. **PTO pump** – existing equipment
8. **Anaerobic fixed film digester** - The fixed-film anaerobic digester is a vertical concrete "silo", 10.5 ft inside diameter and 16 ft inside high. The digester was made of 4 precast concrete sections; a base with a flat bottom (majority is below grade), two middle sections and a top. The walls are 6 inches thick. The 10 inch thick top has two access holes with sealed hatches. A mastic ring was placed between each section during construction. The tank was coated on the inside with coal tar epoxy and was insulated on the outside with 4 inches of foamed in-place urethane. Below grade side walls, the insulation is 4 in of Styrofoam. Eighty percent of the top surface was insulated with 2 in of Styrofoam after the biogas line froze.

   For the fixed film, 4-inch diameter corrugated black plastic drain pipe was placed on a support platform. The pipe was purchased in 250 ft rolls and then cut into 8 ft sections. Seven pipes were bundled together using plastic ties such that the bundle would pass through the hatch and stand vertically on the platform. These bundles were then packed in the digester to completely fill the digester. The total surface area of the plastic pipe is approximately 12,000 ft^2. An upper platform was built above to keep the pipe bundles from floating. See Figure A-2.

   The liquid manure in the digester is 12 ft deep. Excluding the volume occupied by the support structure and the pipe itself, the volume of liquid was estimated to be 1,039 ft^3 or 7,770 gal.

9. **Liquid/solid separator** – a *Fan*™ separator [PSS2-520] with a throughput capacity of 50 gpm was installed on the second floor of the control & separator building. The control for the separator motor was interlocked with the control of the raw manure feed pump. The original screen had 0.750 mm openings. A screen with 1.00 mm opening was installed in December 2003.
10. **Control & separator building** – a 1½ story pole barn 24 ft x 24 ft with metal siding and roof was constructed. The first floor had an 8 ft x 12 ft control room, a location for the heat dump radiator and stairway, and a "two car garage". One side of the "garage" is used for the dump wagon and the other side for the skid mounted mixer/composter. The separator is located on the second floor above the "garage"..
11. **Boilers** – two boilers for heating water were installed in the control room, one for propane and one for biogas. The boilers each had a capacity of 150,000 Btu/hr and were plumbed in series.
12. **Heat exchanger** – a shell & tube heat exchanger for heating the digester was installed in the

control room. The exchanger is 4 inches diameter and 3 ft long, and has 4 passes.

13. **Circulation pump** – a 1 hp centrifugal pump was installed to recirculate the digester contents through the heat exchanger to maintain digester temperature. *McMaster-Carr* Model 4320K61
14. **Back-flush control** – a controller was installed to automatically back-flush the heat exchanger with fresh water to prevent plugging.
15. **Biogas meter** – Roots™, lobe-type meter
16. **Heat dump radiator** – Hydronic, fan motor controlled with a variable frequency drive with digester temperature feedback through a solid state controller. *Modine* Hydronic Fan Heater Model HS-258
17. **Btu meters** – ISTEC Btu Energy Measuring System
18. **Mixer wagon** – *Roto-Mix*™, 270 ft^3, reel-type feed mixer with a 6-inch pipe inlet at the bottom for heated air.

19. **Solids Conveyor** – 2 hp, *Kelley*

OPERATION OF ANAEROBIC FIXED FILM DIGESTER

The separator was started August 2, 2001 and the digester was started October 19, 2001 using the propane boiler to heat the digester. The biogas boiler was started on October 23 when the methane concentration was high enough to burn in the boiler. The system achieved steady state operation in April 2002 and operated 406 days. A list of operating parameters and average values are given in Table 2-2.

Table 2-2. Operating Parameters for Fixed Film Digester.

Parameter	Units	Average
Raw manure from gutter	gal/cow-day	20.1
Raw manure to separator*	gal/cow-day	22.2
Average separator run time	min/day	40
Flow to separator	gpm	38
Flow of separated liquid	gal/cow-day	17.4
Separated liquid from raw manure	percent by volume	76
Liquid manure to digester	gpm	50
* includes water added at pump to reduce clogging (5 gpm)		

Manure flow through system is shown in Figure A-3. The average mass flow through the system with 100 cows is as follows. The values shown are based on the average values for the various parameters for the 13 periods covering 215 days of operation. Each day 2,020 gal of manure and milkhouse wastewater were delivered to the reception pit. Raw manure was pumped to the separator for 40 min, the operating time of the gutter cleaner. The 7.5 hp mixer also operated during this 40 min period. During this period fresh water was added at the pump inlet to eliminate clogging. The flow rate was 5 gpm so a total of 2,220 gal or 18,650 lbs were delivered to the separator each day. [assume 8.3 lbs/gal]

The separated liquid, which amounts to 76 percent by volume or weight (assuming same density) of the raw manure input or 1,690 gal [14,000 lbs assuming 8.3 lb/gal], flows by gravity to the separated liquid pit. The separated solid fraction, the other 22 percent of the weight (4,430 lbs), fell from the separator through a hole in the second floor onto the cross conveyor. These solids could be delivered to either the dump wagon or the composter-drier.

The grinder pump delivered separated liquid to the fixed film digester at 46.5 gpm. The pump operated for every 30 min or 48 events per day. The pump run time was adjusted to deliver the required amount of manure (number of cows) to the digester. The control for the digester feed pump is an adjustable interval timer. For an HRT of 4.2 days, the pump would be operated for 46 s per interval for a total run time of 37 minutes. This would deliver 1,730 gal/day [HRT = 7,380/1,690]. The influent is added 48 times per day to maintain more uniform biological activity during the day. It also reduces the loss of biogas during a feeding event, as the influent can be pumped into the digester faster than the effluent overflows the outlet trap. This raises the level of liquid manure in the digester, which forces biogas through the pressure relief valve. The

relief valve was set at 7 inches of water column.

Separated solids were about 1.5 ft^3 per cow-day at 27 percent total solids and a bulk density of 26 lbs/ft^3. One half of the separated solids were to be composted/ dried, a possible source for bedding and the other half were to be stored for land application or for sale. The cross conveyor (wood slat and chain) was mounted just below the floor joist to convey the separated solids to either the dump wagon or to the mixer/composter/drier. The conveyor is equipped with a reversible motor with manual control.

The skid mounted mixer and the two-wheel dump wagon were parked on either side of a "two car garage" at ground level. This mixer was to compost and dry the solids. Two problems arose. One, the 10 hp motor on the mixer was overloaded and could not be operated when the separator was operating. The pulley size was changed on the motor to slow down the mixer rpm and increase the torque at the augers. The second was the difficulty in delivering heated air from the heat dump radiator into the mixer. Delivery of hot air was not accomplished due to packing of solids above the air inlet pipe at the base of the mixer. There has been no production of composted solids and none of the solids have been used for bedding. The farm manager had no desire to use compost for bedding thus there was no pressure to produce composted solids. All the separated solids were delivered to a storage area. The solids have either been spread on the land or sold as organic matter to landscape operations. For 100 dairy cows, the production of solids direct from the separator would be 2,000 cu yd per year. The farm manager reported an increase yield of hay from the fields where the solids were spread.

Operation of the Digester and Heating System

A list of operating parameters is given in Table 2-3, along with average values and ranges.

Table 2-3. Results of Selected Operating Parameters for Selected Periods

Parameter	Units	Average Value	Range
Cows*		91	71 - 97
Hydraulic Retention Time	days	4.8	4.5 – 6.2
Production of Biogas	cuft/cow-day	24	21-30
Biogas, CO_2	percent	37	32 - 40
Biogas, H_2S	ppm		4,500 - 14,000
Low heating value	Btu/ft^3 @ 70 F	535	506 - 590
Boiler Heat, output	Btu/day	950,000	
Boiler Efficiency	percent	81	54 - 86
Digester Temp	ºF	100	96 - 104

* Lactating cows, manure digested

For analysis purposes, the 406 days of operation of the fixed film digester were divided into 13 periods when the digester was operating at "steady state" (see Table A-1 and Table A-6, Appendix A). There were several foaming incidences when the feeding rate had to be reduced or stopped completely in order to control the foam. These 13 periods, 215 days out of the 406 days, are intended to indicate the performance of the fixed film digester when operating at steady state.

Operation of biogas boiler – the capacity of the boilers is varied by the number of burner tubes in operation. The biogas boiler functioned with 4 or 5 tubes (out of 8 tubes available) depending on biogas production. At 24 ft^3 of biogas per cow-day, 91 cows and 535 Btu/ft^3, the heating value of the biogas is 548,700 Btu/hr or 12,800 Btu/cow-day. With an overall burner efficiency of 81 percent, the energy in the hot water output is 39,400 Btu/hr. For a year, the digester would produce nearly 797,000 ft^3 of biogas with a heating value of 426,000,000 Btu which is equivalent to 4,300 therms and 3,000 gal of fuel oil.

The biogas delivered to the boiler was measured with a gas meter. The average biogas produced during each period is plotted in Figure 2-1 for the fixed film digester.

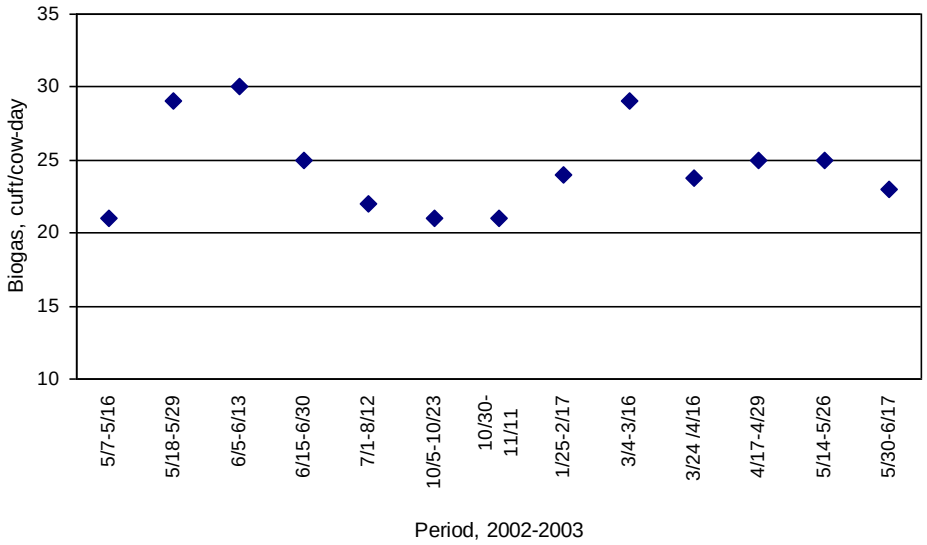


Figure 2-1 Biogas Produced, Fixed Film (no temperature correction)

Operational Issues in Digester

Foam developed in the digester. There were several major foaming incidents in the 13 months. The major reason(s) for this foaming is unclear. They all seem to be related to changes in feed ration but the root cause has not been determined. The pipe that delivers the biogas to the control room and the gas meter was changed to create a positive foam trap to ensure that foam would not enter the gas meter. In April 2004, an antifoam emulsion [DC 7305 Antifoam] was purchased from Dow Corning to determine if the foam could be controlled. This antifoam agent has 5% active silicone emulsion. Dow Corning suggested 100 ppm of active ingredient and then work down. Adding 2 gallons of antifoam [0.1 gallon of active ingredient] to 1,340 gal (one day) of separated liquid (a concentration of 75 ppm) controlled the foam. One gallon of antifoam (37.5 ppm) did not control foam. The antifoam cost $0.85 per pound or $6.80 per gallon. At 2 gallons/day to control the foam, control cost $13.60 for each day there was a foam incidence.

During operation of the digester in the fixed film mode, a scale formed on most of the surfaces inside the digester including the corrugated pipe fixed film. Analysis of the scale revealed that the scale was high in $CaCO_3$. See Table 2-4. The farm manager uses about 150 lbs per day of *Barn No Skid*, a calcium carbonate (calcite) product on the cow walkways in the tiestall barn to prevent slipping. The material contained 37% calcium and 0.28% magnesium. This appeared to be the reason for the scale. Scale formation on fixed film had not been reported in the literature. The amount of scale could not be determined, thus the exact HRT could not be calculated. The hydraulic retention time may have approached 3 days near the end of the run. This shortened retention time could increase the propensity of a

digester to produce foam. A foam overflow pipe was added to direct the overflow foam to the manure storage.

Table 2-4. Analysis of Sludge Attached to the Fixed Film.

Parameter	Units	Values
Total Solids	percent	58
Volatile Solids	percent	12.6
Total Phosphorus as P	mg/kg	2,838
Ortho Phosphorus as P	mg/kg	1,138
Magnesium, total as Mg	mg/kg	17,350
Sulfate	mg/kg	< 100
Calcium, total as Ca	mg/kg	130,700

The separator feed pump operated well as long as fresh water flows (5 gpm) to the lower wear ring of the pump. There were problems with the heat exchanger plugging with manure solids. A manually operated backflush system was installed. Periodically the farm manager would flush the heat exchanger with fresh water. On May 17,2002 the backflush system was automated with motorized valves and time clocks. The original digester feed pump was replaced with a grinder pump on June 7, 2002 to further reduce potential for plugging of the heat exchanger. This pump grinds all solids to ¼ inch. There was the thought that finer solids might increase the biogas production. The data did not support this hypothesis.

The 2-inch PVC gas line froze during extremely cold weather. [PVC was used for the gas line external to the building. Black iron pipe was used inside the building.] Two inches of foam insulation over 80 percent of the top of the digester was added to increase gas temperatures. The pressure relief valve also froze. Wrapping the gas line and relief valve with insulation also solved these problems.

A buildup of scale on the heat exchange tubes of the biogas boiler was a problem. The exchanger has been cleaned 3 times during the 20 months of operation. A wire brush and scraper were used to remove the scale. The scale can be dissolved with muriatic acid. The reason for the build up of this scale may be related to the quality of the biogas and the relative low operating temperature of the boiler causing condensation and buildup of scale on the cast iron surface.

Heating the Digester

The digester was heated by continuously recirculating the liquid manure in the digester through a shell &

tube heat exchanger at a rate of 20 gpm. See Figure A-2. Hot water from the boiler was circulated through the other side of the exchanger. An *Aquastat* on the hot water line to the heat exchanger maintains the water temperature [fixed differential of 5 F] entering the heat exchanger. The setting on the *Aquastat* had to be changed manually to compensate for changes in in-feed amount and temperature, and outside ambient temperature. The temperature of the digester was not maintained as constant as desired. The decision was made to automate the temperature control. On December 17, 2003 the *Aquastat* was removed and an adjustable frequency drive was installed to control the speed of the new 3-phase fan motor on the heat dump radiator. A feedback temperature controller was installed to monitor the digester temperature and send a 0-10VDC signal to the AFD. As the temperature of the digester rose toward set point the speed of the fan increased to remove more heat in the radiator before the water enters the heat exchanger, thus reducing the digester heating rate [Btu/min]. An analysis of heating the digester will be discussed later.

The daily average core temperature of the digester and the average morning outside temperature for the fixed film digester is plotted in Figure 2-2. The daily temperatures are given in Table A-6. The impact of the automatic temperature control with feedback will be discussed in the next section.

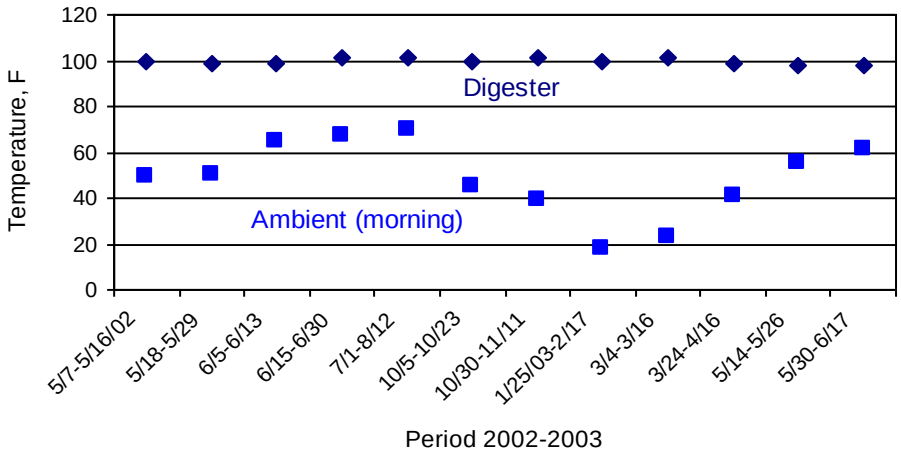


Figure 2-2. Digester and Ambient (morning) Temperatures, Fixed Film

Odor - there was a significant reduction in odor liberated when the liquid manure was spread on cropland. There were no complaints about odors from the Farber's or neighbors during the summer. Anaerobic digestion of the separated liquid has solved the odor problem at the Farber Farm.

Hydrogen sulfide - Hydrogen sulfide was measure in the biogas during the operation of the fixed film digester. The results are shown in Figure 2-3. The reason(s) for the fluctuation in the concentration of Hydrogen Sulfide is unclear. The drinking water had a sulfate concentration of 1.3 mg/l (7 July 03). According to the dairy herd nutritionist the sulfur content of the feed stuff was not changed. The first biogas sample taken during startup (10/7/01) had 30,000 ppm of H_2S. The values at first were exceptionally high when values measured at other on-farm digesters were in the 1,000 to 2,000 ppm. However, one digester in northern New York had H_2S level of 8,000. There was suspicion that the cow feed ration may have had high sulfur content but the nutritionist said no. The well water at the Farber Farm was tested July 7, 2003.

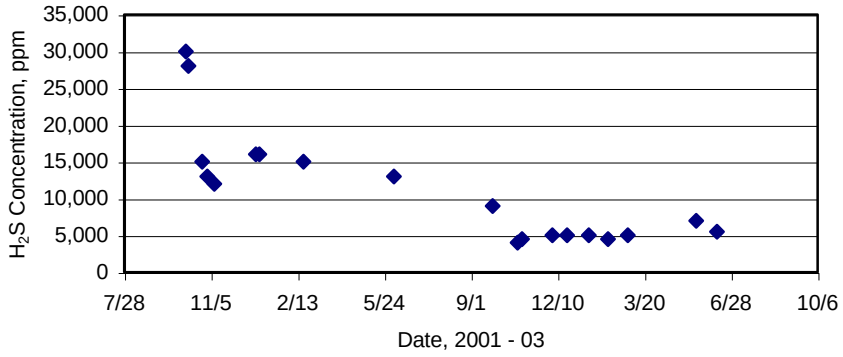


Figure 2-3. Concentration of H_2S in Biogas - Fixed Film Digester.

The results of this test showed a sulfate concentration of 3.3 mg/l, as seen in Table 2-5. The farm manager suggested that the sulfur content of the well water was higher in 2001 because of low water level in well. The high sulfur content of the biogas is believed to be another contributor to the scaling on the boiler tubes. This high concentration would require more frequent oil changes had there been an engine/generator set.

Table 2-5. Water Analysis, July 1, 2003.

Analysis	Result	Units
Hardness	3.5	Mg/L $CaCO_3$
PH	9.08	std units
Sulfate	3.3	Mg/L
Calcium, total (CA)	1.20	Mg/L
Iron, total (FE)	<0.050	Mg/L
Magnesium, total (MG)	0.13	Mg/L

Chemical and Biological Properties

During the operation of the fixed film digester, samples of the raw manure, separated liquid, separated solids and the digester effluent were collected 12 times. Generally, grab samples were taken at each location. The 4 oz sample was iced and delivered to the laboratory that afternoon. These samples were analyzed for a variety of nutrients and other parameters: COD (chemical oxygen demand), total and volatile solids, pH and F. Coli. The results of these analyses are given in Tables A-2, A-3, A-4, and A-5. The test methods used to determine the chemical and biological parameters are listed in Table A-14. The average values and standard deviations for these parameters for the digester influent (separated liquid) and digester effluent are given in Table 2-6. The changes that occurred in the digester are also given. The values for the raw manure and separated solids are also given. The following is a brief discussion of each parameter.

F. Coli F. Coli is not given as a concentration but in MPN (Most Probable Number), a statistical estimate of the concentration. Using the average values for the fixed film digester, the reduction in F. Coli was only 23 percent. The standard deviation for the digester effluent was over 3 times the average. The values reported varied widely. Referring to Tables B-3 and B-4, on 3/3/2003 the MPN/gram in the separated liquid (influent) was 1,600,000 and the effluent was 1,100. Four days later (3/7/2003) the influent was 240,000 and the effluent was 1,600,000 MPN/gram.

Volatile Acids The samples were analyzed only for acetic acid, a volatile acid. In anaerobic digestion volatile acids are converted to biogas. The presence of volatile acids has been used as an indicator of the potential for producing odorous compounds.

Table 2-6. Design Criteria, Summary of Chemical & Biological Analysis, Fixed Film,

"Nutrient"	Averages and Standard Deviation [n=12]					unit
	Sep. Liquid	Dig. Effluent	Change	Raw Manure	Sep. Solids	
F. Coli	620,200 639,500	141,200 459,400	-478,700	675,800 859,400	198,300 179,700	MPN/gram
Volatile acids	2,800 830	930 480	-1,870			mg/L
COD	53,300 3,740	42,400 14,390	-10,900	109,700 33,200	203,800 68,300	mg/L
Dissolved COD	22,200 4,190	15,900 4,140	-6,650	23,100 5,300	17,400 6,500	mg/Kg
NH_3	2,200 320	2,470 280	+250	2,200 320	1,590 420	mg/Kg
TKN	3,850 660	3,700 520	-130	3,900 360	3,350 690	mg/Kg
TP	635 89	592 61	-43	650 70	530 100	mg/Kg
Ortho P	361 47	474 30	+54	380 50	310 80	mg/Kg
TS	4.87 0.38	3.80 0.37	-1.07	9.6 1.2	27.2 2.4	%
TVS	67.7 4.91	64.3 3.39	-3.42	80.7 2.3	89.8 1.5	%
pH	7.43 0.11	7.75 0.08	+0.32	7.8	8.3	std units

According to the farm manager and those near the farm, the odor when the digested effluent was applied to the land was much lower than before. The wife of the farm manager did not know that manure had been spread.

COD Chemical oxygen demand is the oxygen equivalent of the organic matter in manure (wastewater) that can be chemically oxidized. COD is an indication of the ultimate carbonaceous BOD (biological oxygen demand).

Dissolved COD Dissolved (soluble) chemical oxygen demand is a measure of the portion of COD that can be more readily biodegraded.

NH_3 (Ammonia as N) The concentration of ammonia expressed as N (assumed to include NH_3 and NH_4^+) increased about 10 percent while the liquid manure was in the digester. At the same time the pH increased 0.32 units which shift more of the nitrogen to the NH_3 form.

TKN (Total Kjeldahl Nitrogen) TKN is a measure of organic nitrogen and free ammonia. The TKN decreased about 3 percent during digestion. This decrease may not be a "loss" of TKN but more likely the nitrogen is in the settled sludge.

Total Phosphorus Total phosphorus includes orthophosphate, polyphosphate and organic phosphate. The decrease in TP was less than 7 percent. Here the phosphorus may be in the settled solids.

Orthophosphates Ortho P is available for biological metabolism. The concentration of Ortho P in the digester contents increased during digestion. Some of the polyphosphates may have undergone hydrolysis to form Ortho P.

TS (total solids) Total solids are made up of volatile solids and fixed solids (ash). The total solids decreased about 1 percent during digestion. This decrease has to be in the volatile solid fraction.

VS (volatile solids) Volatile solids are those solids that are volatilized or burned when the TS are ignited at 500EC. Generally VS are equated with organic matter. However, there may be inorganic compounds that will break down at these elevated temperatures and counted as organic matter.

Using the number presented in Table 2-6, for every 1,000 lbs of separated liquid added to the digester, 10.7 lbs of total solids, 8.7 lbs of volatile solids and 2.1 lbs of fixed solids were "lost". Most of the volatile (organic) solids were converted to biogas while the remaining settled along with the fixed solids. These calculations assume that 1,000 lbs of effluent was discharged. This cannot be true because some of the influent left as saturated biogas and some settled in the digester.

Mass Flow – Table 2-7 shows the mass flow of several parameters through the system based on the average concentrations listed in the above Table 2-6 and the mass flow of material. The mass flows are given in pounds per day.

Table 2-7. Design Criteria, Mass Flow Analysis, Fixed Film (lbs/day for 100 cows)

	Raw Manure	Separated Liquids (Digester Influent)	Digester Effluent	Separated Solids
Wet Weight	18,400	14,000	14,000*	4,420
TS	1,760	680	530	1,200
VS	1,420	460	340	1,080
FS	340	220	190	120
Ortho P	7.1	5.0	5.8	1.4
TP	12	8.9	8.3	2.3
TKN	71.6	53.6	52	15
NH3	41	31	34	7.0
COD	2,020	750	590	900
VA (acetic acid)		39	13	
*assumes mass effluent = mass influent				

The loss of volatile solids during digestion averaged 130 lb/day per 100 cows. Using the weighted average biogas production of 24 cuft/cow-day, the conversion of volatile solids to biogas was 18.5 cuft/lb V.S. destroyed. This assumes the mass flow rates for influent and effluent were equal and all V.S. unaccounted for were converted to biogas.

On August 23, 2003 the digester was emptied. The fixed film and supporting structures were removed. All the settled solids in the digester were also removed. The settled sludge remaining in the digester after the liquid portion was drained through the effluent drain pipe was removed using a 30 gallon barrel that would fit through the hatch in the top of the digester. The barrel was filled by hand and lifted through the hatch with a small crane. About 72 ft^3 of sludge was removed. The sludge contained considerable grit that was assumed to be the calcium carbonate, as discussed earlier, used in the tiestall barn to reduce cow slippage.

OPERATION OF STANDARD OR TRADITIONAL DIGESTER

On September 5, 2003 the digester at the Farber Farm was operated in a standard mode with an HRT of 8. All operating procedures were the same as with the fixed film digester, daily logging of important parameters and periodic sampling and testing the raw manure, separated liquid, digester effluent and separated solids. The digester was operated in this mode until September 7, 2004 (368 days). The operation of the digester was divided into 18 – steady state periods with a total of 208 days. These periods are listed in Table A-8 along with several operating parameters. The data for the individual periods is given in Table A-9 and the raw data for each day is given in Table A-10.

A list of operating parameters is given in Table 2-8. These values resulted from 4 mass flow tests conducted during the operation. The amount of manure and washwater from the milkhouse delivered to the reception pit was less than during the fixed film test, 17.4 vs 20.1 gal/cow-day. With fewer cows during the standard operation (80 vs 91) and a lower amount of raw manure per cow-day pumped to the separator (18.9 vs 22.2), the separator operated 10 minutes less per day during the standard operation. The flow to the separator was similar, 50 gpm with fixed film and 46.5 gpm during standard operation. In addition, the percent of the separated liquid from the raw manure was 68 percent instead of 76 percent. This gave larger HRT for the same number of cows. This is shown in Table 2-9. The average HRT for standard operation was 8.3 instead of 4.3.

Table 2-8. Operating Parameters for the Standard Digester.

Parameter	Units	Average Values
Raw manure & washwater from gutter	gal/cow-day	17.4
Raw manure to separator*	gal/cow-day	18.9
Average separator run time	minutes	30
Flow to separator**	gpm	41 & 70
Raw manure to separated liquid pit	percent	68
Flow of separated liquid to liquid pit	gal/cow-day	12.8
Liquid manure to digester	gpm	46.5

* Includes water (5 gpm) added at raw manure pump to reduce clogging

** For 56 days the screen on the separator was 0.75 mm and the flow was 41 gpm. For the remaining 152 days the screen was 1.00 mm and the flow was 70 gpm

The production of biogas per cow-day remained nearly the same, 24 for fixed film compared to 21.4 for standard operation. The percent CO_2 did decrease from 37 to 32.5 percent which caused the low heating

value to increase from 535 to 564 Btu/ft^3. The calculated energy into the boiler decreased from 1,171,000 to 962,000 Btu/day [18% reduction]. Because of an apparent reduction in boiler efficiency, 81 to 69 percent, the average boiler output decreased from 950,000 to 623,000 Btu/day [34%].

Table 2-9. Results of Selected Operating Parameters for Standard Digester.

Parameter	Units	Average Value	Range
Cows		80	46 - 101
Hydraulic Retention Time	days	8.0	6 – 13.1
Production of Biogas	cuft/cow-day	21.4	13.6 - 28.7
Biogas, CO_2	percent	32.5	31 - 37
Low heating value	Btu/ft^3 @ 70F	560	533 - 582
Boiler heat, output	Btu/day	623,100	333 - 988,000
Boiler efficiency	percent	69	61 - 77
Digester Temp	°F	99.3	104 - 87

The digester operating under the fixed film mode was more efficient is producing biogas (Btu/day) even though the residence time was 48 percent less. The cost effectiveness of the two operational modes for the same size farm has yet to be determined.

Hydrogen Sulfide

Testing for H2S continued for the standard operation of the digester. The results of these tests are shown in Figure 2-4. The concentrations are similar to those measured in the fixed film digester during the last 8 months of operation (October 25, 2002 to June 12, 2003). This may add credence to the farm manager's contention that the sulfur content of the well water was high in 2001.

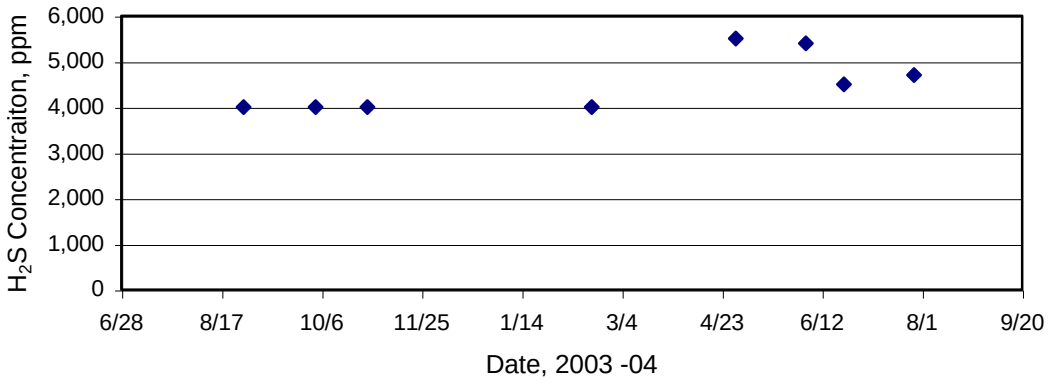


Figure 2- 4. Hydrogen Sulfide Concentration in Biogas - Standard Operation.

Chemical and Biological Properties

The results of the chemical and biological tests on the raw manure, separated liquid and solids, and the digester effluent are given in Table 2-10. The high standard deviation continued to be a challenge. This can be accounted for by the difficulty when the samples are collected at the site plus the sub-sampling done when the samples are analyzed. For the samples taken, the average population of F.Coli, based on MPN, was reduced by a factor of 13 during digestion. The concentration of acetic acids in the digester effluent was nearly the same as the fixed film digester, 1,000 vs 930 mg/l.

A summary of the mass flow of the solids, and the nutrients and chemical parameters for the standard operation are presented in Table 2-11. Bringing together average values from the analysis of these parameters over one year and a snapshot of the mass flow leads to discrepancies. For example, 61 lbs of TKN enter the separator per day, 41 lbs were found in the liquid and 16 lbs in the solids, for a total of 57 lbs. Approximately 4 lbs/day or 3 percent were unaccounted for. For the fixed solids, 316 lbs entered the separator but only 309 lbs were in the separated liquid and solids. At the same time, the mass of T.S. and V.S. exiting the separator was larger than the mass entering the separator. There were 10 lbs/day more fixed solids in the effluent from the digester than in the influent. In addition to this, fixed solids are settling in the digester.

Table 2-10. Design Criteria, "Nutrient" Results, Standard, 9/5/03 - 9/7/04.

"Nutrient"	Averages and Standard Deviation n =26					unit
	Sep. Liquid	Dig. Effluent	Change	Raw Manure	Sep. Solids	
F. Coli	1,495,300 1,680,900	112,300 320,700	- 1,382,000	4,762,000 6,216,000	929,100 2,004,000	MPN/gram
Vol acids	2,800 700	2,640 8,060	- 1,760			mg/L
Dissolved COD	23,150 6,460	19,770 8,250	- 3,380		NA	mg/L
COD	55,550 11,400	38,970 62,600	- 16,580	72,200 20,500	101,700 37,600	mg/Kg
NH_3	2,300 320	2,720 290	420	2,270 590	1,630 340	mg/Kg
TKN	3,860 660	4,010 4,890	- 150	3,850 770	3,200 700	mg/Kg
TP	520 78	500 83	- 20	560 180	460 180	mg/Kg
Ortho P	310 54	370 67	+ 60	320 66	230 80	mg/Kg
TS	5.25 0.82	4.63 1.17	- 0.62	10.4 1.9	22.7 1.8	%
TVS	69.06 4.30	63.0 6.6	- 6.1	80.6 1.8	88.1 2.0	%
Total K	1,770 1,430	1,740 1,360	- 30	1,620 1.37	1,380 0.2	mg/Kg
pH	7.5 0.25	7.9 0.08	+ 0.5	7.6	8.1	std units

Table 2-11. Design Criteria, Mass Flow Analysis, Standard Operation (lbs/day for 100 cows).

	Raw Manure*	Separated Liquid	Digester Effluent	Separated Solids
Wet Weight	15,700	10,680	10,680**	5,024
Total Solids	1,630	560	494	1,140
Volatile Solids	1,310	387	311	1,005
Fixed Solids	320	173	183	135
Ortho P	5.0	3.3	4.0	1.2
Total P	8.8	5.5	5.3	2.3
TKN	61	41	43	16
NH3	36	25	29	8.2
COD	1,130	593	416	511
Volatile Acids		30	11	
*Raw manure to separator * *Assumes effluent mass = influent mass				

To assist in comparing the two modes of operating the Farber digester, Table 2-12 shows the values for the influent, effluent and the changes that took place in the digester. The major differences would appear to be in F. Coli and COD. Both F. Coli and COD decreased much more in the standard digester than the fixed film. There was a decrease in TKN in the fixed film digester but an increase in the standard digester. The differences in these parameters cannot be attributed solely to the type of digester because the two were not operated the same, for example, the difference in HRT. [The number of digits in the values shown in 2-12 does not reflect the accuracy of the numbers.]

Table 2-12. Design Criteria, Comparison of Fixed Film and Standard Operation.

Parameters	Units	Average of Operating Parameters					
		Fixed Film			Standard		
Days of Operation		406	[5/7/02 to 6/17/03]		368	[9/5/03 to 9/7/04]	
Days in ( ) periods		215 (13)			208 (18)		
Retention	HRT, days	4.8			8		
Biogas	cuft/cow-day	24			21.4		
CO_2 level	percent	37			32.5		
		Influent*	Effluent	Change	Influent*	Effluent	Change
F. Coli	MPN/gm	620,192	141,519	-478,673	1,495,278	112,904	-1,382,374
Vol acids	mg/l	2,799	929	-1,870	2,800	1,036	-1,764
Dissolved COD	mg/l	22,246	15,901	-6345	23,154	19773	-3381
COD	mg/kg	53,319	42,417	-10,902	55,552	38,971	-16,581
NH_3	mg/kg	2,214	2,467	253	2,306	2,725	419
TKN	mg/kg	3,847	3,713	-134	3,856	4,010	154
TP	mg/kg	635	592	-43	519	501	-18
Ortho P	mg/kg	361	414	53	306	370	64
Total K	mg/kg				1,771	1,743	-28
TS	percent	4.87	3.8	-1.07	5.25	4.63	-0.6
TVS	percent	67.7	64.3	-3.4	69.1	63.0	-6.1
pH		7.45	7.76	0.3	7.48	7.90	0.4

* Separated Liquid

The sludge remaining in the digester after the liquid portion was removed via the effluent drain pipe was removed using the same technique used following the fixed film experiment. The amount of sludge removed was measured. Approximately 10,700 lbs of wet sludge were removed following 368 days of operation. The average depth of the sludge was 1.5 ft. The results of analyzing the sludge are given in Table 2-13.

Table 2-13. Analysis of Settled Sludge, Standard Digester.

Parameter	Units	Value
Total Solids	percent	55.5
Volatile Solids	percent	10.4
Total Phosphorus as P	mg/kg	1,341
TKN as N	mg/kg	2,340
Ammonia as N	mg/kg	1,884
Calcium, total as Ca	mg/kg	37,075
Potassium, total as K	mg/kg	1,645
Hardness, as $CaCO_3$	mg/kg	106,869
Bulk Density	lbs/ft^3	88

The sludge contained approximately 6,000 lbs of total solids. Using an average number of cow (76), the total solids accumulated at an average rate of 0.21 lbs/cow-day. With about 5.8 lbs of T.S. added per cow-day, 3.7 percent of the total solids settled. The high concentration of Calcium and Calcium Carbonate is due to the use of the Calcite to reduce cow slippage.

Biogas Production

The relationship between HRT (hydraulic retention time) and the production of biogas (cuft/cow-day) for the two modes of operation is shown in Figure 2-5. The plotted data does not show the relationship that was expected. Between an HRT of 1 and 12 days a significant increase in the production of biogas is expected. However, the highest production for the fixed film was 31.7 cuft/cow-day at the longest HRT of 5.6 days. For the standard operation the production of biogas did not appear to change between an HRT of 6 and 12 days. There obviously are several other factors that impact biogas production besides HRT. Further analysis of all the information surrounding these data points might reveal other relationships.

When the cubic feet of biogas produced per pound of VS "lost" the standard digester fed with separated liquid for the 1.00 mm screen was greater than the fixed film digester fed with separated liquid from the 0.75 mm screen. The TVS "lost" per cow-day in the standard digester configuration were 36% less than in the fixed film digester configuration. At the same time the biogas production was only 11% less. This resulted in 41% more biogas produced per lb of TVS lost in the standard digester. These calculations are shown in Table 2-15.

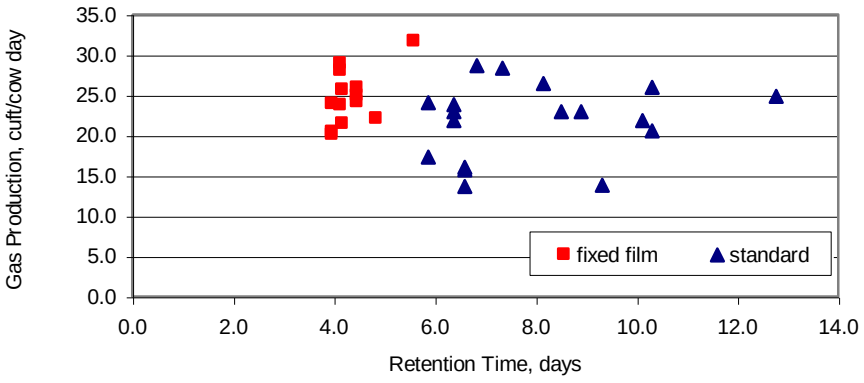


Figure 2-5. Relationship Between HRT and Biogas Production, Fixed Film and Standard Modes.

HEATING THE DIGESTER

Temperature Control

The biogas was burned in a boiler to produce hot water. This hot water was circulated through the heat dump radiator and the heat exchanger for heating the digester. As mentioned earlier, the amount of heat sent to the digester was controlled by the amount of heat removed by the heat dump radiator before the hot water reached the heat exchanger. In mid December 2003 an automatic control with feedback from the digester temperature was added. Effectiveness of this control is shown in Table 2-14 below.

Table 2-14. Effectiveness of Automatic Temperature Control.

State	Time Period	Avg Temperature	Std Deviation
Before	May 19 to Dec 16, 2003	98.1 F	± 4.4
After	Dec 17 to Aug 31, 2004	99.6 F	± 1.9

Figure 2-6 shows the digester and the outside ambient temperatures. Both temperatures were taken in the morning. The average temperatures during each period were plotted. There was automatic temperature control during the period. The use of the energy (Btu/day) for heating the digester was used for heating the separated liquid influent to digester temperature and to compensate for the heat loss.

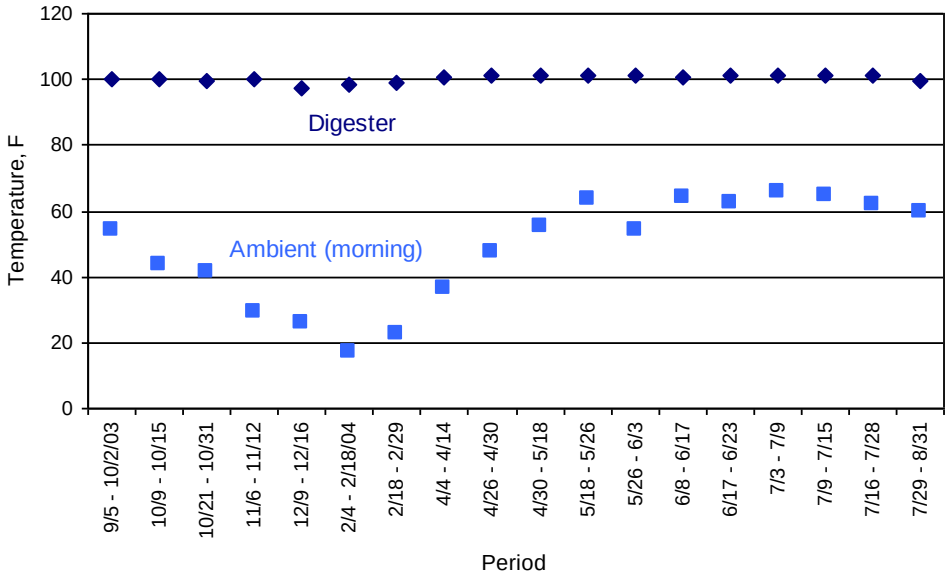


Figure 2-6. Digester and Ambient Temperatures, Standard.

The total energy monitored by Btu meter #2 could not be partitioned into the two separate entities. The temperature of the cold influent was not recorded and only two temperatures of the outside ambient air were manually recorded daily. This was not enough data to calculate heat loss. The excess heat, the heat removed at the heat dump radiator, was plotted in Figure 2-7 for a one year period. There were several times during the year when there was not enough heat available for heating the digester. This probably caused a momentary drop in digester temperature. There were times when the propane boiler was used to compensate for a deficiency in biogas.

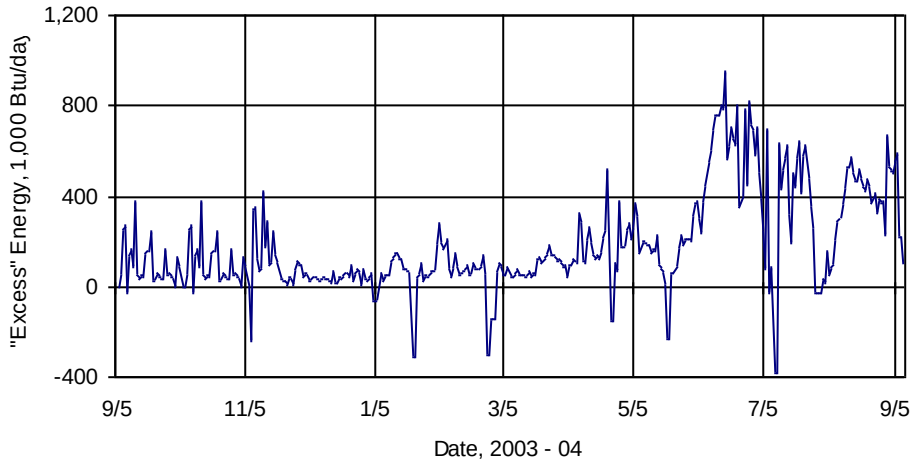


Figure 2-7. Excess Heat, Heat Removed at Heat Dump Radiator for One Year Period.

The operation of the separator was analyzed over three years to explore the differences between the 0.75 and the 1.00 mm screen. During this period, twelve mass flow tests were conducted by Stan Weeks, six for each size screen opening. The results of these tests are shown in Table 2-15.

Table 2-15. Analysis of Separator Operation.

Test Date	Screen	Gallons		min	gpm	Gallons		by volume	Feet		1,000 gal	lbs/cuft
8/14/01	0.75 mm	1,780		50	35.6	1,150		64.6%				
11/4/01		1,560		90	17.3	1,260		80.8%				
12/17/01		2,350		40	58.8	1,850		78.7%	84		35.7	49
9/26/02		2,070		40	51.8	1,620		78.3%	137		66.2	36
(undated 03)		1,440		25	57.6	1,100		76.4%	91		63.2	32
3/1/03		1,375		35	39.3	na			80		58.2	
12/16/03	1.00 mm	1,630		20	81.5	1,190		73.0%	112		68.7	33
6/17/04		1,680		25	67.2	1,230		73.2%	130		77.4	29
7/1/04		2,010		35	57.4	1,350		67.2%	138		68.7	40
7/3/04		2,340		38	61.6	1,490		63.7%	138		59.0	51
7/9/04		1,540		20	77.0	990		64.3%	117		76.0	39
8/4/04		1,900		20	95.0	1,290		67.9%	126		66.3	40
Average	0.75 mm	1,763	gal	47	38	1,396	gal	76%	98	gal	58	39
		14,629	lbs			11,587	lbs		3,042	lbs		
	1.00 mm	1,850	gal	26	70	1,257	gal	68%	127	gal	69	39
		15,355	lbs			10,430	lbs		4,925	lbs		
Assumes the density of raw manure and separated liquid to be 8.3 lbs/gal												
* As measured in the dump wagon where some compaction occurred												

The volumes of raw manure and separated liquid were determined by measuring the changes in depth of the material in their respective concrete tanks. The flow rate through the separator was over 80 percent greater (70 vs 38 gpm) for the 1.00 mm screen. At the same time the volume of liquid separated decreased from 76 to 68 percent of the raw manure which included the washwater and fresh water added at the pump.

The volume of separated solids was determined by leveling the top of the solids in the dump wagon and measuring the depth of solid. The volume of solids recovered per 1,000 gallons of raw manure was calculated by dividing the solid by the gallons of raw manure. More solids were recovered with the 1.00 mm screen which was not expected. The faster flow rate through the separator, the speed of the separator and the setting of the weights may have contributed. There needs to be concerted testing of the bulk density of the raw manure, separated liquid, and separated solids.

Solids Using 84 as the average of cows during the two studies, an average of 20.6 gal manure per cow-day and a solids production of 63 ft^3/1,000 gal of manure, the annual production of solids would be 1,470 yd^3. The Farber Farms is currently being paid $15 per yd^3. The annual revenue would be about $20,000. None of the solids were used as bedding and there was no economic advantage of drying or composting the solids.

Volatile Solids – Based on the averages for the analysis of the digester influent and effluent, the number of cows, the separated liquid digested and the biogas production, the biogas production per pound of volatile solids "destroyed" for the fixed film digester was 21.4 and 28.6 for the standard digester.

Table 2-16 and Figure 2-8 show the partitioning of the solids and nutrients between the separated liquid and separated solids for two different size holes in the screen, 0.75 and 1.00 mm. The partitioning of the nutrients, N and P, follow the partitioning of the liquid and solid in terms of weight. This was 70 to 80 percent for the smaller opening and 60 to 70 percent for the larger hole screen. The volatile solids in the liquid fraction only increased 13 percent when the 1.00 mm screen was used. The bar graph in Figure 2-8 show how little difference there was between the two screens even though the larger opening was a third larger.

Table 2- 16. Design Criteria, Partitioning of the Operation of the Separator.

Raw Manure to Separator

Screen	0.750 mm		12 samples			1.00 mm		13 samples
	Fixed Film 6/5/02-4/24/03	Standard 9/9/03-9/7/04						
Parameter/units	Conc.	Conc.	Avg Conc.	lbs/day		Conc.	lbs/day	
TS, %	9.58	10.2	9.89	1438		11.1	1,753	
VS, %	80.72	80.0	80.36	1156		81.3	1,425	
TKN, mg/kg	3,893	3,899	3,896	57		4,066	64	
NH3, mg/kg	2,218	2,439	2,329	34		2,260	36	
TP, mg/kg	653	604	629	9.1		562	8.9	
OP, mg/kg	385	318	352	5.1		346	5.5	
Avg Mass Flow, lbs/day		14,541				15,796		

Separated Liquid

	0.750 mm					1.00 mm		
					Percent			Percent
Parameter/units	Conc.	Conc.	Avg Conc.	lbs/day	Recovered	Conc.	lbs/day	Recovered
TS, %	4.87	4.9	4.89	555	38.6	5.55	589	33.6
VS, %	67.7	66.7	67.2	373	32.3	71.7	422	29.6
TKN, mg/kg	3,847	4,051	3949	44.8	79.2	3,689	39.1	60.9
NH3, mg/kg	2,214	2,393	2304	26.2	77.3	2,232	23.7	66.3
TP, mg/kg	635	514	575	6.5	71.4	522	5.5	62.4
OP, mg/kg	361	295	328	3.7	72.9	315	3.3	61.1
Avg Mass Flow		11,356	lbs/day		78.1	10,605	lbs/day	67.1

Separated Solids

	0.750 mm					1.00 mm		
					Percent			Percent
	Conc.	Conc.	Avg Conc.	lbs/day	Recovered	Conc.	lbs/day	Recovered
TS, %	27.16	22.7	24.93	794	55.2	22.6	1,173	66.9
VS, %	89.82	87.3	88.56	703	60.8	88.8	1,042	73.1
TKN, mg/kg	3,347	3518	3,433	10.9	19.3	3022	15.7	24.4
NH3, mg/kg	1,588	1,807	1,698	5.4	16.0	1,502	7.8	21.8
TP, mg/kg	527	572	550	1.8	19.2	369	1.9	21.6
OP, mg/kg	313	270	292	0.9	18.2	195	1.0	18.5
Avg Mass Flow, lbs/day		3,185			21.9	5,191		32.9

Assumptions: Density of raw manure and separated liquid are the same, 8.34 lbs/gal.
Weight of separated solids is the difference between the calculated weight of raw manure and separated liquid.

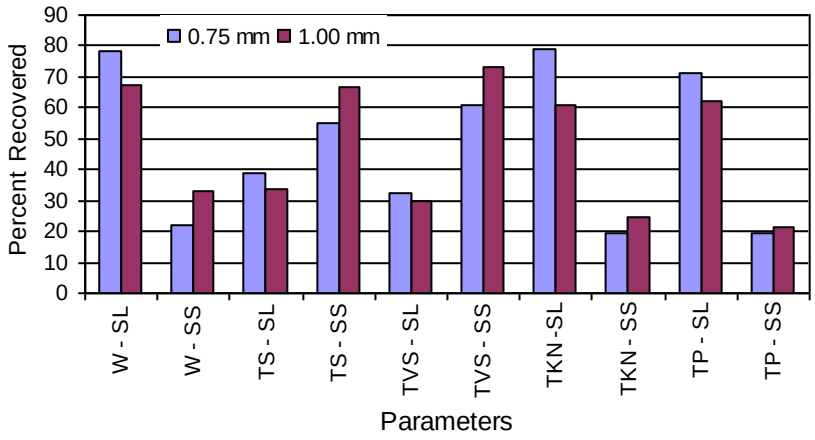


Figure 2- 8. Partitioning of Solids and Nutrients.

Solids Approximately 1,300 yd of separated solids will be produced each year. Some of the separated solids are being sold directly from the separator. The income was only $1,500 per year. The time and effort required to compost and dry the solids is deemed inappropriate at this time. The solids are not being used for bedding. An increase in yield was observed from hayfields where solids were spread.

Electrical energy consumed – the digester system consumed 40 kWh per day and 50 kWh/day in the winter when an electric space heater is used in the separator room. This did not include the composter/mixer. On an annual basis, approximately 45 kWh are used per day or 16,400 kWh per year. At 10¢ per kWh, the annual cost would be $1,640. Table 2-17 shows the electrical energy used by the manure treatment system.

Table 2-17. Electrical Energy Used by the Manure Treatment System.

	Meter Reading	kWh/day
10/14/2003	34,050	
10/21/2003	34,299	35
10/28/2003	34,550	36
11/11/2003	35,306	54
11/25/2003	35,944	46
12/9/2003	36,581	45
12/22/2003	37,165	45
1/26/2004	39,197	58
2/25/2004	41,194	67
3/16/2004	42,088	46
3-29-2004	42,605	40
4/13/2004	43,147	36
4/29/2004	43,665	32
5/13/2004	44,214	39
5/27/2004	44,785	41
6/10/2004	45,291	36

Labor required – Approximately 1 hour is needed per day to manage the manure treatment system.

START-UP OF DIGESTER

After the digester was emptied in the Fall of 2004 at the end of the last experiment, the digester was restarted in preparation for turning the digester over to the farm manager. Figure 2-9 show the progression of the start up process. The digester was filled and heated with the propane boiler. The initial loading rate was 56 cows. By October 14 the CO_2 level in the biogas was 32 percent and the biogas boiler could be started. The loading rate was increased gradually to 98 cows over the next 6 or 7 weeks. Production of biogas increased as the population of acid and methane forming bacteria increased.

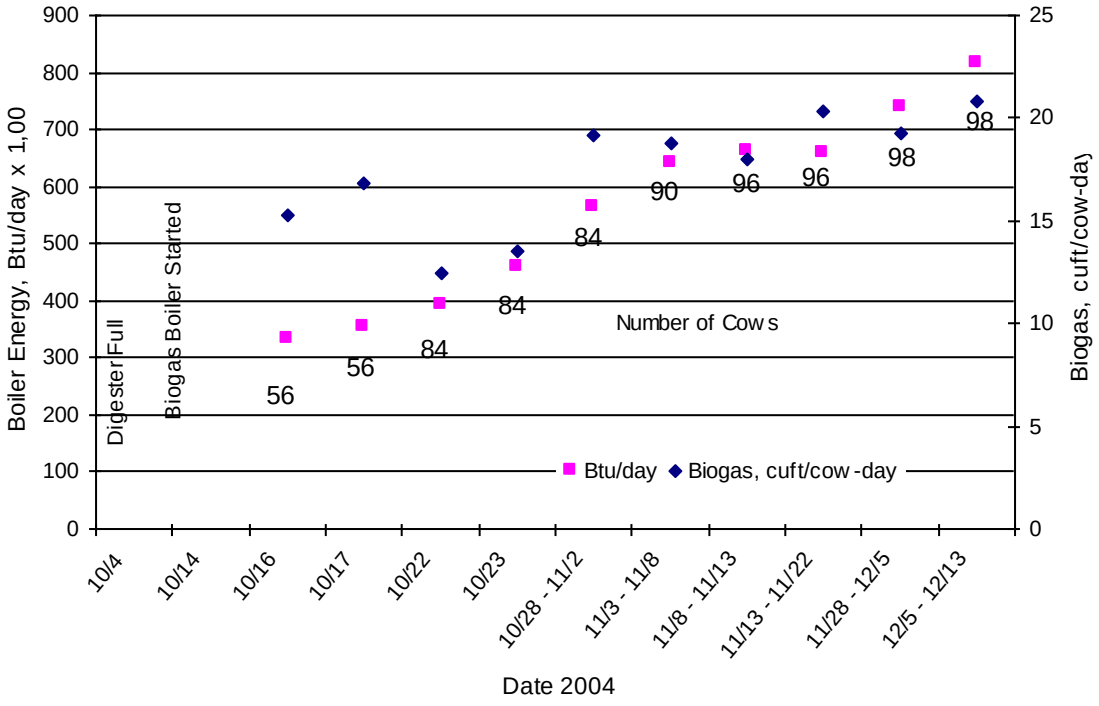


Figure 2-9. Digester Start-Up, Loading Rate, Biogas Production, and Energy for Heating.

The following data in Table 2-18 was taken during starting up the digester in the standard/traditional mode in the Fall 2004.

Table 2-18. "Nutrient" Results for Start-Up, 12/7/2004.

	F. Coli	Volatile acids	COD	NH3	pH	TP	Ortho P	TS	TVS	TKN	Totak K
	m pn/gram	mg/L	mg/kg	mg/kg	std units	mg/kg	mg/kg	%	%	mg/kg	mg/kg
Separated Liquids	1,366,667	3,279	58,900	1,684	7.24	492	292	5.9	66.6	3,731	2,578
Digester Effluent	111,333	1,306	41,867	1,916	7.87	398	286	4.4	65.0	3,472	2,705

ECONOMIC ANALYSIS OF MANURE HANDLING AND TREATMENT AT THE FARBER FARM

With regard to manure treatment and handling at the Farber Farm, the major concern was odor. This came about when a liquid manure handling system with a long-term storage was installed. Two odor control methods were considered for the Farber Farm. One was anaerobic digestion and the second was aeration of the liquid manure. Anaerobic digestion was chosen because there was more information that this system could reduce odor while there was little information about aeration.

Three manure systems were analyzed and presented here. FFA would have been the system before the liquid system was installed and FFB is the liquid system with the long-term storage. The third, FFC, is the anaerobic fixed film digester with long-term storage. These analyses are given in detail in Figures A-15, A-16 and A-17 in the Appendix. A summary of the results is given in Table 2-19. Using 84 as the average number of cows in the tiestall dairy, the annual cost of the initial system (FFA) would have been $280 per cow. Adding the long-term storage (FFB) increased the cost to $440 per cow. This analysis included about $7,000 per year for labor. Providing odor control with an anaerobic digester for the separated liquid and selling some of the separated solids to, the cost increased to $410 per cow.

Table 2-19. Manure Systems Analysis Summary, Farber Farm.

	Total Annual Fixed Costs	Total Annual Manure System Operating Costs	Total Annual Operating Costs, Other Systems	Total Annual Revenue Gen. due to Manure	Total Annual Operating Costs	Total Annual Costs, All Areas
Existing Liquid System without storage cost (FFA)	$4,400	$19,670	$0	$0	$19,670	$24,040
Existing Liquid System with storage cost (FFB)	$16,400	$19,170	$1,500	$0	$20,670	$37,070
Projected ANFFD System with storage cost (FFC)	$35,122	$25,670	-$6,500	$20,000	-$830	$34,292

CONCLUSIONS

The following are comments from the farm manager at Farber Farm.

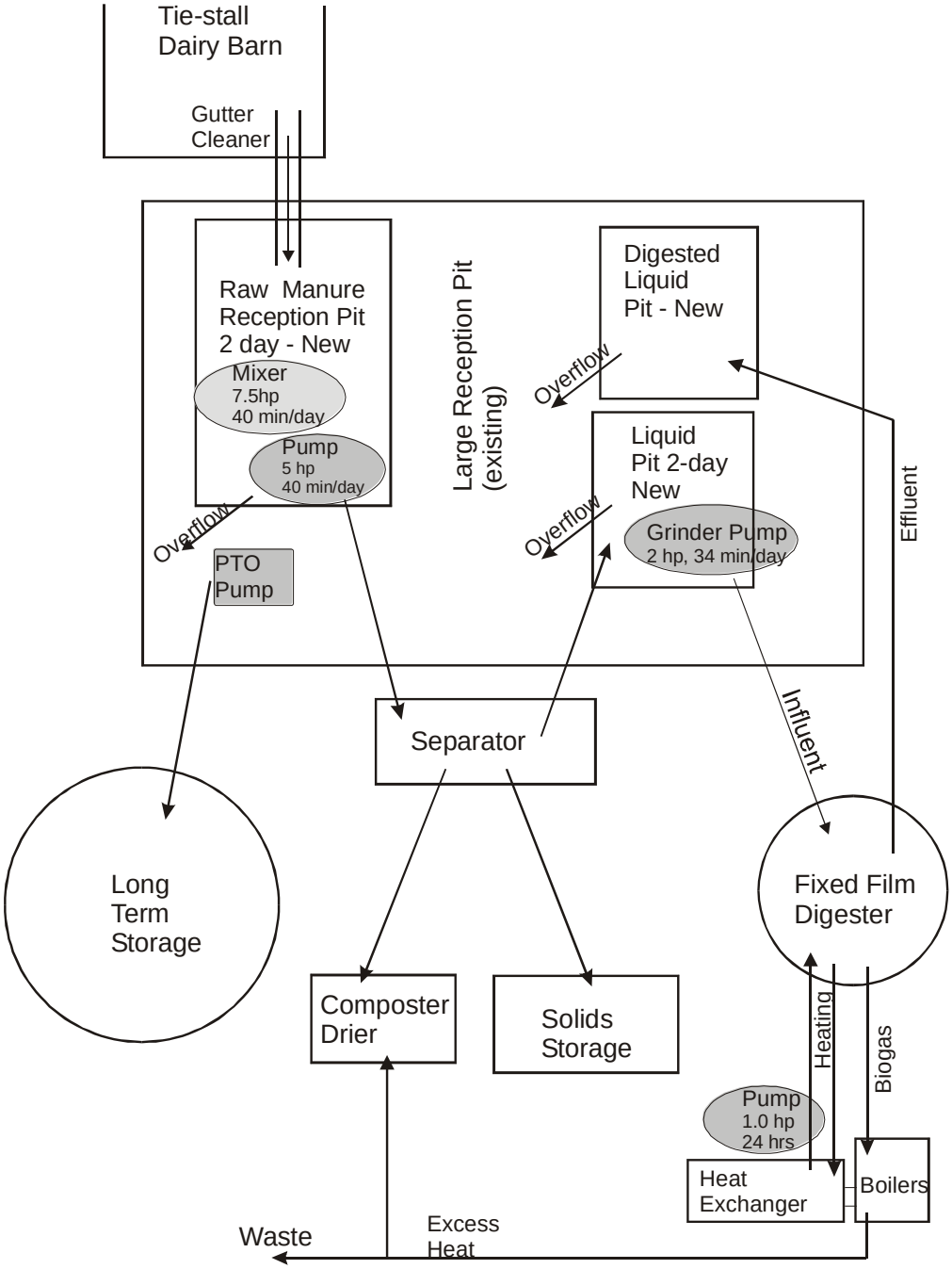
1. The number one goal was odor control and that has been successful. Nobody can agree as to the dollar value of odor control.
2. Manure is now spread on grassland after the first cutting, and that was not possible before due to odor.
3. Separated solids were applied on some sandy soils, and second cutting grass yield was much increased compared to plot where no solids were spread.
4. In the past the long-term storage had to be agitated for about four days (60 HP) at 6 hours per day to get manure slurried up for unloading, and water had to be added. Now, no agitation is needed, as manure flows back into the reception pit from storage, where the vacuum spreader pulls liquid from the pit.
5. In the past, it took approximately 12-15 minutes to load the vacuum spreader, and it now takes 5 minutes for a 3,000 gallon load.
6. Milking center water now goes into the manure, instead of a settling tank-leach field system. There had been issues with plugging of the leach field in the past.
7. Best year for separated solids sales would be $20,000. Those buying the separated solids wanted the solids directly from the separator. No need to dry or compost.

RECOMMENDATIONS FOR FURTHER WORK

These recommendations will improve the manure treatment system, making it more easily adaptable to other dairy farms.

1) Two modifications would be made to the digester:
    a. A conical bottom would be built in the digester. The "cone" will be made from pressure-treated plywood and 2"x 4"s to simulate a concrete cone that would be built into any future digesters. The plywood will be covered with fiberglass to provide a smooth surface. Slope will be 5 on 12.
    b. Drill a hole in the side of the digester, install a link seal, ball valve, and 4"PVC pipe to permit the removal of solids with a vacuum tank.
2) Develop a foam sensor and integrate this into a foam control device to eliminate foam from entering the biogas pipe.
3) Instrumentation and meters: Demonstrate a data acquisition system for digesters on smaller dairy farms. Temperature(s), Energy [Btu(s) meters], Biogas meter, Water meter, and KWh(s) meters will be monitor

APPENDIX A – FIXED-FILM AD DATA



Not to Scale

Figure A-1. Schematic Drawing of FIXED-FILM System Layout at Farber Farm.

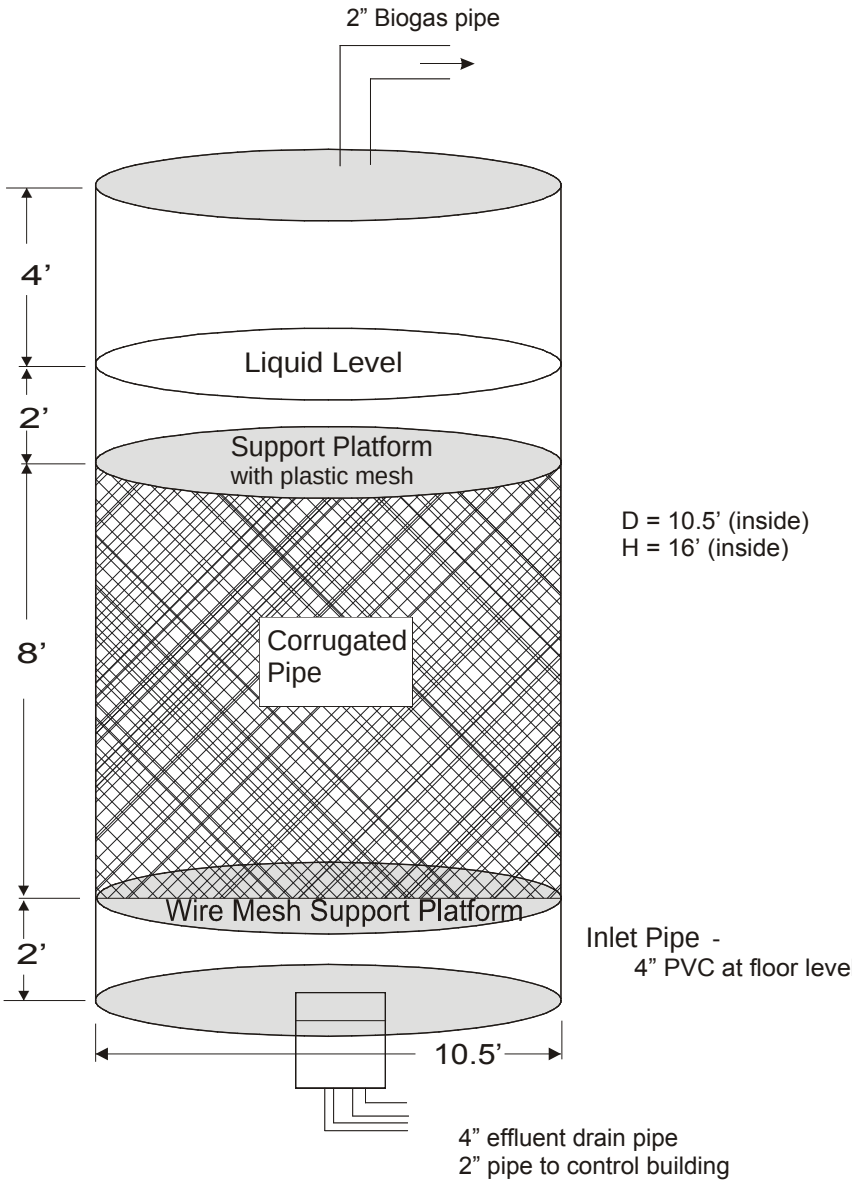


Figure A-2. Fixed Film Digester.

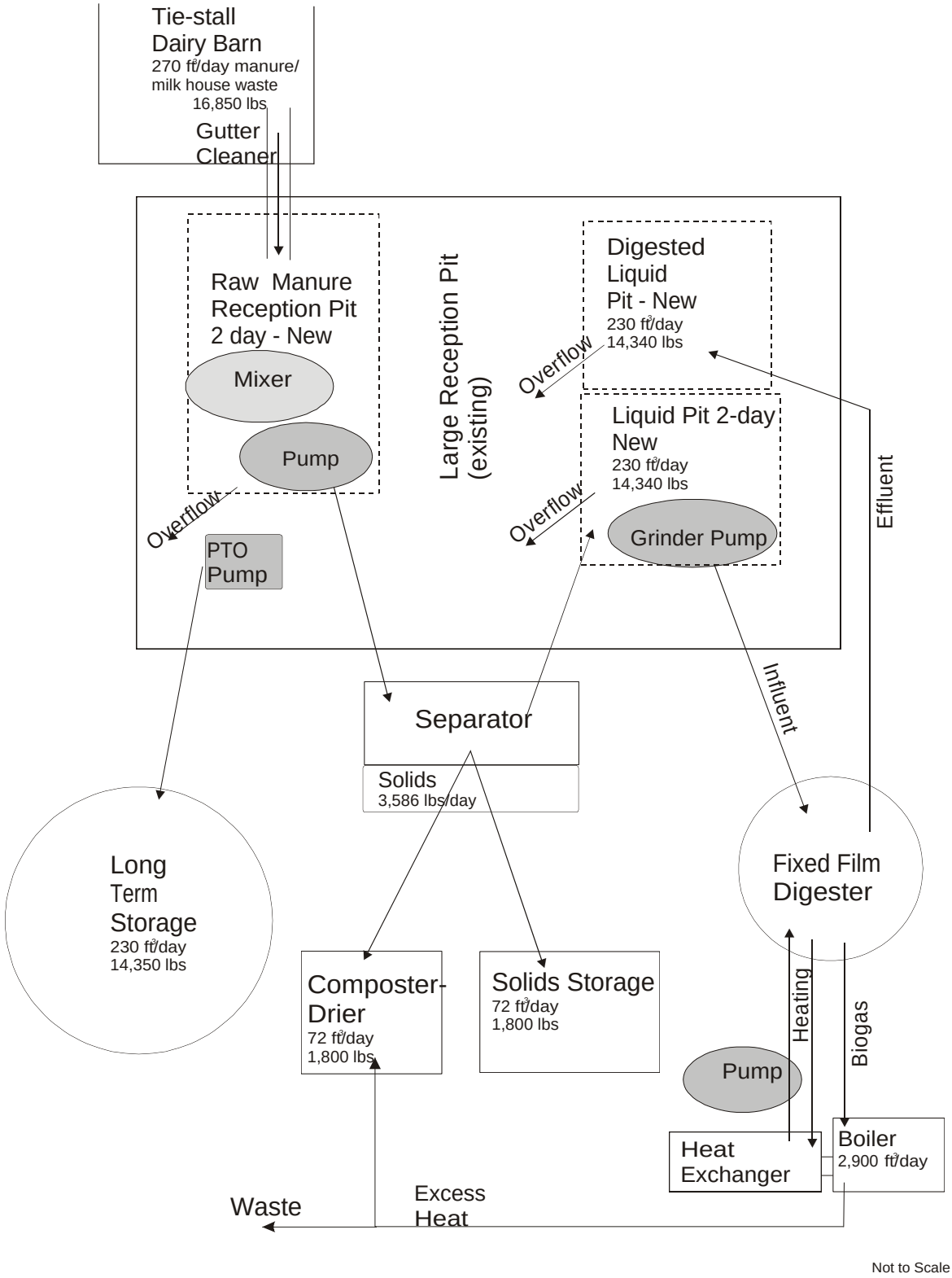


Figure A-3. Mass Flow Diagram of FIXED-FILM System Layout.

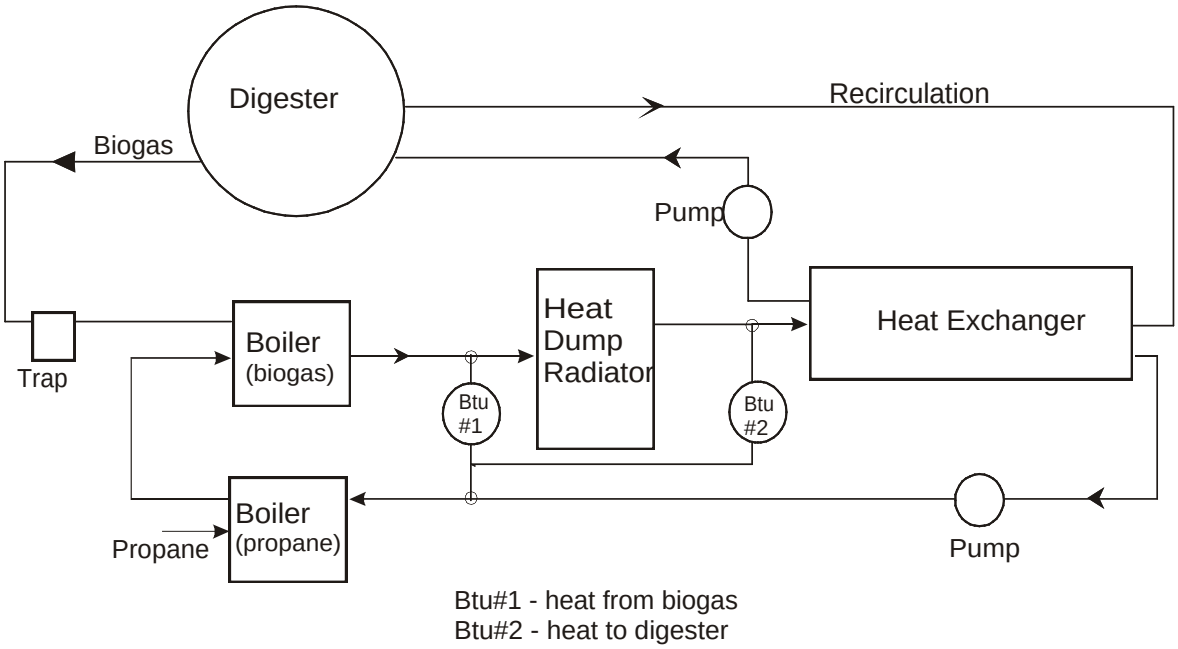


Figure A-4. Farber Farm Heating System.

Table A-1. Farber Farm, Fixed Film Operation, 5/7/02 – 6/17/03 (407 days).

Date	Days	Cows*	HRT	Biogas		Boiler Output		Digester Heat	CO_2	LHV	Btu/day	Boiler
Year 2002			days	cuft/day	cuft/cow-day	Btu 1/day	Btu/cow-day	Btu 2/day	percent	Btu/cuft	Input	Efficiency
5/7-5/16	9	97	4.5	2,074	21	923,889	9,525		40	506	1,049,444	0.88
5/18-5/29	11	97	4.5	2,827	29	1,135,364	11,705		38	523	1,478,521	0.77
6/5-6/13	8	71	6.2	2,117	30	806,375	11,357		37	590	1,249,030	0.65
6/15-6/30	15	90	4.9	2,227	25	959,467	10,661		38	523	1,164,721	0.82
7/1-8/12	42	90	4.9	2,005	22	804,071	8,934		38	523	1,048,615	0.77
10/5-10/23	18	83	5.3	1,775	21	748,333	9,016		38	523	928,325	0.81
10/30-11/11	12	98	4.5	2,039	21	914,167	9,328		38	523	1,066,397	0.86
Year 2003												
1/25-2/17	23	96	4.6	2,337	24	1,160,739	12,091		32	573	1,339,101	0.87
3/4-3/16	12	95	4.6	2,778	29	1,246,667	13,123		36	540	1,500,120	0.83
3/24 /4/16	23	94	4.7	2,234	24	979,696	10,422		37	533	1,190,722	0.82
4/17-4/29	12	90	4.9	2,242	25	931,250	10,347		37	533	1,194,986	0.78
5/14-5/26	12	90	4.9	2,220	25	961,333	10,681	353,625	37	533	1,183,260	0.81
5/30-6/17	18	90	4.9	2,091	23	972,944	10,810	322,778	36	540	1,129,140	0.86
	215											
Averages, weighted		91	4.8	2,168	24	950,102	10,404		37	535	1,171,028	0.81

Averages are weighted with time, periods from 5/7/02 to 6/17/03.

* Number of cows reflects the volume of liquid manure fed to the digester (17.4 gal/cow-day) based on run time of feed pump.
Volume of digester = 7380 gal Volume of digester reduced to 95% of original to account for fixed film and supports.
HRT = 7380/(cows x 22.2 x 0.76)
Based on - 7,380 gal capacity of digester, 22.2 gal/cow-day at raw manure pit and 76%, by volume, of raw manure goes to liquid pit.
LHV =Low Heating Value

Table A-2. Nutrient Results, Farber Raw Manure, Fixed Film Digester, 6/5/02 - 4/24/03.

	F. Coli	Dis COD	COD	NH3	TKN	TP	Ortho P	TS	TVS	pH
Date	mpn/gram	mg/L	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	%	%	std units
6/5/2002	300,000	19,231	161,538	2,169	3,689	756	419	9.30	81.00	7.16
7/16/2002	130,000	17,241	110,345	1,871	3,131	598	383	7.70	81.90	7.36
8/29/2002	130,000			2,361	3,845	596	340	8.00	76.80	7.56
9/2/2002	80,000			2,320	3,820	562	326	7.60	77.40	7.47
9/6/2002	300,000			2,600	4,454	572	342	10.70	80.60	7.56
9/10/2002	170,000			3,014	4,416	655	358	10.20	78.90	7.47
2/27/2003	700,000	27,907	83,721	2,095	3,600	665	368	9.40	81.40	7.47
3/3/2003	1,700,000	15,789	147,368	1,904	3,889	717	419	10.00	83.20	7.73
3/7/2003	3,000,000	31,220	71,795	2,163	3,753	693	399	10.20	79.70	7.53
3/11/2003	800,000	24,390	126,829	2,103	4,046	571	338	10.80	80.70	7.60
3/25/2003	500,000	23,590	100,000	1,986	3,909	683	483	10.30	84.70	7.32
4/24/2003	300,000	25,263	76,190	2,033	4,166	769	443	10.80	82.30	7.49
Average	**675,833**	**23,079**	**109,723**	**2,218**	**3,893**	**653**	**385**	**9.58**	**80.72**	**7.48**
St Deviation	**859,603**	**5,323**	**33,228**	**324**	**360**	**73**	**49**	**1.20**	**2.28**	**0.15**

Table A-3. Nutrient Results, Farber Separated Liquids, Fixed Film Digester, 6/5/02 - 4/24/03.

	F. Coli	Vol Acids	Dis COD	COD	NH3	TKN	TP	Ortho P	TS	TVS	pH
Date	mpn/gram		mg/L	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	%	%	std units
6/5/2002	500,000	2,871	19,231	53,846	2,132	3,463	692	395	5.10	71.30	7.20
7/16/2002	170,000	2,784	13,793	51,724	1,772	3,200	557	329	4.50	71.60	7.34
8/29/2002	110,000	2,735			2,250	3,634	584	298	4.60	65.40	7.59
9/2/2002	2,300	2,780			2,211	3,499	496	318	4.20	55.60	7.45
9/6/2002	80,000	3,633			2,657	4,878	615	316	5.00	63.60	7.50
9/10/2002	140,000	4,207			2,934	5,482	653	373	5.60	66.30	7.46
2/27/2003	500,000	1,042	23,256	51,163	2,265	3,481	709	377	4.80	68.10	7.46
3/3/2003	1,600,000	2,458	26,316	47,368	1,820	3,820	555	317	4.50	70.80	7.52
3/7/2003	240,000	3,217	26,341	56,410	2,009	3,516	748	347	4.90	70.60	7.42
3/11/2003	1,600,000	2,870	24,390	53,658	2,274	3,961	641	442	5.20	74.10	7.50
3/25/2003	1,600,000	1,675	23,590	60,000	2,130	3,686	570	384	4.90	65.70	7.35
4/24/2003	900,000	3,310	21,053	52,381	2,117	3,541	798	433	5.10	69.60	7.56
Average	**620,192**	**2,799**	**22,246**	**53,319**	**2,214**	**3,847**	**635**	**361**	**4.87**	**67.73**	**7.45**
St Deviation	**639,528**	**831**	**4,187**	**3,743**	**322**	**664**	**89**	**48**	**0.38**	**4.91**	**0.11**

Table A-4. Nutrient Results, Farber Digester Effluent, Fixed Film Digester, 6/5/02 - 4/24/03.

	F. Coli	Vol Acids	Dis COD	COD	NH3	TKN	TP	Ortho P	TS	TVS	pH
Date	mpn/gram	mg/L	mg/L	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	%	%	std units
6/5/2002	24,000	1,435	15,385	46,154	2,498	3,639	680	460	4.70	67.60	7.70
7/16/2002	8,000	696	17,241	37,931	1,856	3,091	583	390	3.30	65.80	7.78
8/29/2002	3,000	1,595			2,775	4,015	613	408	3.90	59.90	7.77
9/2/2002	230	1,413			2,445	3,837	593	399	3.70	61.10	7.82
9/6/2002	500	1,195			2,600	4,229	567	387	3.80	59.70	7.93
9/10/2002	800	1,291			2,792	4,671	598	382	4.10	61.90	7.81
2/27/2003	17,000	375	18,605	32,558	2,531	3,229	637	438	3.50	62.60	7.75
3/3/2003	1,100	708	10,526	31,579	2,236	3,448	456	410	3.60	62.00	7.64
3/7/2003	1,600,000	305	22,439	35,897	2,397	3,208	615	427	3.60	67.50	7.74
3/11/2003	30,000	413	9,756	39,024	2,822	4,442	610	398	3.60	68.10	7.83
3/25/2003	2,600	435	16,410	40,000	2,480	3,382	506	397	3.70	67.60	7.67
4/24/2003	11,000	1,290	16,842	76,190	2,168	3,359	649	476	4.10	67.90	7.68
Average	**141,519**	**929**	**15,901**	**42,417**	**2,467**	**3,713**	**592**	**414**	**3.80**	**64.31**	**7.76**
St Deviation	**459,410**	**484**	**4,139**	**14,389**	**281**	**523**	**61**	**30**	**0.37**	**3.39**	**0.08**

Table A-5. Nutrient Results, Farber Separated Solids, Fixed Film Digester, 6/5/02 - 4/24/03.

	F. Coli	Dis COD	COD	NH3	TKN	TP	Ortho P	TS	TVS	pH
Date	mpn/gram	mg/L	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	%	%	std units
6/5/2002	500,000	7,692	261,538	1,450	3,065	634	396	27.80	90.80	8.20
7/16/2002	83,000	10,345	310,345	1,194	2,960	515	300	29.10	92.50	7.95
8/29/2002	90,000			1,999	4,086	711	470	26.40	89.60	8.10
9/2/2002	4,000			771	2,022	339	161	22.90	91.20	8.38
9/6/2002	170,000			2,013	4,591	550	287	25.80	88.70	8.35
9/10/2002	170,000			2,301	3,980	608	362	27.70	89.60	8.41
2/27/2003	300,000	23,256	200,000	1,424	3,120	545	330	29.70	90.70	8.54
3/3/2003	50,000	21,053	225,641	1,388	3,462	483	317	28.00	89.80	8.70
3/7/2003	14,000	22,439	133,333	1,725	3,058	466	288	27.50	86.80	8.39
3/11/2003	300,000	14,634	175,610	1,501	3,474	481	232	30.40	89.50	7.95
3/25/2003	500,000	22,564	120,000	1,699	2,994	462	296	23.50	88.80	8.25
Average	198,273	17,426	203,781	1,588	3,347	527	313	27.16	89.82	8.29
St Deviation	179,741	6,473	68,264	425	691	100	81	2.37	1.50	0.23

Table A-6. Fixed Film Operation, Farber Farm, Selected Periods.

Date	Biogas	Btu meter #1	Btu/day #1 (thousands)	Temp 4	Temp 10		
6-May-02	238,840	120,376		100.4	51.7		
7-May	241,120	121,304	928	101.0	62.3	**5/7-5/16/02**	
8-May	243,490	122,300	996	98.3	49.8	Days	9
9-May	245,864	123,300	1,000	98.5	46.6	Cows	97
10-May	248,158	124,255	955	99.0	53.3	Biogas/cow-day	21
11-May	250,714	125,326	1,071	101.1	43.5	Avg Btu 1/day	923,889
12-May	253,027	126,430	1,104	101.4	50.6	Avg Btu 1/cow-day	9,525
13-May	255,527	127,433	1,003	100.9	49.5	Avg temp 4	100
14-May	256,469	128,161	728	100.4	44.6	Avg temp 10	49
15-May	257,972	128,858	697	98.5	39.0		
16-May	259,783	129,619	761	99.2	47.8		
17-May	261,743	130,356	737	96.7	55.4		
18-May	264,287	131,365	1,009	100.2	34.4	**5/18-5/29**	
19-May	267,171	131,490	125	100.6	38.2	Days	11
20-May	269,833	132,661	1,171	98.8	36.7	Cows	97
21-May	272,637	133,945	1,284	99.6	37.7	Biogas/cow-day	29
22-May	275,621	135,348	1,403	100.1	45.2	Avg Btu 1/day	1,135,364
23-May	278,494	136,727	1,379	98.5	49.9	Avg Btu 1/cow-day	11,705
24-May	281,337	138,061	1,334	97	64.4	Avg temp 4	99
25-May	284,151	138,887	826	99.3	43.2	Avg temp 10	50
26-May	287,085	140,235	1,348	99.1	61.4		
27-May	289,949	141,545	1,310	98.4	57.0		
28-May	292,744	142,754	1,209	97.7	63.9		
29-May	295,387	143,854	1,100	98.1	68.3		
30-May	296,259	144,209	355	96.1	69.3		
4-Jun	na	146,708		100.0	50.4		
5-Jun	301,663	148,081	1,373	100.7	82.4	**6/5-6/13**	
6-Jun	303,982	149,004	923	98.7	53.0	Days	8
7-Jun	305,117	149,461	457	101.0	55.5	Cows	71
8-Jun	307,279	150,234	773	99.6	63.2	Biogas/cow-day	30
9-Jun	309,302	151,117	883	98.5	62.4	Avg Btu 1/day	806,375
10-Jun	311,352	151,843	726	97.3	59.8	Avg Btu 1/cow-day	11,357
11-Jun	313,679	152,741	898	100.3	77.1	Avg temp 4	99
12-Jun	316,176	153,727	986	98.6	73.2	Avg temp 10	65
13-Jun	318,596	154,532	805	98.5	60.3		
14-Jun	321,085	155,419	887	99.0	57.8		
15-Jun	323,565	156,369	950	102.0	54.1	**6/15-6/30**	
16-Jun	326,186	157,457	1,088	100.0	57.8	Days	15
17-Jun	328,465	158,433	976	99.2	58.2	Cows	90
18-Jun	330,764	159,409	976	100.6	56.2	Biogas/cow-day	25
19-Jun	833,160	160,405	996	101.7	65.8	Avg Btu 1/day	959,467
20-Jun	335,403	161,335	930	101.4	58.6	Avg Btu 1/cow-day	10,661
21-Jun	337,819	162,333	998	101.7	68.8	Avg temp 4	101
22-Jun	339,068	162,838	505	102.0	72.2	Avg temp 10	67
23-Jun	340,293	163,342	504	101.6	75.1		
24-Jun	342,772	164,349	1,007	100.6	74.6		
25-Jun	345,131	165,316	967	100.5	71.9		
26-Jun	347,556	166,338	1,022	101.2	66.4		
27-Jun	349,819	167,292	954	100.7	69.1		
28-Jun	352,229	168,300	1,008	99.3	74.7		
29-Jun	354,519	169,257	957	99.7	70.0		
30-Jun	356,966	170,761	1,504	101.0	70.7		

Table A-6 cont.

Date	Biogas	Btu meter #1	Btu/day #1 (thousands)	Temp 4	Temp 10		
1-Jul	361,836	172,348	1,587	103.8	70.6	**7/1-8/12**	
2-Jul	364,251	173,414	1,066	101.7	80.4	Days	42
3-Jul	366,349	174,310	896	100.6	72.0	Cows	90
4-Jul	368,438	175,206	896	100.6	77.9	Biogas/cow-day	22
5-Jul	371,553	176,524	1,318	99.9	61.2	Avg Btu 1/day	804,071
6-Jul	372,548	176,954	430	100.4	60.0	Avg Btu 1/cow-day	8,934
7-Jul	374,616	177,954	1,000	98.5	63.3	Avg temp 4	99
8-Jul	376,592	178,714	760	99.4	65.1	Avg temp 10	70
9-Jul	378,849	179,683	969	99.4	69.4		
10-Jul	380,982	180,624	941	100.6	61.9		
11-Jul	383,900	181,924	1,300	100.2	64.5		
12-Jul	385,018	182,402	478	100.3	62.1		
13-Jul	388,224	183,766	1,364	101.3	74.1		
14-Jul	389,434	184,296	530	100.3	71.3		
15-Jul	391,729	185,273	977	100.6	71.5		
16-Jul	393,979	186,144	871	100.5	67.1		
17-Jul	396,291	187,095	951	99.9	69.8		
18-Jul	398,555	188,058	963	99.7	77.7		
19-Jul	400,907	189,030	972	100.7	78.7		
20-Jul	403,261	189,627	597	100.8	68.5		
21-Jul	406,538	191,052	1,425	102.9	78.9		
22-Jul	407,737	191,574	522	103.0	72.6		
23-Jul	409,945	192,528	954	104.0	78.9		
24-Jul	412,204	192,671	143	102.7	58.4		
25-Jul	414,212	193,523	852	101.5	67.9		
26-Jul	416,168	194,400	877	100.6	65.4		
27-Jul	418,261	195,316	916	99.9	66.7		
28-Jul	421,218	196,602	1,286	102.2	73.5		
29-Jul	422,051	196,984	382	102.7	71.8		
30-Jul	423,363	196,907	-77	101.9	75.5		
31-Jul	424,073	197,215	308	103.0	77.9		
1-Aug	426,691	198,345	1,130	103.3	67.0		
2-Aug	428,995	199,307	962	104.0	65.5		
3-Aug	429,834	199,687	380	102.6	67.1		
4-Aug	432,286	200,126	439	101.4	83.3		
5-Aug	433,263	200,542	416	100.5	69.4		
6-Aug	435,068	201,312	770	10.4	57.7		
7-Aug	437,696	202,456	1,144	100.1	66.5		
8-Aug	438,812	202,952	496	100.3	64.7		
9-Aug	440,483	203,658	706	100.0	75.9		
10-Aug	442,221	204,431	773	99.6	81.5		
11-Aug	444,114	205,268	837	99.6	61.2		
12-Aug	446,038	206,119	851	99.5	63.6		
13-Aug	447,339	206,688	569	97.0	64.6		
4-Oct	na	235,055		98.3	55.7	**10/5-10/23**	
5-Oct	472,835	235,584	529	99.1	70.5	Days	18
6-Oct	474,408	236,280	696	100.4	43.3	Cows	83
7-Oct	476,284	237,095	815	100.6	59.0	Biogas/cow-day	21
8-Oct	478,134	237,977	882	101.7	41.2	Avg Btu 1/day	748,333
9-Oct	479,918	238,861	884	101.2	35.3	Avg Btu 1/cow-day	9,016
10-Oct	481,745	239,782	921	100.4	55.2	Avg temp 4	100
11-Oct	484,362	240,070	288	100.7	53.6	Avg temp 10	45
12-Oct	485,400	240,542	472	100.4	54.7		
13-Oct	487,273	241,398	856	99.8	56.4		
14-Oct	488,978	241,750	352	99.6	36.3		
15-Oct	490,686	242,528	778	100.4	27.4		
16-Oct	492,426	243,329	801	100.0	45.8		
17-Oct	494,194	244,124	795	100.0	44.7		
18-Oct	495,962	244,916	792	100.0	35.6		
19-Oct	497,689	245,677	761	99.8	48.9		
20-Oct	499,541	246,496	819	99.8	40.2		
21-Oct	501,482	247,420	924	99.9	40.2		
22-Oct	503,110	248,208	788	100.0	31.9		
23-Oct	504,779	249,054	846	99.7	33.4		

Table A-6 cont.

Date	Biogas	Btu meter #1	Btu/day #1 (thousands)	Temp 4	Temp 10		
29-Oct	512,534	253,004	253,004	102.1	31.9		
30-Oct	514,334	255,855	2,851	99.6	37.9	**10/30-11/11**	
31-Oct	516,165	254,823	-1,032	99.5	24.7	Days	12
1-Nov	518,079	255,834	1,011	98.8	38.0	Cows	98
2-Nov	520,033	256,867	1,033	101.5	24.5	Biogas/cow-day	21
3-Nov	522,156	257,983	1,116	102.8	30.6	Avg Btu 1/day	914,167
4-Nov	524,196	259,079	1,096	102.1	34.7	Avg Btu 1/cow-day	9,328
5-Nov	526,311	260,204	1,125	101.8	36.3	Avg temp 4	101
6-Nov	528,388	261,296	1,092	101.8	39.4	Avg temp 10	39
7-Nov	530,505	262,420	1,124	101.5	30.9		
8-Nov	532,536	263,519	1,099	101.1	43.0		
9-Nov	534,660	264,647	1,128	100.0	40.9		
10-Nov	536,736	265,742	1,095	99.4	61.5		
11-Nov	538,802	266,825	1,083	98.5	66.7		
25-Jan-03	594,973	334,876		103.2	14.8		
26-Jan	597,655	336,122	1,246	101.8	24.6	**1/25-2/17**	
27-Jan	604,345	337,872	1,750	101.5	-1.5	Days	23
28-Jan	602,717	338,527	655	102.5	4.1	Cows	96
29-Jan	605,353	339,780	1,253	101.3	21.3	Biogas/cow-day	24
30-Jan	606,276	340,902	1,122	100.1	2.4	Avg Btu 1/day	1,160,739
31-Jan	608,501	342,010	1,108	100.2	15.8	Avg Btu 1/cow-day	12,091
1-Feb	611,271	343,310	1,300	99.6	37.7	Avg temp 4	100
2-Feb	614,047	344,602	1,292	99.0	32.0	Avg temp 10	18
3-Feb	616,726	345,864	1,262	99.2	28.6		
4-Feb	619,953	347,368	1,504	98.9	41.4		
5-Feb	na						
6-Feb	620,236	348,508		97.3	29.9		
7-Feb	621,658	349,169	661	97.4	28.6		
8-Feb	624,267	350,339	1,170	99.5	13.1		
9-Feb	627,130	351,609	1,270	99.8	22.8		
10-Feb	629,902	352,855	1,246	99.4	26.1		
11-Feb	632,917	354,206	1,351	99.8	5.1		
12-Feb	635,731	355,476	1,270	99.9	22.8		
13-Feb	638,506	356,756	1,280	100.1	7.0		
14-Feb	641,075	357,948	1,192	100.3	5.2		
15-Feb	643,788	359,209	1,261	100.4	9.6		
16-Feb	646,279	360,375	1,166	101.7	4.5		
17-Feb	648,720	361,573	1,198	100.2	15.8		
3-Mar	682,848	378,965		100.2	-2.6	**3/4-3/16**	
4-Mar	685,455	380,207	1,242	101.3	4.1	Days	12
5-Mar	688,047	381,432	1,225	99.7	44.7	Cows	95
6-Mar	690,908	382,752	1,320	99.6	23.3	Biogas/cow-day	29
7-Mar	693,621	384,023	1,271	102.1	-2.7	Avg Btu 1/day	1,246,667
8-Mar	696,533	385,408	1,385	101.0	31.5	Avg Btu 1/cow-day	13,123
9-Mar	699,298	386,702	1,294	99.9	33.7	Avg temp 4	101
10-Mar	702,057	387,794	1,092	101.6	12.3	Avg temp 10	23
11-Mar	704,607	389,213	1,419	102.1	7.0		
12-Mar	707,429	390,545	1,332	100.1	38.4		
13-Mar	711,639	392,545	2,000	99.4	25.9		
14-Mar	712,958	392,400	-145	100.9	14.3		
15-Mar	715,863	393,785	1,385	100.5	34.9		
16-Mar	718,789	395,167	1,382	99.6	34.1		
17-Mar	721,712	396,491	1,324	100.1	38.4		

Table A-6 cont.

Date	Biogas	Btu meter #1	Btu/day #1 (thousands)	Temp 4	Temp 10		
23-Mar	na	399,717		97.8	38.7		
24-Mar	725,046	400,785	1,068	98.0	48.3	**3/24-4/16**	
25-Mar	726,600	401,403	618	99.6	54.7	Days	23
26-Mar	729,398	402,511	1,108	100.1	53.0	Cows	94
27-Mar	732,221	403,637	1,126	101.2	37.0	Biogas/cow-day	24
28-Mar	734,953	404,735	1,098	101.5	50.8	Avg Btu 1/day	979,696
29-Mar	737,703	405,846	1,111	100.4	56.6	Avg Btu 1/cow-day	10,422
30-Mar	740,527	406,986	1,140	101.2	34.4	Avg temp 4	99
31-Mar	743,238	408,077	1,091	102.8	23.4	Avg temp 10	41
1-Apr	745,800	409,127	1,050	101.9	24.9		
2-Apr	749,231	410,548	1,421	97.5	43.3		
3-Apr	750,617	411,111	563	98.4	39.7		
4-Apr	753,253	412,174	1,063	99.5	34.8		
5-Apr	756,059	413,325	1,151	100.4	32.8		
6-Apr	na						
7-Apr	na						
8-Apr	757,197	415,353		99.1	34.2		
9-Apr	758,573	415,904	551	99.1	33.3		
10-Apr	761,325	417,031	1,127	98.9	42.6		
11-Apr	763,917	418,106	1,075	99	37.8		
12-Apr	766,607	419,213	1,107	97.9	38.9		
13-Apr	769,179	420,283	1,070	98.4	33.3		
14-Apr	771,592	421,298	1,015	99.1	30.5		
15-Apr	774,032	422,319	1,021	97.4	48.9		
16-Apr	776,433	423,318	999	96.9	66.9		
17-Apr	778,688	424,230		99.5	29.6	**4/17-4/29**	
18-Apr	780,511	425,125	895	100.2	37.6	Days	12
19-Apr	782,752	426,074	949	99	44.2	Cows	90
20-Apr	784,899	426,922	848	99	46.3	Biogas/cow-day	25
21-Apr	787,046	427,794	872	97.7	51.3	Avg Btu 1/day	931,250
22-Apr	789,330	428,714	920	99.1	49.1	Avg Btu 1/cow-day	10,347
23-Apr	791,766	429,715	1,001	100.3	35.1	Avg temp 4	100
24-Apr	794,233	430,746	1,031	101.6	32	Avg temp 10	45
25-Apr	796,556	431,703	957	100.9	43.6		
26-Apr	798,806	432,619	916	99.5	59		
27-Apr	801,057	433,525	906	100	49.4		
28-Apr	803,245	434,428	903	100.1	44.1		
29-Apr	805,595	435,405	977	100	61.2		

Table A-6 cont.

Date	Biogas	Btu meter #1	Btu/day #1 (thousands)	Temp 4	Temp 10
14-May	818,365	444,806		98.5	52.1
15-May	819,464	445,294	488	97.3	51.2
16-May	821,558	446,225	931	97.8	50.4
17-May	823,637	447,165	940	98.3	42.7
18-May	825,882	448,176	1,011	96.9	47.5
				97.7	46.1

Date	Biogas	Btu #1	Btu/day #1	Btu #2	Btu/day #2	Temp 4	Temp 10
19-May-03	828,013	449,132	956	21	21	97.5	73.9
20-May	830,306	449,737	605	404	383	98.4	57.2
21-May	832,652	450,781	1,044	804	400	98.5	72.7
22-May	835,078	451,870	2,738	1,263	459	99.7	47.7
23-May	837,491	452,961	3,224	1,656	393	99.8	51.3
24-May	840,042	454,113	3,332	2,012	356	99.9	56.3
25-May	843,706	455,755	3,885	2,637	625	98.9	61.1
26-May	845,003	456,342	3,381	2,850	213	98.4	53.9
30-May	849,229	458,785		4,005		98.5	58.9
31-May	851,689	459,885	1,100	4,424	419	98.7	56.4
1-Jun	854,207	461,000	1,115	4,813	389	98.7	58.5
2-Jun	856,748	462,137	1,137	5,285	472	99.9	47.2
3-Jun	859,339	463,325	1,188	5,509	224	98.6	60.3
4-Jun	861,530	464,314	989	5,818	309	96.9	64.7
5-Jun	864,008	465,431	1,117	6,171	353	97.0	63.5
6-Jun	866,400	466,998	1,567	6,626	455	98.8	54.1
7-Jun	na						
8-Jun	na						
9-Jun	na						
10-Jun	868,638	468,192		7,503		98.5	56.4
11-Jun	872,052	469,679	1,487	8,106	603	99.0	68.5
12-Jun	873,397	470,279	600	8,263	157	99.4	66.5
13-Jun	875,999	471,436	1,157	8,586	323	98.5	68.6
14-Jun	878,626	472,600	1,164	8,871	285	98.2	62.8
15-Jun	881,423	473,837	1,237	9,221	350	98.5	63.4
16-Jun	884,127	475,052	1,215	9,523	302	98.3	56.5
17-Jun	886,863	476,298	1,246	9,815	292	97.7	61.8

5/14-5/26	
Days	12
Cows	90
Biogas/cow-day	25
Avg Btu 1/day	961,333
Avg Btu 1/cow-day	10,681
Avg Btu 2/day	353,625
Avg temp 4	98
Avg temp 10	55

5/30-6/17	
Days	18
Cows	90
Biogas/cow-day	23
Avg Btu 1/day	972,944
Avg Btu 1/cow-day	10,810
Avg Btu 2/day	322,778
Avg temp 4	98
Avg temp 10	61

Table A-7. Raw Data for Fixed Film Operation, Farber Farm.

Date	Biogas	Btu Meter 1	Temp 4	Temp 10
17-Jan-02	99,603	53,446	98.2	32.0
18-Jan	101,156	54,222	98.8	29.2
19-Jan	102,842	54,937	97.5	14.8
20-Jan	104,353	55,481	98.2	9.7
21-Jan	105,118	56,029	94.2	31.4
22-Jan	106,918	56,846	94.3	41.4
23-Jan	108,038	57,337	94.6	24.3
24-Jan	109,491	57,961	96.8	34.7
25-Jan	111,360	58,670	95.8	27.9
26-Jan	113,026	59,279	98.1	37.3
27-Jan	114,043	59,730	95.0	23.8
28-Jan	na	61,032	99.8	27.5
29-Jan	144,116	61,100	96.4	56.0
30-Jan	115,023	61,522	96.5	38.7
31-Jan	116,412	62,081	96.3	29.9
1-Feb	117,872	62,647	95.1	37.4
2-Feb	119,301	63,185	94	20.4
3-Feb	120,605	63,589	91.0	28.3
4-Feb	121,717	64,131	94.5	21.5
5-Feb	123,100	64,889	96.8	7.2
6-Feb	124,773	65,774	98.2	27.7
7-Feb	126,397	66,447	98.7	26.1
8-Feb	128,074	67,135	98.5	32.3
9-Feb	129,677	67,794	99.1	26.3
10-Feb	131,332	68,471	100.2	38.0
11-Feb	132,890	69,112	99.2	28.0
12-Feb	134,387	69,728	97.8	29.1
13-Feb	135,867	70,335	98.8	21.6
14-Feb	137,344	70,950	97.9	10.5
15-Feb	138,847	71,574	98.1	27.6
16-Feb	104,386	72,214	98.2	33.6
17-Feb	141,974	72,863	98.5	31.5
18-Feb	143,531	73,506	98.6	20.5
19-Feb	145,109	74,180	99.1	21.4
20-Feb	146,774	74,894	99.1	47.0
21-Feb	148,506	75,616	99.7	43.4
22-Feb	150,264	76,360	99.9	34.1
23-Feb	151,971	77,094	100.0	24.3
24-Feb	153,589	77,594	99.9	18.8
25-Feb	155,263	78,325	100.8	35.2
26-Feb	155,329	78,935	100.5	48.9
27-Feb		80,211	98	23.5
28-Feb				
1-Mar	155,331	80,384	95.5	29.3
2-Mar	156,362	80,906	93.8	38.9
3-Mar	157,647	81,537	90.0	57.3
4-Mar	158,362	81,901	85.2	21.9
5-Mar	159,145	82,359	87.8	26.2
6-Mar	160,073	82,908	88.9	32.7
7-Mar	161,202	83,582	95.8	32.3
8-Mar	162,449	84,146	99.8	35.3
9-Mar				
10-Mar				
11-Mar	165,504	85,150	94.7	27.3
12-Mar	166,281	85,759	96.3	36.4
13-Mar	167,138	86,286	99.8	37.6
14-Mar	168,061	86,806	95.4	43.1
15-Mar	169,158	86,955	94.3	52.7
16-Mar	170,320	87,521	92.0	40.5
17-Mar	171,197	87,992	91.0	25.7
18-Mar	172,340	88,707	97.3	30.4
19-Mar	173,566	89,288	99.3	31.5
20-Mar	174,813	89,458	93.5	34.9
21-Mar	175,891	89,983	85.8	33.6
22-Mar	176,917	90,668	90.6	8.0
23-Mar	178,090	91,267	94.7	23.1
24-Mar	179,344	91,867	95.5	26.8
25-Mar	180,653	92,646	98.9	36.3
26-Mar	181,835	93,250	95.3	33.1
27-Mar	183,118	93,979	93.8	35.3
28-Mar	184,362	94,608	92.3	30.5
29-Mar	185,454	95,114	91.2	34.6
30-Mar	186,483	95,630	90.6	49.7
31-Mar	187,665	96,234	97.3	50.5
1-Apr	na			
2-Apr	189,728	97,344	90.1	36.5
3-Apr	190,797	98,048	92.8	58.5
4-Apr	191,908	98,648	95.4	32.2
5-Apr	193,122	99,326	96.7	25.2
6-Apr	194,290	99,929	94.4	29.0
7-Apr	195,436	100,659	96.3	18.0
8-Apr	196,632	101,308	98.4	39.8
9-Apr	197,987	102,054	97.1	52.2
10-Apr	199,418	102,826	97.4	38.0
11-Apr	200,879	103,607	97.7	42.7
12-Apr	202,377	104,357	97.0	48.8
13-Apr	203,800	105,077	98.0	59.7
14-Apr	205,476	105,830	9538.0	63.5
15-Apr	207,074	106,523	100.7	58.9
16-Apr	208,678	107,277	95.5	53.5
17-Apr	210,248	107,978	92.3	57.7
18-Apr	211,720	108,609	88.3	64.1
19-Apr	213,236	109,354	98.0	56.4
20-Apr	214,947	110,077	98.0	52.0
21-Apr	216,501	110,770	92.3	40.9
22-Apr	217,766	111,290	93.4	37.3
23-Apr	219,058	111,924	95.5	32.3
24-Apr	220,692	112,643	96.0	29.2
25-Apr	na			
26-Apr	222,455	113,853	99.0	49.5
27-Apr	223,207	114,268	101.2	35.7
28-Apr	224,245	114,820	97.0	42.0
29-Apr	225,761	115,119	96.9	36.7
30-Apr	227,383	115,893	97.0	38.0

Table A-7 cont.

Date	Biogas	Btu Meter 1	Temp 4	Temp 10
1-May	229,045	116,637	96.9	37.3
2-May	230,798	117,393	97.0	46.0
3-May	232,734	118,234	97.6	41.2
4-May	234,554	118,670	99.1	41.4
5-May	236,660	119,497	99.7	51.9
6-May	238,840	120,376	100.4	51.7
7-May	241,120	121,304	101.0	62.3
8-May	243,490	122,300	98.3	49.8
9-May	245,864	123,300	98.5	46.6
10-May	248,158	124,255	99.0	53.3
11-May	250,714	125,326	101.1	43.5
12-May	253,027	126,430	101.4	50.6
13-May	255,527	127,433	100.9	49.5
14-May	256,469	128,161	100.4	44.6
15-May	257,972	128,858	98.5	39.0
16-May	259,783	129,619	99.2	47.8
17-May	261,743	130,356	96.7	55.4
18-May	264,287	131,365	100.2	34.4
19-May	267,171	131,490	100.6	38.2
20-May	269,833	132,661	98.8	36.7
21-May	272,637	133,945	99.6	37.7
22-May	275,621	135,348	100.1	45.2
23-May	278,494	136,727	98.5	49.9
24-May	281,337	138,061	97	64.4
25-May	284,151	138,887	99.3	43.2
26-May	287,085	140,235	99.1	61.4
27-May	289,949	141,545	98.4	57.0
28-May	292,744	142,754	97.7	63.9
29-May	295,387	143,854	98.1	68.3
30-May	296,259	144,209	96.1	69.3
31-May	296,763	144,485	97.7	62.2
1-Jun	297,789	144,902	97.5	62.9
2-Jun	na			
3-Jun		146,708	100.0	50.4
4-Jun		147211	99.1	56.6
5-Jun	301,663	148,081	100.7	82.4
6-Jun	303,982	149,004	98.7	53.0
7-Jun	305,117	149,461	101.0	55.5
8-Jun	307,279	150,234	99.6	63.2
9-Jun	309,302	151,117	98.5	62.4
10-Jun	311,352	121,843	97.3	59.8
11-Jun	313,679	152,741	100.3	77.1
12-Jun	316,176	153,727	98.6	73.2
13-Jun	318,596	154,532	98.5	60.3
14-Jun	321,085	155,419	99.0	57.8
15-Jun	323,565	156,369	102.0	54.1
16-Jun	326,186	157,457	100.0	57.8
17-Jun	328,465	158,433	99.2	58.2
18-Jun	330,764	159,409	100.6	56.2
19-Jun	833,160	160,405	101.7	65.8
20-Jun	335,403	161,335	101.4	58.6
21-Jun	337,819	162,333	101.7	68.8
22-Jun	339,068	162,838	102.0	72.2
23-Jun	340,293	163,342	101.6	75.1
24-Jun	342,772	164,349	100.6	74.6
25-Jun	345,131	165,316	100.5	71.9
26-Jun	347,556	166,338	101.2	66.4
27-Jun	349,819	167,292	100.7	69.1
28-Jun	352,229	168,300	99.3	74.7
29-Jun	354,519	169,257	99.7	70.0
30-Jun	356,966	170,761	101.0	70.7
1-Jul	361,836	172,348	103.8	70.6
2-Jul	364,251	173,414	101.7	80.4
3-Jul	366,349	174,310	100.6	72.0
4-Jul	368,438	175,206	100.6	77.9
5-Jul	371,553	176,524	99.9	61.2
6-Jul	372,548	176,954	100.4	60.0
7-Jul	374,616	177,954	98.5	63.3
8-Jul	376,592	178,714	99.4	65.1
9-Jul	378,849	1,749,683	99.4	69.4
10-Jul	380,982	180,624	100.6	61.9
11-Jul	383,900	181,924	100.2	64.5
12-Jul	385,018	182,402	100.3	62.1
13-Jul	388,224	183,766	101.3	74.1
14-Jul	389,434	184,296	100.3	71.3
15-Jul	391,729	185,273	100.6	71.5
16-Jul	393,979	186,144	100.5	67.1
17-Jul	396,291	187,095	99.9	69.8
18-Jul	398,555	188,058	99.7	77.7
19-Jul	400,907	189,030	100.7	78.7
20-Jul	403,261	189,627	100.8	68.5
21-Jul	406,538	191,052	102.9	78.9
22-Jul	407,737	191,574	103.0	72.6
23-Jul	409,945	192,528	104.0	78.9
24-Jul	412,204	192,671	102.7	58.4
25-Jul	414,212	193,523	101.5	67.9
26-Jul	416,168	194,400	100.6	65.4
27-Jul	418,261	195,316	99.9	66.7
28-Jul	421,218	196,602	102.2	73.5
29-Jul	422,051	196,984	102.7	71.8
30-Jul	423,363	196,907	101.9	75.5
31-Jul	424,073	197,215	103.0	77.9
1-Aug	426,691	198,345	103.3	67.0
2-Aug	428,995	199,307	104.0	65.5
3-Aug	429,834	199,687	102.6	67.1
4-Aug	432,286	200,126	101.4	83.3
5-Aug	433,263	200,542	100.5	69.4
6-Aug	435,068	201,312	10.4	57.7
7-Aug	437,696	202,456	100.1	66.5
8-Aug	438,812	202,952	100.3	64.7
9-Aug	440,483	203,658	100.0	75.9
10-Aug	442,221	204,431	99.6	81.5
11-Aug	444,114	205,268	99.6	61.2
12-Aug	446,038	206,119	99.5	63.6
13-Aug	447,339	206,688	97.0	64.6
14-Aug	na			

Table A-7 cont.

Date	Biogas	Btu Meter 1	Temp 4	Temp 10
15-Aug	447,393	206,816	95.9	90.0
16-Aug	448,777	203,387	100.0	77.3
17-Aug	450,890	208,275	104.0	67.5
18-Aug	453,026	209,201	103.3	69.5
19-Aug	445,004	210,087	101.0	61.1
20-Aug	456,848	210,936	99.9	66.9
21-Aug	458,608	211,735	102.2	55.1
22-Aug	460,510	212,607	102.6	58.2
23-Aug	462,413	213,495	102.0	63.1
24-Aug	464,247	214,385	101.9	59.9
25-Aug	466,153	215,303	102.8	63.5
26-Aug	467,826	216,132	102.6	46.1
27-Aug	469,632	217,044	102.9	53.6
28-Aug	471,334	217,819	102.4	51.4
29-Aug	472,488	218,367	99.3	55.5
30-Aug		218,773	98.7	71.5
31-Aug		219,396	101.7	53.2
1-Sep		220,209	102.9	56.8
2-Sep		221,020	103.7	55.3
3-Sep	472,543	221,775	102.4	73.7
4-Sep		222,214	102.4	62.7
5-Sep		222,914	103.4	62.3
6-Sep		223,639	100.4	56.3
7-Sep		224,303	100.8	47.1
8-Sep		224,251	101.4	48.8
9-Sep		224,841	99.4	59.0
10-Sep		225,107	97.4	55.4
11-Sep		na		
12-Sep		na		
13-Sep		na		
14-Sep		na		
15-Sep		na		
16-Sep		na		
17-Sep		225,413	96.9	75.6
18-Sep		226,135	104.9	46.4
19-Sep		226,961	105.1	70.7
20-Sep				
21-Sep		226,961	98.1	73.1
22-Sep		227,384	98.1	69.6
23-Sep		227,625	99.6	54.6
24-Sep		228,146	101.5	42.1
25-Sep		228,606	101.6	41.1
26-Sep		229,038	101.6	49.5
27-Sep		229,638	101.2	52.3
28-Sep		230,318	100.8	54.2
29-Sep		231,076	100.6	44.4
30-Sep		231,831	100.3	49.9
1-Oct		232,590	99.7	71.5
2-Oct		233,412	99.0	54.2
3-Oct		234,234	98.3	63.5
4-Oct		235,055	98.3	55.7
5-Oct	472,835	235,584	99.1	70.5

Date	Biogas	Btu Meter 1	Temp 4	Temp 10
6-Oct	474,408	236,280	100.4	43.3
7-Oct	476,284	237,095	100.6	59.0
8-Oct	478,134	237,977	101.7	41.2
9-Oct	479,918	238,861	101.2	35.3
10-Oct	481,745	239,782	100.4	55.2
11-Oct	484,362	240,070	100.7	53.6
12-Oct	485,400	240,542	100.4	54.7
13-Oct	487,273	241,398	99.8	56.4
14-Oct	488,978	241,750	99.6	36.3
15-Oct	790,686	242,528	100.4	27.4
16-Oct	492,426	246,629	100.0	45.8
17-Oct	494,194	244,124	100.0	44.7
18-Oct	495,962	244,916	100.0	35.6
19-Oct	497,689	245,677	99.8	48.9
20-Oct	499,541	246,496	99.8	40.2
21-Oct	501,482	247,420	99.9	40.2
22-Oct	503,110	248,208	100.0	31.9
23-Oct	504,779	249,054	99.7	33.4
24-Oct	505,915	249,916	99.5	24.7
25-Oct	505,938	249,963	99.7	35.2
26-Oct	507,287	250,565	98.7	43.3
27-Oct	508,920	251,282	99.2	36.0
28-Oct	510,743	252,141	100.8	39.2
29-Oct	512,534	253,004	102.1	31.9
30-Oct	514,334	255,855	99.6	37.9
31-Oct	516,165	254,823	99.5	24.7
1-Nov	518,079	255,834	98.8	38.0
2-Nov	520,033	256,867	101.5	24.5
3-Nov	522,156	257,983	102.8	30.6
4-Nov	524,196	259,079	102.1	34.7
5-Nov	526,311	260,204	101.8	36.3
6-Nov	528,388	261,296	101.8	39.4
7-Nov	530,505	262,420	101.5	30.9
8-Nov	532,536	263,519	101.1	43.0
9-Nov	534,660	264,647	100.0	40.9
10-Nov	536,736	265,742	99.4	61.5
11-Nov	538,802	266,825	98.5	66.7
12-Nov	541,861	268,363	99.8	43.7
13-Nov	543,031	268,982	99.2	41.4
14-Nov		269,839	99	49.6
15-Nov				
16-Nov				
17-Nov				
18-Nov		270,630	96.1	36.0
19-Nov				
20-Nov		270,751	96.6	27.4
21-Nov		270,948	96.7	44.5
22-Nov		271,301	95.2	36.0
23-Nov		271,711	97.2	28.6
24-Nov		272,122	97.6	35.9
25-Nov		272,728	98.5	37.0
26-Nov		273,332	99.1	33.2
27-Nov		273,942	99.7	26.5

Table A-7 cont.

Date	Biogas	Btu Meter 1	Temp 4	Temp 10
28-Nov		274,866	98.2	14.3
29-Nov		275,902	100.3	26.8
30-Nov		276,905	97.5	40.2
1-Dec		278,015	99.9	21.3
2-Dec		279,069	100.9	27.0
3-Dec		280,175	100.4	6.0
4-Dec		281,282	100.5	15.2
5-Dec	546,665	282,396	99.5	22.3
6-Dec	548,701	283,522	99.0	24.2
7-Dec	550,838	284,690	100.2	3.2
8-Dec	551,334	285,245	99.9	26.9
9-Dec	553,520	286,509	100.3	13.5
10-Dec	555,000	287,511	100.9	3.8
11-Dec	557,122	288,645	99.9	17.6
12-Dec	559,166	289,880	98.6	46.6
13-Dec	562,058	291,618	97.5	38.9
14-Dec	564,011	292,779	99.6	34.4
15-Dec	556,098	293,048	101.1	32.8
16-Dec	567,244	293,766	99.8	32.2
17-Dec	569,062	294,960	100.8	7.5
18-Dec	570,826	296,145	101.9	7.1
19-Dec	572,822	297,538	99.3	31.5
20-Dec	573,765	298,110	98.1	51.3
21-Dec	575,800	299,323	99.7	34.7
22-Dec		300,444	98.9	35.1
23-Dec		301,588	98.3	30.2
24-Dec		302,798	99.7	26.3
25-Dec		304,139	110.7	30.6
26-Dec		305,300	100.9	23.0
27-Dec		306,545	100.8	26.8
28-Dec		308,343	103.7	28.6
29-Dec		309,075	101.0	30.0
30-Dec		310,242	98.4	19.1
31-Dec		311,266	98.5	40.9
1-Jan		312,593	100.0	32.9
2-Jan		312,950	101.5	21.5
3-Jan		314,346	102.3	27.0
4-Jan		316,233	101.0	26.5
5-Jan		316,826	100.8	25.6
6-Jan		317,834	100.4	18.8
7-Jan		318,824	99.9	16.5
8-Jan		319,753	101.1	30.1
9-Jan		320,416	98.0	35.4
10-Jan		320,954	93.3	25.1
11-Jan		321,794	96.2	17.3
12-Jan		323,349	103.0	-5.0
13-Jan		323,457	102.0	18.3
14-Jan		323,964	103.1	11.5
15-Jan		324,851	97.1	3.8
16-Jan	577,247	325,714	97.5	13.1
17-Jan	579,011	326,595	97.7	6.9
18-Jan	580,756	327,486	99.0	-9.4
19-Jan	582,028	328,539	101.0	19.3
20-Jan	583,907	329,404	99.7	18.3
21-Jan	585,997	330,383	98.4	-7.4
22-Jan	588,078	331,423	98.0	1.3
23-Jan	590,206	332,618	100.2	1.5
24-Jan	592,535	333,742	101.0	3.3
25-Jan	594,973	348,760	103.2	14.8
26-Jan	597,655	336,122	101.8	24.6
27-Jan	604,345	337,872	101.5	-1.5
28-Jan	602,717	338,527	102.5	4.1
29-Jan	605,353	339,780	101.3	21.3
30-Jan	606,276	340,902	100.1	2.4
31-Jan	608,501	342,010	100.2	15.8
1-Feb	611,271	343,310	99.6	37.7
2-Feb	614,047	344,602	99.0	32.0
3-Feb	616,726	345,864	99.2	28.6
4-Feb	619,953	347,368	98.9	41.4
5-Feb	na			
6-Feb	620,236	348,508	97.3	29.9
7-Feb	621,658	349,169	97.4	28.6
8-Feb	624,267	350,339	99.5	13.1
9-Feb	627,130	351,609	99.8	22.8
10-Feb	629,902	352,855	99.4	26.1
11-Feb	632,917	354,206	99.8	5.1
12-Feb	635,731	355,476	99.9	22.8
13-Feb	638,506	356,756	100.1	7.0
14-Feb	641,075	357,948	100.3	5.2
15-Feb	643,788	359,209	100.4	9.6
16-Feb	646,279	360,375	101.7	4.5
17-Feb	648,720	361,573	100.2	15.8
18-Feb	649,234	362,268	97.0	23.9
19-Feb	650,818	363,381	97.8	24.8
20-Feb	653,641	364,691	101.2	30.5
21-Feb	656,249	365,994	101.2	10.8
22-Feb	658,790	367,300	99.7	36.2
23-Feb	661,401	368,614	99.4	45.0
24-Feb	663,915	369,836	100.5	20.2
25-Feb	666,277	371,024	100.9	12.0
26-Feb	668,702	372,307	101.8	-4.0
27-Feb	671,385	373,614	101.6	15.4
28-Feb	674,312	374,988	100.9	21.6
1-Mar	677,200	376,347	100.0	30.4
2-Mar	680,137	377,715	99.3	36.9
3-Mar	682,848	378,965	100.2	-2.6
4-Mar	685,455	380,207	101.3	4.1
5-Mar	688,047	381,432	99.7	44.7
6-Mar	690,908	382,752	99.6	23.3
7-Mar	693,621	384,023	102.1	-2.7
8-Mar	696,533	385,408	101.0	31.5
9-Mar	699,298	386,702	99.9	33.7
10-Mar	702,057	387,794	101.6	12.3
11-Mar	704,607	389,213	102.1	7.0
12-Mar	707,429	390,545	100.1	38.4
13-Mar	711,639	392,545	99.4	25.9

Table A-7 cont.

Date	Biogas	Btu Meter 1	Temp 4	Temp 10
14-Mar	712,958	392,400	100.9	14.3
15-Mar	715,863	393,785	100.5	34.9
16-Mar	718,789	395,167	99.6	34.1
17-Mar	721,712	396,491	100.1	38.4
18-Mar	na			
19-Mar	na	397,021	97.8	27.8
20-Mar	na	397,623	97.1	38.1
21-Mar	na	398,334	97.6	39.1
22-Mar	na	398,995	97.7	46.6
23-Mar	na	399,717	97.8	38.7
24-Mar	725,046	400,785	98.0	48.3
25-Mar	726,600	401,403	99.6	54.7
26-Mar	729,398	402,511	100.1	53.0
27-Mar	732,221	403,637	101.2	37.0
28-Mar	734,953	404,735	101.5	50.8
29-Mar	737,703	405,846	100.4	56.6
30-Mar	740,527	406,986	101.2	34.4
31-Mar	743,238	408,077	102.8	23.4
1-Apr	745,800	409,127	101.9	24.9
2-Apr	749,231	410,548	97.5	43.3
3-Apr	750,617	411,111	98.4	39.7
4-Apr	753,253	412,174	99.5	34.8
5-Apr	756,059	413,325	100.4	32.8
6-Apr	na			
7-Apr	na			
8-Apr	757,197	415,353	99.1	34.2
9-Apr	758,573	415,904	99.1	33.3
10-Apr	761,325	417,031	98.9	42.6
11-Apr	763,917	418,106	99	37.8
12-Apr	766,607	419,213	97.9	38.9
13-Apr	769,179	420,283	98.4	33.3
14-Apr	771,592	421,298	99.1	30.5
15-Apr	774,032	422,319	97.4	48.9
16-Apr	776,433	423,318	96.9	66.9
17-Apr	778,688	424,230	99.5	29.6
18-Apr	780,511	425,125	100.2	37.6
19-Apr	782,752	426,074	99	44.2
20-Apr	784,899	426,922	99	46.3
21-Apr	787,046	427,794	97.7	51.3
22-Apr	789,330	428,714	99.1	49.1
23-Apr	791,766	429,715	100.3	35.1
24-Apr	794,233	430,746	101.6	32
25-Apr	796,556	431,703	100.9	43.6
26-Apr	798,806	432,619	99.5	59
27-Apr	801,057	433,525	100	49.4
28-Apr	803,245	464,428	100.1	44.1

Date	Biogas	Btu Meter 1	Temp 4	Temp 10
29-Apr	805,595	435,405	100	61.2
30-Apr	807,814	436,338	98.7	42.2
1-May	na			
2-May	na			
3-May	na			
4-May	na			
5-May	na			
6-May	807,817	438,563	101.7	68
7-May	809,268	439,154	102	40.8
8-May	811,549	440,111	99.2	54.1
9-May	813,768	441,065	99.7	51.8
10-May	815,806	441,961	99.1	46.7
11-May	na			
12-May	816,604	442,914	99.6	57.2
13-May	na			
14-May	818,365	444,806	98.5	52.1
15-May	819,464	445,294	97.3	51.2
16-May	821,558	446,225	97.8	50.4
17-May	823,637	447,165	98.3	42.7
18-May	825,882	448,176	96.9	47.5
19-May	828,013	449,132	97.7	46.1

Date	Biogas	Btu #1	Btu #2	Temp 4	Temp 10
19-May-03	828,353	448,867	21	97.5	73.9
20-May	830,306	449,737	404	98.4	57.2
21-May	832,652	450,781	804	98.5	72.7
22-May	835,078	451,870	1,263	99.7	47.7
23-May	837,491	452,961	1,656	99.8	51.3
24-May	840,042	454,113	2,012	99.9	56.3
25-May	843,706	455,755	2,637	98.9	61.1
26-May	845,003	456,342	2,850	98.4	53.9
27-May	na				
28-May	na				
29-May	na				
30-May	849,229	458,785	4,005	98.5	58.9
31-May	851,689	459,885	4,424	98.7	56.4
1-Jun	854,207	461,000	4,813	98.7	58.5
2-Jun	856,748	462,137	5,285	99.9	47.2
3-Jun	859,339	463,325	5,509	98.6	60.3
4-Jun	861,530	464,314	5,818	96.9	64.7
5-Jun	864,008	465,431	6,171	97.0	63.5
6-Jun	866,400	466,998	6,626	98.8	54.1
7-Jun	na				
8-Jun	na				
9-Jun	na				
10-Jun	868,638	468,192	7,503	98.5	56.4
11-Jun	872,052	469,679	8,106	99.0	68.5
12-Jun	873,397	470,279	8,263	99.4	66.5
13-Jun	875,999	471,436	8,586	98.5	68.6
14-Jun	878,626	472,600	8,871	98.2	62.8
15-Jun	881,423	473,837	9,221	98.5	63.4
16-Jun	884,127	475,052	9,523	98.3	56.5
17-Jun	886,863	476,298	9,815	97.7	61.8

Table A-8. Farber Farm, STANDARD OPERATION, 9/5/03 - 9/7/04 (368 days).

Time Period	Days	Cows*	HRT	BioGas		Boiler Output		Digester Heat	CO_2	LHV	Btu/day	Efficiency
Year 2003			days	cuft/day	cuft/cow-day	Btu 1/day	Btu 1/cow-day	Btu 2/day	percent	Btu/cuft	Input	Boiler
9/5 - 10/2	27	64	9.4	NA		333,148	5,205	235,963	32	573		
10/9 - 10/15	6	90	6.7	NA		558,333	6,204	366,500	36	540		
10/21- 10/31	10	90	6.7	1,397	15.7	534,500	5,939	483,600	32.5	569	795,121	0.67
11/6-11/12	6	90	6.7	1,214	13.6	502,333	5,581	401,833	33	564	684,508	0.73
12/9-12/16	7	59	10.2	1,268	21.8	534,286	9,056	425,000	32	573	726,318	0.74
Year 2004												
2/4-2/18	14	46	13.1	1,141	24.8	445,071	9,675	389,643	35	548	625,385	0.71
2/18-2/29	11	58	10.4	1,364	23.9	544,545	9,389	411,364	32	573	781,572	0.70
4/4-4/14	10	67	9.0	1,516	22.9	620,300	9,258	414,700	33	564	855,024	0.73
4/26-4/30	4	69	8.8	1,520	22.0	652,250	9,453	446,500	34	556	845,120	0.77
4/30-5/18	18	81	7.5	2,265	28.3	988,444	12,203	440,000	33	564	1,277,397	0.77
5/18-5/26	8	87	6.9	2,466	28.7	979,000	11,253	360,000	33	564	1,390,895	0.70
5/26-6/3	8	93	6.5	2,468	26.8	970,750	10,438	364,625	32	573	1,414,164	0.69
6/8-6/17	9	93	6.5	2,113	23.0	747,222	8,035	350,667	31	582	1,229,507	0.61
6/17-6/23	6	101	6.0	2,403	24.0	868,000	8,594	402,333	33	564	1,355,386	0.64
7/3-7/9	6	58	10.4	1,171	20.5	423,333	7,299	274,167	37	533	624,143	0.68
7/9-7/15	6	72	8.4	1,904	26.4	744,833	10,345	286,500	32	573	1,091,183	0.68
7/16-7/28	12	93	6.5	2,009	21.8	762,167	8,195	329,146	32	573	1,151,348	0.66
7/29-9/7	40	101	6.0	1,488	14.9	582,122	5,764	368,146	32	573	852,624	0.68
	208											
Weighted Averages		80	8.0	1,694	21.4	623,157	7,919	363,788	32.5	564	961,764	0.69

All averages are weighted for all periods from 9/5/03 to 9/7/04
* Number of cows reflects the volume of liquid manure fed to the digester based on the run time of the of the feed pump.
HRT = 7,770/ (cows*18.9*0.68)
Based on - 7770 gal capacity of digester, 18.9 gal/cow-day at raw manure pit and 68% of raw manure goes to liquid pit,
LHV - Low Heating Value
Btu 1 - Energy output from biogas boiler
Btu 2 - Energy used to heat digester

Table A-9. Nutrient Results, Farber Raw Manure, Standard Digester, 9/9/03 - 9/7/04.

	F. Coli	COD	NH3	TKN	TP	Ortho P	TS	TVS	Total K	pH	sulfate
Date	mpn/gram	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	%	%	mg/kg	std units	mg/kg
9/9/2003	220,000	70,000	2,574	3,582	605	354	8.90	78.40		7.51	
9/15/2003	300,000	10,000	2,850	4,067	631	393	10.20	77.20		8.08	
9/23/2003	9,000,000	57,100	2,228	3,393	601	308	8.30	79.50		7.41	100
9/30/2003	30,000,000	85,800	2,179	3,513	619	333	10.70	80.70		7.66	100
10/7/2003	1,700,000	60,000	2,456	4,040	306	310	12.50	82.30		7.64	100
10/14/2003	2,200,000	60,000	2,682	4,688	1242	334	10.90	76.80		7.91	140
10/21/2003	5,000,000	57,200	1,443	3,450	490	293	7.50	80.60		6.89	100
10/28/2003	500,000	66,700	2,324	3,798	449	265	10.10	79.90		7.67	132
11/11/2003	5,000,000	71,800	3,257	4,598	661	325	12.60	81.10		7.41	100
11/25/2003	5,200,000	60,000	2,280	3,391	673	325	9.90	79.80		7.54	168
12/9/2003	1,300,000	100,000	2,609	4,195	436	260	11.10	81.80		7.95	
12/16/2003			2,391	4,078	532	310	10.10	82.00		7.85	
12/22/2003		78,000	3,370	5,484	491	352	10.60	83.10	103	7.77	100
1/26/2004	500,000	85,800	1,056	3,734	556	299	10.50	79.50	120	7.41	100
2/25/2004	5,000,000	70,000	1,681	3,691	508	297	10.10	80.90	41	7.27	129
3/16/2004	3,666,667	80,700	2,265	3,487	536	285	11.40	81.97	118	7.37	172
3/29/2004	5,833,333	89,000	2,224	3,890	539	309	11.33	84.03	272	7.20	120
4/13/2004	7,000,000	82,533	1,881	3,447	545	289	11.03	84.20	1,489	7.32	196
4/29/2004	13,666,667	83,333	2,356	4,233	566	346	11.93	80.23	2,694	7.53	168
5/13/2004	1,600,000	103,333	2,565	4,959	668	487	11.63	80.07	2,991	7.37	100
5/27/2004	4,133,333		2,092	3,525	596	377	11.50	79.10	2,499	7.49	100
6/10/2004	2,366,667		2,999	4,312	621	383	11.13	81.10	2,969	7.52	
7/27/2004	800,000		2,003	3,479	435	260	11.00	81.00	1,906	7.06	
8/26/2004	1,966,667		714	1,113	203	103	3.20	78.67	705	8.06	
8/30/2004	3,866,667		2,234	4,043	530	337	11.27	79.73	2,889	8.11	
9/7/2004	3,466,667		2,399	3,987	589	388	10.53	82.00	3,856	7.88	
Average	**4,761,944**	**72,174**	**2,274**	**3,853**	**563**	**320**	**10.38**	**80.60**	**1,618**	**7.6**	**125.0**
Std Dev	**6,216,541**	**20,466**	**593**	**766**	**175**	**66**	**1.86**	**1.83**	**1,367**	**0.31**	**32.47**

Table A-10. Nutrient Results, Farber Separated Liquids, Standard Digester, 9/9/03 - 9/7/04.

	F. Coli	Vol Acids	Dis COD	COD	NH3	TKN	TP	Ortho P	TS	TVS	Total K	pH	sulfate
Date	mpn/gram	mg/L	mg/L	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	%	%	mg/Kg	std units	mg/kg
9/9/2003	170,000	2,577	15,000	50,000	2,472	3,663	486	255	4.60	70.20		7.35	100
9/15/2003	220,000	1,660	10,000	45,000	2,395	3,637	489	320	4.50	68.50		7.78	100
9/23/2003	900,000	2,643	23,800	38,100	2,179	3,881	462	291	4.20	69.30		7.31	100
9/30/2003	5,000,000	1,944	23,800	34,100	1,769	2,894	405	240	3.10	65.50		7.26	100
10/7/2003	1,600,000	3,232	20,000	50,000	2,511	3,950	582	315	5.00	62.50		7.67	100
10/14/2003	900,000	2,992	19,000	55,000	2,822	4,800	605	282	6.10	66.70		7.80	143
10/21/2003	500,000	3,034	19,000	52,400	2,560	4,825	626	327	5.50	63.70		7.77	100
10/28/2003	300,000	2,013	23,800	38,100	1,823	3,154	350	169	3.50	53.60		7.51	100
11/11/2003	1,600,000	3,189	25,600	76,900	2,747	4,702	601	451	6.80	70.20		7.36	100
11/25/2003	1,600,000	3,211	40,000	50,000	2,300	3,216	521	327	5.00	70.30		7.52	270
12/9/2003	500,000	3,248	19,500	55,000	2,501	4,387	481	268	5.20	69.10		7.64	
12/16/2003		3,732			2,638	5,506	564	298	5.30	71.10		7.84	
12/22/2003		3,232	19,500	58,500	2,963	4,492	600	315	5.50	71.30	51	7.70	100
1/26/2004	1,600,000	3,522	29,300	76,200	2,168	4,095	483	269	6.70	68.80	53	7.33	148
2/25/2004	500,000	3,177	25,000	65,000	1,958	3,397	553	307	6.00	69.90	30	7.29	167
3/16/2004	1,600,000	3,278	26,000	59,033	2,389	3,288	554	349	5.47	74.13	93	7.28	123
3/29/2004	1,366,667	3,930	27,333	66,667	2,085	3,628	560	342	5.57	74.13	248	7.15	128
4/13/2004	1,600,000	3,225	23,333	63,967	1,725	3,200	518	278	5.47	74.23	1130	7.14	180
4/29/2004	7,500,000	3,313		51,667	2,196	3,788	529	330	5.40	71.33	2339	7.33	132
5/13/2004	1,566,667	2,825		63,333	2,181	3,757	590	360	5.70	70.27	3587	7.24	119
5/27/2004	3,466,667	3,463		65,000	2,480	3,121	545	384	5.60	70.37	2859	7.30	
6/10/2004	1,073,333	2,076		73,167	2,489	3,926	628	350	5.57	72.77	2642	7.32	
7/27/2004	376,667	2,180		48,333	1,994	3,813	429	278	5.23	71.00	2190	7.11	
8/26/2004	146,667	1,781		51,667	2,135	2,823	476	317	5.53	66.47	3134	7.63	
8/30/2004	1,233,333	1,875		45,000	2,111	4,169	342	233	4.97	69.73	2934	7.96	
9/7/2004	566,667	1,450		56,667	2,369	4,153	504	301	5.07	70.33	3,497	7.85	
Average	**1,495,278**	**2,800**	**23,154**	**55,552**	**2,306**	**3,856**	**519**	**306**	**5.25**	**69.06**	**1,771**	**7.48**	**128**
St Deviation	**1,680,895**	**700**	**6,460**	**11,411**	**317**	**656**	**78**	**54**	**0.82**	**4.27**	**1,426**	**0.25**	**44**

Table A-11. Nutrient Results, Farber Digester Effluent, Standard Digester, 9/9/03 - 9/7/04.

	F. Coli	Vol Acids	Dis COD	COD	NH3	TKN	TP	Ortho P	TS	TVS	Total K	pH	sulfate
Date	mpn/gram	mg/L	mg/L	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	%	%	mg/Kg	std units	mg/kg
9/9/2003	2,300	1,179	15,000	35,000	2,841	3,941	415	299	4.00	64.70		7.98	117
9/15/2003	3,000	743	10,000	30,000	2,903	4,049	575	353	4.20	64.20		7.86	100
9/23/2003	5,000	681	23,800	42,900	3,158	4,264	587	428	4.00	63.00		7.97	100
9/30/2003	160,000	743	19,000	34,100	2,830	3,862	532	354	3.50	63.10		7.85	100
10/7/2003	90,000	874	20,000	30,000	2,672	3,897	508	338	3.60	63.50		7.98	100
10/14/2003	90,000	1,791	9,500	35,000	2,694	4,688	447	357	4.30	65.60		7.86	100
10/21/2003	2,100	2,177	19,000	47,600	3,168	5,212	470	482	4.70	62.40		7.96	100
10/28/2003	11,000	1,583	28,600	47,600	2,858	4,224	554	400	4.50	59.20		7.86	100
11/11/2003	50,000	1,442	20,500	35,900	2,618	4,477	498	401	4.80	64.50		7.86	100
11/25/2003	25,000	655	25,000	35,000	2,369	6,220	513	405	4.20	64.20		7.90	100
12/9/2003	30,000	445	9,700	35,000	2,366	3,922	453	344	4.00	65.50		7.81	
12/16/2003	missing -->												
12/22/2003		1,274	9,700	19,500	3,030	4,253	526	397	3.90	64.20	85	7.89	112
1/26/2004	1,100	1,042	24,400	47,600	2,925	4,280	500	332	6.10	62.70	112	7.80	100
2/25/2004	23,000	783	25,000	45,000	3,051	3,381	576	387	9.10	35.10	43	7.86	100
3/16/2004	43,333	638	21,147	52,967	2,510	3,239	479	341	6.60	52.23	108	7.90	100
3/29/2004	41,267	1,267	41,267	41,267	2,674	3,931	544	450	4.13	67.13	260	7.86	134
4/13/2004	86,667	618	14,533	38,333	2,483	3,495	502	332	4.17	65.93	1,538	7.77	100
4/29/2004	43,333	786		35,900	2,304	3,464	456	362	3.90	66.27	2,026	7.80	100
5/13/2004	80,000	670		43,333	2,742	3,686	518	419	4.47	67.60	3,072	7.84	100
5/27/2004	56,667	1,008		45,000	2,934	3,558	546	427	4.50	64.50	2,815	7.96	100
6/10/2004	333	479		42,267	3,163	4,432	727	501	5.20	67.40	2,634	8.02	
7/27/2004	193,333	707		33,333	2,335	3,701	397	277	4.50	63.33	2,161	7.80	
8/26/2004	200	2,093		45,000	2,842	3,462	516	389	5.07	65.50	2,631	7.92	
8/30/2004	1,600,000	1,332		35,000	2,206	2,828	283	194	4.30	65.40	3,164	8.05	
9/7/2004	56,667	903		41,667	2,442	3,785	399	281	4.03	67.33	3,750	7.89	
Average	**112,263**	**1,036**	**19,773**	**38,971**	**2,725**	**4,010**	**501**	**370**	**4.63**	**62.98**	**1,743**	**7.89**	**103**
St Deviation		**480**	**8,254**	**7,303**	**289**	**683**	**83**	**67**	**1.17**	**6.59**	**1,359**	**0.07**	**9**

Table A-12. Nutrient Results, Farber Separated Solids, Standard Digester, 9/9/03 - 9/7/04.

	F. Coli	COD	NH3	TKN	TP	Ortho P	TS	TVS	Total K	pH	sulfate
Date	mpn/gram	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	%	%	mg/kg	std units	
9/9/2003	130,000	50,000	1,780	3,195	919	394	20.60	85.70		8.11	133
9/15/2003	300,000	15,000	2,326	3,282	1,097	418	22.10	82.30		8.09	
9/23/2003	220,000	81,000	1,483	3,348	565	356	22.20	89.10		8.25	100
9/30/2003	9,000,000	167,000	1,515	3,083	512	225	21.20	87.90		7.67	100
10/7/2003	300,000	95,000	2,160	3,497	520	287	22.90	88.10		8.03	100
10/14/2003	500,000	85,000	2,229	4,228	453	236	23.30	87.40		8.20	128
10/21/2003	500,000	124,000	1,279	3,450	533	269	20.10	89.00		7.66	100
10/28/2003	900,000	85,700	1,704	3,602	328	139	25.70	87.50		8.13	127
11/11/2003	500,000	108,000	1,683	4,114	523	231	25.00	88.30		8.08	100
11/25/2003	105,000	80,000	1,575	3,024	608	253	24.50	88.90		8.36	100
12/9/2003	50,000	160,000	1,946	3,767	398	168	23.70	87.40		8.36	
12/16/2003			2,007	3,626	410	266	21.50	86.30		8.31	
12/22/2003		117,000	1,803	5,265	353	119	22.60	91.50	112	8.42	
1/26/2004	11,000	162,000	1,333	2,996	332	161	22.50	87.90	98	8.55	100
2/25/2004	160,000	115,000	1,569	2,795	332	164	22.80	90.30	32	8.30	165
3/16/2004	433,333	112,333	1,624	2,598	283	155	23.93	88.83	101	7.95	132
3/29/2004	416,667	98,400	1,322	2,800	300	106	23.70	90.70	259	8.09	106
4/13/2004	1,000,000	109,667	1,228	2,527	378	173	25.50	91.30	1,139	8.30	134
4/29/2004	1,233,333	101,667	1,650	3,294	375	240	23.67	87.57	1,974	8.00	116
5/13/2004	83,333	65,000	1,168	2,657	341	167	20.43	88.70	2,438	7.93	
5/27/2004	316,667		1,828	2,570	430	285	23.90	87.13	2,122	8.06	
6/10/2004	156,667		1,987	3,447	447	269	23.03	88.90	2,221	8.32	
7/27/2004	280,000		1,291	2,247	346	166	20.67	85.00	1,364	7.72	100
8/26/2004	303,333		1,129	1,894	356	227	23.27	89.17	1,854	8.37	
8/30/2004	5,200,000		1,417	3,502	406	232	23.87	87.43	2,935	8.20	
9/7/2004	200,000		1,308	2,588	468	301	17.57	89.33	2,653	8.29	
Average	**929,139**	**101,672**	**1,629**	**3,208**	**462**	**231**	**22.70**	**88.14**	**1,379**	**8.14**	**116**
St Deviation	**2,004,235**	**37,602**	**337**	**695**	**184**	**80**	**1.84**	**1.95**	**1,075**	**0.23**	**20**

Table A-13. Standard Operation, Farber Farm, Selected Periods.

Date	Biogas	Btu #1	Btu/day #1	Btu #2	Btu/day #2	Temp4	Temp10		
4-Sep-03	892,244	491,089		19,828		100.0	65.5		
5-Sep		492,407	1,318	20,147	319	100.3	56.3	9/5 - 10/2/03	
6-Sep		492,743	336	20,486	339	100.6	46.7	Days:	27
7-Sep		493,036	293	20,722	236	101.3	51.6	cows	64
8-Sep		493,383	347	20,819	97	100.8	59.4	Biogas, cuft/day	NA
9-Sep		493,688	305	20,854	35	101.5	43.9	Avg Btu 1/day	333,148
10-Sep		493,971	283	21,170	316	100.8	41.9	Avg. Btu 1/cow-day	5,288
11-Sep		494,301	330	21,363	193	99.8	56.2	Avg. Btu 2/day	235,963
12-Sep	892,273	494,635	334	21,527	164	100.7	58.4	Avg Temp4:	99.9
13-Sep	892,844	494,925	290	21,732	205	99.3	63.4	Avg Temp10, morming	54.0
14-Sep		495,497	572	21,925	193	97.1	73.4		
15-Sep		495,687	190	22,060	135	97.5	68.2		
16-Sep		496,045	358	22,386	326	98.5	56.2		
17-Sep		496,381	336	22,674	288	99.1	43.0		
18-Sep		496,729	348	22,979	305	102.0	53.0		
19-Sep		496,996	267	23,099	120	100.0	65.7		
20-Sep		497,346	350	23,289	190	100	62.5		
21-Sep		497,829	483	23,527	238	98.6	55.2		
22-Sep		498,000	171	23,675	148	99.0	51.9		
23-Sep		498,312	312	23,955	280	101.4	64.9		
24-Sep		498,634	322	24,216	261	100.8	42.6		
25-Sep		498,956	322	24,494	278	100.4	51.6		
26-Sep		499,208	252	24,711	217	99.3	51.7		
27-Sep		499,560	352	25,026	315	100.2	65.9		
28-Sep		499,933	373	25,236	210	98.9	65.2		
29-Sep		500,322	389	25,574	338	99.5	48.3		
30-Sep		500,761	439	25,956	382	100.0	35.7		
1-Oct		501,167	406	26,316	360	100.5	44.3		
2-Oct		501,402	235	26,518	202	99.8	33.5		
10/8		504,165		28952	424	100.9	35.1	10/9 - 10/15 Days	6
9-Oct		504,645	480	29,084	132	100.5	46.1	Cows	89
10-Oct		505,030	385	29,348	264	99.0	43.8	Biogas, cuft/day	NA
11-Oct		505,588	558	29,838	490	100.5	39.4	Avg Btu 1/day	558,333
12-Oct		506,092	504	30,259	421	101.4	46.8	Avg. Btu 1/cow-day	6,273
13-Oct		506,744	652	30,493	234	99.3	45.4	Avg. Btu/day #2	366,500
14-Oct		507,346	602	30,921	428	99.8	34.5	Avg Temp4:	99.9
15-Oct		507,995	649	31,283	362	99.0	50.5	Avg Temp10	43.8
10/20	896833	510,797		33394	356	97	26.2	10/21 - 10/31/03 Days	10
21-Oct	897,975	511,280	483	33,842	448	98.4	61.5	Cows	89
22-Oct	899,431	511,750	470	34,290	448	98.6	36.2	Biogas, cuft/day	1397
23-Oct	900,332	512,240	490	34,758	468	98.8	29.0	Avg. Btu 1/day	534,500
24-Oct	900,911	512,480	240	34,989	231	98.7	32.4	Avg. Btu 1/cow-day	6,006
25-Oct	902,917	513,272	792	35,740	751	98.3	25.3	Avg. Btu/day #2	483,600
26-Oct	904,208	513,920	648	36,359	619	98.9	59.2	Avg Temp4:	99.4
27-Oct	905,883	514,112	192	36,543	184	99.3	57.5	Avg Temp10, morning	41.4
28-Oct	907,469	514,749	637	37,101	558	100.2	35.0		
29-Oct	909,034	515,472	723	37,715	614	100.9	43.8		
30-Oct	910,570	516,088	616	38,236	521	101.1	40.8		
31-Oct	911,949	516,625	537	38,678	442	100.6	35.2		
5-Nov	916,744	518,831		40,683		100.1	52.0	11/6-11/12/03 Days	6
6-Nov	918,178	519,503	672	41,312	629	101.3	43.4	Cows	89
7-Nov	919,370	519,997	494	41,776	464	100.8	37.2	Biogas, cuft/day	1214
8-Nov	920,606	520,521	524	42,275	499	100.5	27.3	Avg. Btu 1/day	502,333
9-Nov	921,740	521,007	486	42,729	454	100.5	14.9	Avg. Btu 1/cow-day	5,644
10-Nov	922,917	521,506	499	43,188	459	99.6	16.7	Avg. Btu 2/day	470,833
11-Nov	924,060	521,982	476	43,631	443	99.4	23.2	Avg Temp4:	100.3
12-Nov	925,460	522,517	535	44,137	506	100.3	41.6	Avg Temp10 morning	29.2

Table A-13 cont.

Date	Biogas	Btu #1	Btu/day #1	Btu #2	Btu/day #2	Temp4	Temp10		
8-Dec	938,204	532,733		53,263		94.2	15.4	12/9-12/16/03 Days	7
9-Dec	939,196	533,135	402	53,610	347	94.5	14.1	Cows	58
10-Dec	940,357	533,608	473	54,029	419	95.5	36.3	Biogas, cuft/day	1268
11-Dec	941,634	534,130	522	54,501	472	97.1	47.5	Avg. Btu 1/day	534,286
12-Dec	942,998	534,687	557	54,946	445	97.7	28.3	Avg. Btu 1/cow-day	9,212
13-Dec	944,293	535,239	552	55,368	422	98.0	14.7	Avg. Btu 2/day	425,000
14-Dec	945,535	535,781	542	55,759	391	97.8	22.8	Avg Temp4:	97.1
15-Dec	946,833	536,344	563	56,178	419	98.1	24.8	Avg Temp10 morning	25.9
16-Dec	948,069	536,875	531	56,585	407	98.2	18.3		
3-Feb	985,293	557,470		72,935		97.7	31.2		
4-Feb	986,272	557,868	398	73,285	350	97.8	30.6	2/4-2/18/04	
5-Feb	987,311	558,394	526	73,729	444	98.9	20.0	Days:	14
6-Feb	988,335	558,732	338	74,027	298	97.6	26.6	Cows	46
7-Feb	989,382	559,153	421	74,407	380	92.9	33.0	Biogas, cuft/day	1141
8-Feb	990,380	559,500	347	74,694	287	96.7	5.8	Avg. Btu 1/day	445,071
9-Feb	991,596	560,115	615	75,234	540	99.1	4.4	Avg. Btu 1/cow-day	9,675
10-Feb	992,660	560,508	393	75,574	340	98.5	31.4	Avg. Btu 2/day	389,643
11-Feb	993,816	560,941	433	75,956	382	98.8	23.8	Avg Temp4:	98.2
12-Feb	994,965	561,358	417	76,322	366	98.3	4.8	Avg Temp10 morning	17.1
13-Feb	996,113	561,783	425	76,701	379	98.4	26.3		
14-Feb	997,305	562,219	436	77,087	386	98.4	25.5		
15-Feb	998,527	562,683	464	77,485	398	98.6	6.8		
16-Feb	999,690	563,163	480	77,919	434	99.5	-2.2		
17-Feb	1,001,127	563,729	566	78,422	503	100.2	9.7		
18-Feb	1,002,249	564,099	370	78,740	318	99.5	10.6		
17-Feb	1,001,127	563,729		78,422		100.2	9.7		
18-Feb	1,002,249	564,099	370	78,740	318	99.5	10.6	2/18-2/29/04	
19-Feb	1,003,597	564,632	533	79,150	410	99.1	26.6	Days:	11
20-Feb	1,005,017	565,189	557	79,574	424	99.0	21.4	Cows	57
21-Feb	1,006,345	565,711	522	79,988	414	98.9	38.1	Biogas, cuft/day	1364
22-Feb	1,007,786	566,276	565	80,427	439	99.0	28.1	Avg. Btu 1/day	544,545
23-Feb	1,009,256	566,821	545	80,824	397	98.7	23.9	Avg. Btu 1/cow-day	9,553
24-Feb	1,010,532	567,352	531	81,175	351	99.1	24.0	Avg. Btu 2/day	411,364
25-Feb	1,011,933	567,926	574	81,609	434	99.1	13.9	Avg Temp4:	99.1
26-Feb	1,013,254	568,459	533	82,007	398	99.0	10.6	Avg Temp10 morning	22.6
27-Feb	1,014,610	569,012	553	82,427	420	98.9	23.1		
28-Feb	1,015,957	569,562	550	82,860	433	99.2	30.4		
29-Feb	1,017,253	570,089	527	83,265	405	99.2	20.2		
3-Apr	1,058,701	588,465		96,218		100.5	41.3		
4-Apr	1,060,341	589,119	654	96,611	393	100.9	38	4/4-4/14/04	
5-Apr	1,061,969	589,796	677	96,918	307	99.5	18	Days:	10
6-Apr	1,063,589	590,478	682	97,289	371	98.8	22.2	Cows	66
7-Apr	1,065,093	591,099	621	97,762	473	99.4	40.8	Biogas, cuft/day	1516
8-Apr	1,066,724	591,764	665	98,229	467	101	35.6	Avg. Btu 1/day	620,300
9-Apr	1,068,182	592,363	599	98,635	406	101	34.3	Avg. Btu 1/cow-day	9,398
10-Apr	1,069,544	592,928	565	99,019	384	100.6	46.3	Avg. Btu 2/day	414,700
11-Apr	1,071,082	593,561	633	99,468	449	100.5	36.6	Avg Temp4:	100.4
12-Apr	1,072,472	594,126	565	99,886	418	100.8	37.7	Avg Temp10 morning	36.4
13-Apr	1,073,969	594,724	598	100,319	433	100.9	40.7		
14-Apr	1,075,500	595,322	598	100,758	439	101.3	50.3		
25-Apr	1,085,954	599,747		104,204		100.2	41.3	4/26-4/30/04 Days	4
26-Apr	1,087,288	600,342	595	104,575	371	100.7	47.1	Cows	69
27-Apr	1,088,796	600,997	655	105,043	468	101.2	44.1	Biogas, cuft/day	1520
28-Apr	1,090,237	601,609	612	105,445	402	100.9	31.3	Avg. Btu 1/day	652,250
29-Apr	1,091,673	602,258	649	105,881	436	100.8	39	Avg. Btu 1/cow-day	9,453
30-Apr	1,093,367	602,951	693	106,361	480	101.3	75	Avg. Btu 2/day	446,500
								Avg Temp4:	101.0
								Avg Temp10 morning	47.3

Table A-13 cont.

Date	Biogas	Btu #1	Btu/day #1	Btu #2	Btu/day #2	Temp4	Temp10		
29-Apr	1,091,673	602,258		105,881		100.8	39		
30-Apr	1,093,367	602,951	693	106,361	480	101.3	75	4/30-5/18/04	
1-May	1,095,134	603,679	728	106,891	530	101.4	57.4	Days:	18
2-May	1,097,073	604,463	784	107,359	468	101.4	64	Cows	80
3-May	1,099,158	605,302	839	107,832	473	101.1	43.7	Biogas, cuft/day	2265
4-May	1,101,140	606,120	818	108,273	441	100.7	37	Avg. Btu 1/day	988,444
5-May	1,102,929	606,920	800	108,773	500	100.6	44.4	Avg. Btu 1/cow-day	12,356
6-May	1,104,543	607,640	720	109,255	482	100.1	39.4	Avg. Btu 2/day	440,000
7-May	1,106,709	608,559	919	109,798	543	101.1	53.6	Avg Temp4:	100.9
8-May	1,108,933	609,515	956	110,304	506	101.5	46.8	Avg Temp10 morning	55.5
9-May	1,111,271	610,530	1,015	110,764	460	100.9	52.3		
10-May	1,113,635	611,563	1,033	111,190	426	100.8	58.6		
11-May	1,116,269	612,713	1,150	111,644	454	101.1	66.7		
12-May	1,118,672	613,795	1,082	111,967	323	101.3	61.7		
13-May	1,121,317	614,980	1,185	112,390	423	101.4	62		
14-May	1,123,994	616,160	1,180	112,808	418	101.7	64.9		
15-May	1,126,672	617,334	1,174	113,178	370	101.6	65.5		
16-May	1,129,392	618,439	1,105	113,498	320	100.9	51.4		
17-May	1,131,563	619,608	1,169	113,712	214	98.2	46.8		
18-May	1,134,135	620,743	1,135	114,281	569	100.9	64.1		
17-May	1,131,563	619,608		113,712		98.2	46.8		
18-May	1,134,135	620,743	1,135	114,281	569	100.9	64.1	5/18-5/26/04	
19-May	1,136,569	621,797	1,054	114,707	426	101.6	57.2	Days:	8
20-May	1,138,916	622,862	1,065	115,064	357	100.3	59.8	Cows	86
21-May	1,141,007	623,929	1,067	115,477	413	101.1	63.0	Biogas, cuft/day	2466
22-May	1,144,831	625,207	1,278	116,132	655	101.7	74.0	Avg. Btu 1/day	979,000
23-May	1,146,155	626,385	1,178	116,507	375	101.8	77.8	Avg. Btu 1/cow-day	11,384
24-May	1,148,780	626,931	546	116,702	195	102.1	62.2	Avg. Btu 2/day	360,000
25-May	1,151,255	627,468	537	116,836	134	101.8	58.1	Avg Temp4:	101.3
26-May	1,153,864	628,575	1,107	117,161	325	100.8	58.1	Avg Temp10 morning	63.8
25-May	1,151,255	627,468		116,836		101.8	58.1		
26-May	1,153,864	628,575	1,107	117,161	325	100.8	58.1	5/26-6/3/04	
27-May	1,156,523	629,663	1,088	117,802	641	104.5	61.4	Days:	8
28-May	1,159,003	630,711	1,048	118,032	230	101.8	63.0	Cows	92
29-May	1,161,486	631,766	1,055	118,370	338	100.5	42.6	Biogas, cuft/day	2468
30-May	1,163,834	632,788	1,022	118,705	335	100.5	47.8	Avg. Btu 1/day	970,750
31-May	1,166,217	633,799	1,011	119,132	427	101.4	47.6	Avg. Btu 1/cow-day	10,552
1-Jun	1,168,788	634,890	1,091	119,516	384	100.1	63.5	Avg. Btu 2/day	364,625
2-Jun	1,171,204	635,606	716	119,727	211	101.5	51.9	Avg Temp4:	101.3
3-Jun	1,173,611	636,341	735	120,078	351	101.0	52.6	Avg Temp10 morning	54.3
7-Jun	1,179,260	638,779		121,532		99.2	59.4		
8-Jun	1,180,461	639,296	517	121,960	428	97.5	77.1	6/8-6/17/04	
9-Jun				122,341	381	100	71	Days:	9
10-Jun	1,183,029	640,338		122,722	381	101.5	65.2	Cows	92
11-Jun	1,185,837	641,367	1,029	123,117	395	100.6	57.3	Biogas, cuft/day	2113
12-Jun	1,188,063	642,206	839	123,524	407	101.4	48.5	Avg. Btu 1/day	747,222
13-Jun	1,190,449	643,102	896	123,901	377	101.5	61.5	Avg. Btu 1/cow-day	8,122
14-Jun	1,192,857	643,994	892	124,223	322	101.5	61.1	Avg. Btu 2/day	350,667
15-Jun	1,195,011	644,822	828	124,428	205	100.7	70.2	Avg Temp4:	100.7
16-Jun	1,197,208	645,477	655	124,763	335	101.0	61.7	Avg Temp10 morning	64.0
17-Jun	1,199,474	646,021	544	125,116	353	101.6	66.5		
16-Jun	1,197,208	645,477		124,763		101.0	61.7	6/17-6/23 Days	6
17-Jun	1,199,474	646,021	544	125,116	353	101.6	66.5	Cows	100
18-Jun	1,201,981	646,875	854	125,471	355	101.1	67.5	Biogas, cuft/day	2403
19-Jun	1,204,122	647,640	765	125,798	327	101.0	64.6	Avg. Btu 1/day	868,000
20-Jun	1,206,491	648,514	874	126,098	300	100.7	48.6	Avg. Btu 1/cow-day	8,680
21-Jun	1,209,482	649,623	1,109	126,566	468	100.7	67.1	Avg. Btu 2/day	402,333
22-Jun	1,211,453	650,341	718	126,874	308	101.3	63.8	Avg Temp4:	101.1
23-Jun	1,213,893	651,229	888	127,177	303	101.2	58.5	Avg Temp10 morning	62.4

Table A-13 cont.

Date	Biogas	Btu #1	Btu/day #1	Btu #2	Btu/day #2	Temp4	Temp10		
2-Jul	1,220,888	654,232		128,440		99.9	68.0	7/3-7/9/04 Days	6
3-Jul	1,220,890	654,452	220	128,645	205	101.0	72.0	Cows	57
4-Jul	1,221,801	655,013	561	129,045	400	101.1	79.6	Biogas, cuft/day	1171
5-Jul	1,222,833	655,335	322	129,316	271	100.9	65.6	Avg. Btu 1/day	423,333
6-Jul	1,224,012	655,660	325	129,555	239	100.8	58.8	Avg. Btu 1/cow-day	7,427
7-Jul	1,225,225	656,027	367	129,821	266	101.1	60.0	Avg. Btu 2/day	274,167
8-Jul	1,226,502	656,475	448	130,061	240	101.1	67.9	Avg Temp4:	101.0
9-Jul	1,227,916	656,992	517	130,290	229	101.0	58.5	Avg Temp10 morning	66.1
8-Jul	1,226,502	656,475		130,061		101.1	67.9	7/9-7/15/04 Days	6
9-Jul	1,227,916	656,992	517	130,290	229	101.0	58.5	Cows	72
10-Jul	1,229,549	657,607	615	130,598	308	101.2	60.0	Biogas, cuft/day	1904
11-Jul	1,231,263	658,262	655	130,886	288	101.2	76.5	Avg. Btu 1/day	744,833
12-Jul	1,233,191	659,017	755	131,197	311	101.4	66.7	Avg. Btu 1/cow-day	10,345
13-Jul	1,235,145	659,794	777	131,442	245	101.0	63.6	Avg. Btu 2/day	286,500
14-Jul	1,237,239	660,626	832	131,742	300	101.4	64.6	Avg Temp4:	101.2
15-Jul	1,239,342	661,461	835	132,009	267	101.3	64.6	Avg Temp10 morning	64.9
15-Jul	1,239,342	661,461		132,009		101.3	64.6		
16-Jul	1,241,402	662,258	797	132,301	292	101.1	60.5	7/16-7/28/04	
17-Jul	1,243,509	663,062	804	132,641	340	101.1	64.8	Days:	12
18-Jul	1,245,676	663,875	813	132,992	351	101.5	60.9	Cows	92
19-Jul	1,247,779	664,674	799	133,273	281	101.7	60.7	Biogas, cuft/day	2009
20-Jul	1,249,917	665,483	809	133,604	331	101.0	61.6	Avg. Btu 1/day	762,167
21-Jul	1,251,964	666,257	774	133,936	332	101.2	57.7	Avg. Btu 1/cow-day	8,284
22-Jul	1,254,041	667,037	780	134,294	358	101.6	64.4	Avg. Btu 2/day	329,417
23-Jul	1,256,140	667,818	781	134,603	309	101.2	74.1	Avg Temp4:	101.2
24-Jul	1,258,050	668,544	726	134,891	288	100.8	57.3	Avg Temp10 morning	62.1
25-Jul	1,259,943	669,269	725	135,245	354	101.6	54.2		
26-Jul	1,261,870	670,008	739	135,575	330	100.7	64.3		
27-Jul	1,263,611	670,673	665	135,912	337	101.2	63.8		
28-Jul	1,265,514	671,404	731	136,254	342	101.2	62.8		
28-Jul	1,265,514	671,404		136,254		101.2	62.8		
29-Jul	1,267,448	672,140	736	136,617	363	101	61.7	7/29-9/7/04	
30-Jul	1,269,464	672,906	766	137,001	384	101.0	61.4	Days:	41
31-Jul	1,271,441	673,660	754	137,531	530	101.6	74.8	Cows	100
1-Aug	1,273,588	674,488	828	137,693	162	101.2	72.0	Biogas, cuft/day	1488
2-Aug	1,275,698	675,293	805	137,970	277	100.9	63.2	Avg. Btu 1/day	582,122
3-Aug	1,277,888	676,141	848	138,309	339	101.2	66.1	Avg. Btu 1/cow-day	5,821
4-Aug	1,280,017	676,965	824	138,627	318	101.1	69.3	Avg. Btu 2/day	368,146
5-Aug	1,282,399	677,881	916	138,986	359	100.8	65.0	Avg Temp4:	99.7
6-Aug	1,284,735	678,798	917	139,315	329	101.6	46.9	Avg Temp10 morning	59.6
7-Aug	1,286,497	679,504	706	139,800	485	101.6	51.6		
8-Aug	1,287,615	679,956	452	140,036	236	97.6	47.1		
9-Aug	1,289,049	680,536	580	140,523	487	98.1	61.3		
10-Aug	1,290,908	681,275	739	141,124	601	101.4	55.6		
11-Aug	1,292,877	682,051	776	141,482	358	100.1	63.0		
12-Aug	1,294,734	682,795	744	141,874	392	99.9	61.2		
13-Aug	1,296,962	683,715	920	142,383	509	101.4	65.9		
14-Aug	1,298,901	684,511	796	142,790	407	101.6	60.1		
15-Aug	1,300,666	685,242	731	143,165	375	100.9	62.8		
16-Aug	1,302,560	686,015	773	143,599	434	101.3	64.0		
17-Aug	1,304,006	686,621	606	143,993	394	101.2	50.0		
18-Aug	1,305,115	687,022	401	144,357	364	100.4	54.6		
19-Aug	1,306,591	687,578	556	144,758	401	100.5	63.2		
20-Aug	1,307,896	688,100	522	145,186	428	100.5	64.2		
21-Aug	1,308,750	688,435	335	145,402	216	97.6	66.6		
22-Aug	1,310,368	689,006	571	145,867	465	99.5	44.3		
23-Aug	1,310,493	689,049	43	145,901	34	93.9	46.5		
24-Aug	1,311,499	689,389	340	146,185	284	94.5	50.8		
25-Aug	1,312,707	689,824	435	146,376	191	94.5	51.4		
26-Aug	1,314,247	690,211	387	146,875	499	96.6	67.7		
27-Aug	1,315,329	690,589	378	147,187	312	96.4	55.6		
28-Aug	1,316,439	691,118	529	147,643	456	97.6	66.5		
29-Aug	1,317,657	691,719	601	148,165	522	99.6	61.9		
30-Aug	1,318,997	692,307	588	148,675	510	101.2	74.6		
31-Aug	1,320,075	692,790	483	149,067	392	101.1	65.5		
1-Sep	1,321,328	693,312	522	149,454	387	100	51.3		
2-Sep	1,322,561	693,825	513	149,870	416	100.6	54.1		
3-Sep	1,323,779	694,331	506	150,295	425	100.4	50.1		
4-Sep	1,325,012	694,838	507	150,721	426	100.6	50.4		
5-Sep	1,326,219	695,265	427	151,085	364	100.3	60.8		
6-Sep	1,327,434	695,639	374	151,399	314	98.4	61.1		

Table A-14. Raw Data for Standard Operation, Farber Farm.

Date	Biogas	Btu Meter #1	Btu/day #1 (thousands)	Btu Meter #2	Btu/day #2 (thouands)	Btu/day Dif (thousands)	Temp 4	Temp 10	Cows*	Comments
4-Sep-03	892,244	491,089		19,828			100.0	65.5		
5-Sep		492,407	1,318	20,147	319		100.3	56.3	64	OK
6-Sep		492,743	336	20,486	339	-3	100.6	46.7		"
7-Sep		493,036	293	20,722	236	57	101.3	51.6		"
8-Sep		493,383	347	20,819	97	250	100.8	59.4		"
9-Sep		493,688	305	20,854	35	270	101.5	43.9		"
10-Sep		493,971	283	21,170	316	-33	100.8	41.9		"
11-Sep		494,301	330	21,363	193	137	99.8	56.2		"
12-Sep	892,273	494,635	334	21,527	164	170	100.7	58.4		"
13-Sep	892,844	494,925	290	21,732	205	85	99.3	63.4		"
14-Sep		495,497	572	21,925	193	379	97.1	73.4		"
15-Sep		495,687	190	22,060	135	55	97.5	68.2		"
16-Sep		496,045	358	22,386	326	32	98.5	56.2		"
17-Sep		496,381	336	22,674	288	48	99.1	43.0		"
18-Sep		496,729	348	22,979	305	43	102.0	53.0		"
19-Sep		496,996	267	23,099	120	147	100.0	65.7		"
20-Sep		497,346	350	23,289	190	160	100	62.5		"
21-Sep		497,829	483	23,527	238	245	98.6	55.2		"
22-Sep		498,000	171	23,675	148	23	99.0	51.9		"
23-Sep		498,312	312	23,955	280	32	101.4	64.9		"
24-Sep		498,634	322	24,216	261	61	100.8	42.6		"
25-Sep		498,956	322	24,494	278	44	100.4	51.6		"
26-Sep		499,208	252	24,711	217	35	99.3	51.7		"
27-Sep		499,560	352	25,026	315	37	100.2	65.9		"
28-Sep		499,933	373	25,236	210	163	98.9	65.2		"
29-Sep		500,322	389	25,574	338	51	99.5	48.3		"
30-Sep		500,761	439	25,956	382	57	100.0	35.7		"
1-Oct		501,167	406	26,316	360	46	100.5	44.3		"
2-Oct		501,402	235	26,518	202	33	99.8	33.5		"
3-Oct		501,419	17	26,533	15	2	99.5	37.2	90	Foam
4-Oct		502,231	812	27,213	680	132	99	45.7		"
5-Oct		502,927	696	27,820	607	89	98.1	31.6		"
6-Oct		503,171	244	28,062	242	2	98.1	31.6		"
7-Oct		503,400	229	28,528	466	-237	100.7	30.7		"
8-Oct		504,165	765	28,952	424	341	100.9	35.1		"
9-Oct		504,645	480	29,084	132	348	100.5	46.1		"
10-Oct		505,030	385	29,348	264	121	99.0	43.8		"
11-Oct		505,588	558	29,838	490	68	100.5	39.4		"
12-Oct		506,092	504	30,259	421	83	101.4	46.8		"
13-Oct		506,744	652	30,493	234	418	99.3	45.4		"
14-Oct		507,346	602	30,921	428	174	99.8	34.5		"
15-Oct		507,995	649	31,283	362	287	99.0	50.5		"
16-Oct		508,548	553	31,742	459	94	100.1	39.2		"
17-Oct		509,186	638	32,267	525	113	101.4	26.7		"
18-Oct	894,340	509,811	625	32,649	382	243	100.1	29.9		"
19-Oct		510,340	529	33,038	389	140	99.7	39.7		"
20-Oct	896,833	510,797	457	33,394	356	101	97.0	26.2		"
21-Oct	897,975	511,280	483	33,842	448	35	98.4	61.5		"
22-Oct	899,431	511,750	470	34,290	448	22	98.6	36.2		"
23-Oct	900,332	512,240	490	34,758	468	22	98.8	29.0		"
24-Oct	900,911	512,480	240	34,989	231	9	98.7	32.4		"
25-Oct	902,917	513,272	792	35,740	751	41	98.3	25.3		"
26-Oct	904,208	513,920	648	36,359	619	29	98.9	59.2		"
27-Oct	905,883	514,112	192	36,543	184	8	99.3	57.5		"
28-Oct	907,469	514,749	637	37,101	558	79	100.2	35.0		"
29-Oct	909,034	515,472	723	37,715	614	109	100.9	43.8		"
30-Oct	910,570	516,088	616	38,236	521	95	101.1	40.8		Foam

Table A-14 cont.

Date	Biogas	Btu Meter #1	Btu/day #1 (thousands)	Btu Meter #2	Btu/day #2 (thouands)	Btu/day Dif (thousands)	Temp 4	Temp 10	Cows*	Comments
31-Oct	911,949	516,625	537	38,678	442	95	100.6	35.2		"
1-Nov	912,248	516,816	191	38,831	153	38	100.2	50.3		"
2-Nov	913,248	517,259	443	39,218	387	56	99.0	48.2		"
3-Nov	914,412	517,757	498	39,667	449	49	98.9	63.8		"
4-Nov	915,578	518,242	485	40,124	457	28	99.2	43.5		"
5-Nov	916,744	518,831	589	40,683	559	30	100.1	52.0		"
6-Nov	918,178	519,503	672	41,312	629	43	101.3	43.4		"
7-Nov	919,370	519,997	494	41,776	464	30	100.8	37.2		"
8-Nov	920,606	520,521	524	42,275	499	25	100.5	27.3		"
9-Nov	921,740	521,007	486	42,729	454	32	100.5	14.9		"
10-Nov	922,917	521,506	499	43,188	459	40	99.6	16.7		"
11-Nov	924,060	521,982	476	43,631	443	33	99.4	23.2		"
12-Nov	925,460	522,517	535	44,137	506	29	100.3	41.6		"
13-Nov	926,900	523,016	499	44,612	475	24	100.0	46.0		"
14-Nov	927,998	523,200	184	44,782	170	14	97.1	23.8		"
15-Nov	927,905	523,871	671	45,384	602	69	101.2	22.7		"
16-Nov	928,180	524,051	180	45,546	162	18	99.7	33.9		"
17-Nov	928,180	524,106	55	45,589	43	12	98.5	37.4		"
18-Nov	929,277	524,763	657	46,200	611	46	99.5	48.3		"
19-Nov	930,483	525,270	507	46,675	475	32	99.8	49.3		"
20-Nov	932,347	526,005	735	47,362	687	48	98.1	36.7		"
21-Nov	932,913	526,620	615	47,919	557	58	98.0	48.3		"
22-Nov	933,911	527,048	428	48,307	388	40	98.5	47.3		"
23-Nov	935,376	527,595	547	48,757	450	97	97.9	30.4		"
24-Nov	935,860	527,786	191	48,922	165	26	92.8	34.6		"
25-Nov	936,277	528,565	779	49,638	716	63	97.2	29.0		"
26-Nov	936,277	529,233	668	50,233	595	73	98.4	27.3		"
27-Nov		529,647	414	50,590	357	57	93.2	45.9		"
28-Nov	936,680	529,832	185	50,768	178	7	87.4	56.1	64	"
29-Nov	937,325	530,639	807	51,502	734	73	95.4	31.3		"
30-Nov	937,331	530,882	243	51,715	213	30	97.9	32.2		"
1-Dec	937,474	531,022	140	51,832	117	23	97.1	42.5		"
2-Dec		531,236	214	52,000	168	46	99.3	21.9		"
3-Dec		531,546	310	52,253	253	57	101.2	9.9		"
4-Dec				52,317	64	-64	99	14		"
5-Dec		531,823		52,380	64	-64	96.0	18.0		"
6-Dec		532,086	263	52,701	321	-58	94.7	49.8		"
7-Dec	937,700	532,519	433	53,075	374	59	94.5	18.7		"
8-Dec	938,204	532,733	214	53,263	188	26	94.2	15.4		"
9-Dec	939,196	533,135	402	53,610	347	55	94.5	14.1	59	OK
10-Dec	940,357	533,608	473	54,029	419	54	95.5	36.3		"
11-Dec	941,634	534,130	522	54,501	472	50	97.1	47.5		"
12-Dec	942,998	534,687	557	54,946	445	112	97.7	28.3		"
13-Dec	944,293	535,239	552	55,368	422	130	98.0	14.7		"
14-Dec	945,535	535,781	542	55,759	391	151	97.8	22.8		"
15-Dec	946,833	536,344	563	56,178	419	144	98.1	24.8		"
16-Dec	948,069	536,875	531	56,585	407	124	98.2	18.3	87	Foam
17-Dec	949,512	537,464	589	57,051	466	123	95.9	43.2		"
18-Dec	950,827	537,981	517	57,494	443	74	96.1	27.5		"
19-Dec	952,272	538,542	561	57,982	488	73	95.9	17.4		"
20-Dec	953,680	539,116	574	58,489	507	67	95.8	22.8		"
21-Dec	954,811	539,548	432	58,865	376	56	93.6	11.6		"
22-Dec				59,175	310	-310	95	25	15	Restart
23-Dec	954,870	540,293		59,484	310	-310	96.5	38.2		"
24-Dec	954,780	540,519	226	59,667	183	43	96.8	51.1	32	"
25-Dec	954,870	540,768	249	59,859	192	57	96.0	35.6		"
26-Dec	957,916	541,432	664	60,419	560	104	97.7	32.5	52	"
27-Dec	955,408	541,624	192	60,585	166	26	96.9	30.5		"
28-Dec	956,295	541,980	356	60,889	304	52	95.8	28.9		Restart
29-Dec	956,983	542,356	376	61,219	330	46	96.7	29.5	64	"
30-Dec	958,280	542,864	508	61,673	454	54	96.5	41.9		OK
31-Dec	959,581	543,385	521	62,128	455	66	97.2	31.4		OK

Table A-14 cont.

Date	Biogas	Btu Meter #1	Btu/day #1 (thousands)	Btu Meter #2	Btu/day #2 (thouands)	Btu/day Dif (thousands)	Temp 4	Temp 10	Cows*	Comments
1-Jan-04	961,000	543,960	575	62,635	507	68	98.0	32.0	75	Gas Freeze
2-Jan	962,300	544,530	570	63,131	496	74	98.5	35.7	32	Up
3-Jan	963,800	545,076	546	63,483	352	194	99.0	40.2		"
4-Jan	965,190	545,671	595	63,794	311	284	98.8	41.4		"
5-Jan	966,428	546,210	539	64,143	349	190	99.1	32.3		"
6-Jan	967,644	546,727	517	64,496	353	164	98.7	23.0		"
7-Jan	969,222	547,486	759	65,046	550	209	98.9	13.0		"
8-Jan	970,350	547,942	456	65,427	381	75	98.3	15.1		"
9-Jan	970,948	548,183	241	65,629	202	39	98.2	-3.3		"
10-Jan	972,094	548,600	417	65,960	331	86	96.5	-3.6		"
11-Jan		549,182	582	66,397	437	145	97.2	21.9		"
12-Jan	972,599	549,502	320	66,634	237	83	97.8	30.0		"
13-Jan	972,618	549,740	238	66,825	191	47	97.5	30.9	14	Restart
14-Jan	973,100	549,981	241	67,004	179	62	95.8	7.3		"
15-Jan	974,095	550,343	362	67,295	291	71	96.4	-0.8		"
16-Jan	974,800	550,582	239	67,459	164	75	96.5	-0.6		"
17-Jan	975,234	550,975	393	67,759	300	93	97.2	11.9		"
18-Jan	976,163	551,299	324	68,033	274	50	96.5	31.6		"
19-Jan	977,105	551,627	328	68,297	264	64	95.9	12.3		"
20-Jan	978,084	552,114	487	68,683	386	101	97.2	12.7		"
21-Jan	979,082	552,522	408	69,011	328	80	97.2	7.7		"
22-Jan	980,153	553,008	486	69,424	413	73	98.2	23.8		"
23-Jan	981,161	553,449	441	69,774	350	91	98.6	5.3		"
24-Jan		554,102	653	70,289	515	138	99.4	2.2		"
25-Jan	981,974	554,306	204	70,442	153	51	91.7	12.5	22	"
26-Jan				70,743	301	-301	96	14		"
27-Jan	982,215	555,015		71,043	301	-301	99.4	14.9		"
28-Jan				71,190	147	-147	99	15	14	"
29-Jan				71,338	147	-147	99	16	12	"
30-Jan	982,317	555,718		71,485	147	-147	98.2	16.3		"
31-Jan	982,798	556,014	296	71,709	224	72	97.6	10.9		"
1-Feb	983,442	556,471	457	72,065	356	101	97.5	15.7		"
2-Feb	984,536	557,034	563	72,546	481	82	96.9	47.3	46	OK
3-Feb	985,293	557,470	436	72,935	389	47	97.7	31.2		"
4-Feb	986,272	557,868	398	73,285	350	48	97.8	30.6		"
5-Feb	987,311	558,394	526	73,729	444	82	98.9	20.0		"
6-Feb	988,335	558,732	338	74,027	298	40	97.6	26.6		"
7-Feb	989,382	559,153	421	74,407	380	41	92.9	33.0		"
8-Feb	990,380	559,500	347	74,694	287	60	96.7	5.8		"
9-Feb	991,596	560,115	615	75,234	540	75	99.1	4.4		"
10-Feb	992,660	560,508	393	75,574	340	53	98.5	31.4		"
11-Feb	993,816	560,941	433	75,956	382	51	98.8	23.8		"
12-Feb	994,965	561,358	417	76,322	366	51	98.3	4.8		"
13-Feb	996,113	561,783	425	76,701	379	46	98.4	26.3		"
14-Feb	997,305	562,219	436	77,087	386	50	98.4	25.5		"
15-Feb	998,527	562,683	464	77,485	398	66	98.6	6.8		"
16-Feb	999,690	563,163	480	77,919	434	46	99.5	-2.2		"
17-Feb	1,001,127	563,729	566	78,422	503	63	100.2	9.7		"
18-Feb	1,002,249	564,099	370	78,740	318	52	99.5	10.6	58	"
19-Feb	1,003,597	564,632	533	79,150	410	123	99.1	26.6		"
20-Feb	1,005,017	565,189	557	79,574	424	133	99.0	21.4		"
21-Feb	1,006,345	565,711	522	79,988	414	108	98.9	38.1		"
22-Feb	1,007,786	566,276	565	80,427	439	126	99.0	28.1		"
23-Feb	1,009,256	566,821	545	80,824	397	148	98.7	23.9		"
24-Feb	1,010,532	567,352	531	81,175	351	180	99.1	24.0		"
25-Feb	1,011,933	567,926	574	81,609	434	140	99.1	13.9		OK
26-Feb	1,013,254	568,459	533	82,007	398	135	99.0	10.6		"
27-Feb	1,014,610	569,012	553	82,427	420	133	98.9	23.1		"
28-Feb	1,015,957	569,562	550	82,860	433	117	99.2	30.4		"
29-Feb	1,017,253	570,089	527	83,265	405	122	99.2	20.2		"

Table A-14 cont.

Date	Biogas	Btu Meter #1	Btu/day #1 (thousands)	Btu Meter #2	Btu/day #2 (thouands)	Btu/day Dif (thousands)	Temp 4	Temp 10	Cows*	Comments
1-Mar	1,018,543	570,611	522	83,681	416	106	99.6	30.4		"
2-Mar	1,019,812	571,122	511	84,105	424	87	100.2	55.6	69	Foam
3-Mar	1,021,161	571,487	365	84,371	266	99	97.3	36.9		"
4-Mar	1,022,521	571,675	188	84,517	146	42	96.9	39.4		"
5-Mar	1,023,063	572,205	530	84,950	433	97	99.3	42.0		"
6-Mar	1,024,393	572,769	564	85,419	469	95	100.3	50.9		"
7-Mar	1,025,827	573,328	559	85,860	441	118	99.6	28.8		"
8-Mar	1,027,123	573,873	545	86,300	440	105	102.0	36.8		"
9-Mar	1,028,545	574,570	697	86,676	376	321	100.6	33.0		"
10-Mar	1,030,667	575,456	886	87,282	606	280	99.9	29.3		"
11-Mar	1,031,433	575,769	313	87,486	204	109	99.6	25.6		"
12-Mar	1,032,709	576,284	515	87,894	408	107	98.8	29.6		"
13-Mar	1,033,832	576,895	611	88,294	400	211	99.2	22.5		"
14-Mar	1,035,244	577,587	692	88,720	426	266	99.2	22.3		"
15-Mar	1,036,065	578,088	501	89,030	310	191	99.8	36.6		"
16-Mar	1,037,424	578,681	593	89,481	451	142	98.8	23.7		"
17-Mar	1,038,382	579,187	506	89,868	387	119	98.5	21.4		"
18-Mar	1,039,952	579,804	617	90,342	474	143	98.3	29.3		"
19-Mar	1,041,343	580,398	594	90,814	472	122	99.2	24.3		"
20-Mar	1,042,321	581,028	630	91,287	473	157	99.5	25.9		"
21-Mar	1,043,714	581,671	643	91,714	427	216	100.5	38.6		"
22-Mar	1,045,315	582,351	680	92,139	425	255	98.7	12.9		"
23-Mar	1,046,181	583,105	754	92,375	236	518	99.8	35.5	46	Ok
24-Mar	1,046,318	583,150	45	92,574	199	-154	97.4	40.0		"
25-Mar	1,046,850	583,195	45	92,770	196	-151	98.1	44.9		"
26-Mar	1,048,166	583,770	575	93,240	470	105	99.4	46.6		"
27-Mar	1,049,394	584,292	522	93,692	452	70	100.9	52.9		"
28-Mar	1,050,583	584,926	634	93,947	255	379	101.1	38.8	58	"
29-Mar	1,051,637	585,410	484	94,260	313	171	100.6	42.7		"
30-Mar	1,052,825	585,959	549	94,635	375	174	100.7	41.7		"
31-Mar	1,054,108	586,504	545	94,998	363	182	100.7	44.7	64	"
1-Apr	1,055,548	587,141	637	95,381	383	254	100.4	39.4		"
2-Apr	1,057,078	587,812	671	95,772	391	280	100.5	39.4		"
3-Apr	1,058,701	588,465	653	96,218	446	207	100.5	41.3		"
4-Apr	1,060,341	589,119	654	96,611	393	261	100.9	38	67	"
5-Apr	1,061,969	589,796	677	96,918	307	370	99.5	18		"
6-Apr	1,063,589	590,478	682	97,289	371	311	98.8	22.2		"
7-Apr	1,065,093	591,099	621	97,762	473	148	99.4	40.8		"
8-Apr	1,066,724	591,764	665	98,229	467	198	101	35.6		"
9-Apr	1,068,182	592,363	599	98,635	406	193	101	34.3		"
10-Apr	1,069,544	592,928	565	99,019	384	181	100.6	46.3		"
11-Apr	1,071,082	593,561	633	99,468	449	184	100.5	36.6		"
12-Apr	1,072,472	594,126	565	99,886	418	147	100.8	37.7		"
13-Apr	1,073,969	594,724	598	100,319	433	165	100.9	40.7		"
14-Apr	1,075,500	595,322	598	100,758	439	159	101.3	50.3		"
15-Apr	1,077,100	595,961	639	101,170	412	227	100.8	38.2		"
16-Apr	1,078,250	596,394	433	101,511	341	92	99.1	33.9		"
17-Apr	1,079,466	596,827	433	101,865	354	79	99.2	44.7	29	Foam
18-Apr	1,080,382	597,200	373	102,175	310	63	99.7	49.8		Foam
19-Apr	1,080,527	597,265	65	102,230	55	10	97.4	51.1	46	Foam
20-Apr				102,461	231	-231	98	50		OK
21-Apr	1,081,534	597,844		102,692	231	-231	97.7	48.5	58	OK
22-Apr	1,082,325	598,186	342	102,975	283	59	97.4	55.6		OK
23-Apr	1,083,091	598,509	323	103,237	262	61	97.4	43.4		OK
24-Apr	1,084,456	599,100	591	103,732	495	96	99.5	44.4		OK
25-Apr	1,085,954	599,747	647	104,204	472	175	100.2	41.3		"
26-Apr	1,087,288	600,342	595	104,575	371	224	100.7	47.1	69	"
27-Apr	1,088,796	600,997	655	105,043	468	187	101.2	44.1		"
28-Apr	1,090,237	601,609	612	105,445	402	210	100.9	31.3		"
29-Apr	1,091,673	602,258	649	105,881	436	213	100.8	39		"
30-Apr	1,093,367	602,951	693	106,361	480	213	101.3	75	81	"

Table A-14 cont.

Date	Biogas	Btu Meter #1	Btu/day #1 (thousands)	Btu Meter #2	Btu/day #2 (thouands)	Btu/day Dif (thousands)	Temp 4	Temp 10	Cows*	Comments
1-May	1,095,134	603,679	728	106,891	530	198	101.4	57.4		"
2-May	1,097,073	604,463	784	107,359	468	316	101.4	64		"
3-May	1,099,158	605,302	839	107,832	473	366	101.1	43.7		"
4-May	1,101,140	606,120	818	108,273	441	377	100.7	37		"
5-May	1,102,929	606,920	800	108,773	500	300	100.6	44.4		"
6-May	1,104,543	607,640	720	109,255	482	238	100.1	39.4		"
7-May	1,106,709	608,559	919	109,798	543	376	101.1	53.6		"
8-May	1,108,933	609,515	956	110,304	506	450	101.5	46.8		"
9-May	1,111,271	610,530	1,015	110,764	460	555	100.9	52.3		"
10-May	1,113,635	611,563	1,033	111,190	426	607	100.8	58.6		"
11-May	1,116,269	612,713	1,150	111,644	454	696	101.1	66.7		"
12-May	1,118,672	613,795	1,082	111,967	323	759	101.3	61.7		"
13-May	1,121,317	614,980	1,185	112,390	423	762	101.4	62		"
14-May	1,123,994	616,160	1,180	112,808	418	762	101.7	64.9		"
15-May	1,126,672	617,334	1,174	113,178	370	804	101.6	65.5		"
16-May	1,129,392	618,439	1,105	113,498	320	785	100.9	51.4		"
17-May	1,131,563	619,608	1,169	113,712	214	955	98.2	46.8		"
18-May	1,134,135	620,743	1,135	114,281	569	566	100.9	64.1	87	"
19-May	1,136,569	621,797	1,054	114,707	426	628	101.6	57.2		"
20-May	1,138,916	622,862	1,065	115,064	357	708	100.3	59.8		"
21-May	1,141,007	623,929	1,067	115,477	413	654	101.1	63.0		"
22-May	1,144,831	625,207	1,278	116,132	655	623	101.7	74.0		"
23-May	1,146,155	626,385	1,178	116,507	375	803	101.8	77.8		"
24-May	1,148,780	626,931	546	116,702	195	351	102.1	62.2		"
25-May	1,151,255	627,468	537	116,836	134	403	101.8	58.1		"
26-May	1,153,864	628,575	1,107	117,161	325	782	100.8	58.1	93	"
27-May	1,156,523	629,663	1,088	117,802	641	447	104.5	61.4		"
28-May	1,159,003	630,711	1,048	118,032	230	818	101.8	63.0		"
29-May	1,161,486	631,766	1,055	118,370	338	717	100.5	42.6		"
30-May	1,163,834	632,788	1,022	118,705	335	687	100.5	47.8		"
31-May	1,166,217	633,799	1,011	119,132	427	584	101.4	47.6		"
1-Jun	1,168,788	634,890	1,091	119,516	384	707	100.1	63.5		"
2-Jun	1,171,204	635,606	716	119,727	211	505	101.5	51.9		"
3-Jun	1,173,611	636,341	735	120,078	351	384	101.0	52.6		"
4-Jun	1,174,279	636,830	489	120,325	247	242	97.1	68.1		"
5-Jun	1,175,949	637,384	554	120,802	477	77	100.3	48.6		"
6-Jun	1,178,345	638,527	1,143	121,251	449	694	101.0	57.6		"
7-Jun	1,179,260	638,779	252	121,532	281	-29	99.2	59.4		"
8-Jun	1,180,461	639,296	517	121,960	428	89	97.5	77.1		"
9-Jun				122,341	381	-381	100	71		"
10-Jun	1,183,029	640,338		122,722	381	-381	101.5	65.2		"
11-Jun	1,185,837	641,367	1,029	123,117	395	634	100.6	57.3		"
12-Jun	1,188,063	642,206	839	123,524	407	432	101.4	48.5		"
13-Jun	1,190,449	643,102	896	123,901	377	519	101.5	61.5		"
14-Jun	1,192,857	643,994	892	124,223	322	570	101.5	61.1		"
15-Jun	1,195,011	644,822	828	124,428	205	623	100.7	70.2		"
16-Jun	1,197,208	645,477	655	124,763	335	320	101.0	61.7		"
17-Jun	1,199,474	646,021	544	125,116	353	191	101.6	66.5	101	Raw pump
18-Jun	1,201,981	646,875	854	125,471	355	499	101.1	67.5		Repair
19-Jun	1,204,122	647,640	765	125,798	327	438	101.0	64.6		OK
20-Jun	1,206,491	648,514	874	126,098	300	574	100.7	48.6		OK
21-Jun	1,209,482	649,623	1,109	126,566	468	641	100.7	67.1		OK
22-Jun	1,211,453	650,341	718	126,874	308	410	101.3	63.8		OK
23-Jun	1,213,893	651,229	888	127,177	303	585	101.2	58.5		"
24-Jun	1,216,097	652,050	821	127,374	197	624	100.8	55.7		"
25-Jun	1,217,791	652,715	665	127,567	193	472	101.7	57.3		"
26-Jun	1,219,198	653,259	544	127,763	196	348	101.2	52.0		"
27-Jun	1,220,376	653,702	443	127,956	193	250	100.4	51.8		"
28-Jun				127,985	29	-29	100	59		"
29-Jun				128,014	29	-29	99	66		"
30-Jun				128,042	29	-29	98	73		"

Table A-14 cont.

Date	Biogas	Btu Meter #1	Btu/day #1 (thousands)	Btu Meter #2	Btu/day #2 (thouands)	Btu/day Dif (thousands)	Temp 4	Temp 10	Cows*	Comments
1-Jul	1,220,486	653,833		128,071	29	-29	97.3	79.6	58	Boiler
2-Jul	1,220,888	654,232	399	128,440	369	30	99.9	68.0		cleaned
3-Jul	1,220,890	654,452	220	128,645	205	15	101.0	72.0		OK
4-Jul	1,221,801	655,013	561	129,045	400	161	101.1	79.6		"
5-Jul	1,222,833	655,335	322	129,316	271	51	100.9	65.6		"
6-Jul	1,224,012	655,660	325	129,555	239	86	100.8	58.8		"
7-Jul	1,225,225	656,027	367	129,821	266	101	101.1	60.0		"
8-Jul	1,226,502	656,475	448	130,061	240	208	101.1	67.9		"
9-Jul	1,227,916	656,992	517	130,290	229	288	101.0	58.5	72	"
10-Jul	1,229,549	657,607	615	130,598	308	307	101.2	60.0		"
11-Jul	1,231,263	658,262	655	130,886	288	367	101.2	76.5		"
12-Jul	1,233,191	659,017	755	131,197	311	444	101.4	66.7		"
13-Jul	1,235,145	659,794	777	131,442	245	532	101.0	63.6		"
14-Jul	1,237,239	660,626	832	131,742	300	532	101.4	64.6	93	"
15-Jul	1,239,342	661,461	835	132,009	267	568	101.3	64.6		"
16-Jul	1,241,402	662,258	797	132,301	292	505	101.1	60.5		"
17-Jul	1,243,509	663,062	804	132,641	340	464	101.1	64.8		"
18-Jul	1,245,676	663,875	813	132,992	351	462	101.5	60.9		"
19-Jul	1,247,779	664,674	799	133,273	281	518	101.7	60.7		"
20-Jul	1,249,917	665,483	809	133,604	331	478	101.0	61.6		"
21-Jul	1,251,964	666,257	774	133,936	332	442	101.2	57.7		"
22-Jul	1,254,041	667,037	780	134,294	358	422	101.6	64.4		"
23-Jul	1,256,140	667,818	781	134,603	309	472	101.2	74.1		"
24-Jul	1,258,050	668,544	726	134,891	288	438	100.8	57.3		"
25-Jul	1,259,943	669,269	725	135,245	354	371	101.6	54.2		"
26-Jul	1,261,870	670,008	739	135,575	330	409	100.7	64.3		"
27-Jul	1,263,611	670,673	665	135,912	337	328	101.2	63.8		"
28-Jul	1,265,514	671,404	731	136,254	342	389	101.2	62.8	101	Foam
29-Jul	1,267,448	672,140	736	136,617	363	373	101	61.7		"
30-Jul	1,269,464	672,906	766	137,001	384	382	101.0	61.4		"
31-Jul	1,271,441	673,660	754	137,531	530	224	101.6	74.8		"
1-Aug	1,273,588	674,488	828	137,693	162	666	101.2	72.0		"
2-Aug	1,275,698	675,293	805	137,970	277	528	100.9	63.2		"
3-Aug	1,277,888	676,141	848	138,309	339	509	101.2	66.1		"
4-Aug	1,280,017	676,965	824	138,627	318	506	101.1	69.3		"
5-Aug	1,282,399	677,881	916	138,986	359	557	100.8	65.0		"
6-Aug	1,284,735	678,798	917	139,315	329	588	101.6	46.9		"
7-Aug	1,286,497	679,504	706	139,800	485	221	101.6	51.6		"
8-Aug	1,287,615	679,956	452	140,036	236	216	97.6	47.1		"
9-Aug	1,289,049	680,536	580	140,523	487	93	98.1	61.3		"
10-Aug	1,290,908	681,275	739	141,124	601	138	101.4	55.6		"
11-Aug	1,292,877	682,051	776	141,482	358	418	100.1	63.0		"
12-Aug	1,294,734	682,795	744	141,874	392	352	99.9	61.2		"
13-Aug	1,296,962	683,715	920	142,383	509	411	101.4	65.9		"
14-Aug	1,298,901	684,511	796	142,790	407	389	101.6	60.1		"
15-Aug	1,300,666	685,242	731	143,165	375	356	100.9	62.8		"
16-Aug	1,302,560	686,015	773	143,599	434	339	101.3	64.0		"
17-Aug	1,304,006	686,621	606	143,993	394	212	101.2	50.0		"
18-Aug	1,305,115	687,022	401	144,357	364	37	100.4	54.6		"
19-Aug	1,306,591	687,578	556	144,758	401	155	100.5	63.2		"
20-Aug	1,307,896	688,100	522	145,186	428	94	100.5	64.2		Foam
21-Aug	1,308,750	688,435	335	145,402	216	119	97.6	66.6		"
22-Aug	1,310,368	689,006	571	145,867	465	106	99.5	44.3		"
23-Aug	1,310,493	689,049	43	145,901	34	9	93.9	46.5		"
24-Aug	1,311,499	689,389	340	146,185	284	56	94.5	50.8		"

Table A-14 cont.

Date	Biogas	Btu Meter #1	Btu/day #1 (thousands)	Btu Meter #2	Btu/day #2 (thouands)	Btu/day Dif (thousands)	Temp 4	Temp 10	Cows*	Comments
25-Aug	1,312,707	689,824	435	146,376	191	244	94.5	51.4		"
26-Aug	1,314,247	690,211	387	146,875	499	-112	96.6	67.7		"
27-Aug	1,315,329	690,589	378	147,187	312	66	96.4	55.6		"
28-Aug	1,316,439	691,118	529	147,643	456	73	97.6	66.5		"
29-Aug	1,317,657	691,719	601	148,165	522	79	99.6	61.9		"
30-Aug	1,318,997	692,307	588	148,675	510	78	101.2	74.6	101	Added
31-Aug	1,320,075	692,790	483	149,067	392	91	101.1	65.5		Foam
1-Sep	1,321,328	693,312	522	149,454	387	135	100	51.3		Control
2-Sep	1,322,561	693,825	513	149,870	416	97	100.6	54.1		OK
3-Sep	1,323,779	694,331	506	150,295	425	81	100.4	50.1		"
4-Sep	1,325,012	694,838	507	150,721	426	81	100.6	50.4		"
5-Sep	1,326,219	695,265	427	151,085	364	63	100.3	60.8		"
6-Sep	1,327,434	695,639	374	151,399	314	60	98.4	61.1		"
7-Sep	1,328,444	696,007	368	151,711	312	56	98.0	61.4		"
8-Sep	1,329,561	696,469	462	152,108	397	65	98.3	56.5		"
9-Sep	1,330,730	696,954	485	152,532	424	61	101.3	66.2		"

Temp 4 = Ambient air temperature in the morning
Temp 10 = Temperature of the digester
* Number of cows reflects the volume of manure fed to the digester based on the run time of the feed pump.

Table A-15. Manure Systems Analysis, Existing Liquid System without Storage Cost, Farber Farm.

Initial Investments and Fixed Cost Calculation — Real Interest Rate 0.05

Fixed Costs		Fixed costs		Fixed costs	
Initial Investment	0	Initial Investment	0	Initial Investment	0
Useful Life	0	Useful Life	0	Useful Life	0
Salvage Value	0	Salvage Value	0	Salvage Value	0
Interest Investment	0.05	Interest Investment	0.05	Interest Investment	0.05
Average Investment	0	Average Investment	0	Average Investment	0
Annual Interest charge	0	Annual Interest charge	0	Annual Interest charge	0
Depreciation	0	Depreciation	0	Depreciation	0

Fixed Costs	Spreaders, Liquid	Fixed costs		Fixed costs	Existing Equipment, pump
Initial Investment	14000	Initial Investment	0	Initial Investment	12000
Useful Life	8	Useful Life	0	Useful Life	6
Salvage Value	0	Salvage Value	0	Salvage Value	0
Interest Investment	0.05	Interest Investment	0.05	Interest Investment	0.05
Average Investment	7000	Average Investment	0	Average Investment	6000
Annual Interest charge	350	Annual Interest charge	0	Annual Interest charge	300
Depreciation	1750	Depreciation	0	Depreciation	2000

Total Annual Fixed Costs **$4,400**

Annual Operating Costs

Operating costs of manure system, over annual period, dollars

			Livestock Facility Removal	Manure Systems	Field Application
Repairs/Maintenance, including parts and service fees			0	1200	2000
Utilities			500	0	0
Gas			0	0	0
Hired Labor			0	0	0
Management Labor	$20/hr	346 hrs	0	6920	0
Owner Labor & Management			0	0	0
Fuel	included in Other below		0	0	0
Supplies			0	0	0
Consulting			0	0	0
Insurance			0	400	0
Taxes			0	0	0
Other	Tractor 25 dollars/ hr. (includes all costs), 346 hours		0	0	8650
		TOTAL of Columns	500	8520	10650

Total Annual Manure System Operating Costs **$19,670**

Operating costs of other systems impacted by manure system, such as crop enterprise, dairy enterprise, or overall business
Negative is a benefit

Bedding	0
Feed usage	0
Fertilizer	0
Herbicides	0
Crop Rotations	0
Tillage operations	0
Other Improved soils	0

Total Annual Operating Costs, Other Systems **0** Added to Total

Revenue Generation due to manure system

gas	0
electricity	0
solids	0
liquids	0
related farm products	0

Total Annual Revenue Generation due to Manure **0** Subtracted from Total

Total Annual Operating Costs **$19,670**

Total Annual Costs, All Areas **$24,070**

Table A-16. Manure Systems Analysis, Existing Liquid System with Storage Cost, Farber Farm.

Initial Investments and Fixed Cost Calculation — Real Interest Rate 0.05

Fixed Costs		Fixed costs	Concrete Storage	Fixed costs	
Initial Investment	0	Initial Investment	160000	Initial Investment	0
Useful Life	0	Useful Life	20	Useful Life	0
Salvage Value	0	Salvage Value	0	Salvage Value	0
Interest Investment	0.05	Interest Investment	0.05	Interest Investment	0.05
Average Investment	0	Average Investment	80000	Average Investment	0
Annual Interest charge	0	Annual Interest charge	4000	Annual Interest charge	0
Depreciation	0	Depreciation	8000	Depreciation	0

Fixed Costs	Spreaders, Liquid	Fixed costs		Fixed costs	Existing Equipment, pump
Initial Investment	14000	Initial Investment	0	Initial Investment	12000
Useful Life	8	Useful Life	0	Useful Life	6
Salvage Value	0	Salvage Value	0	Salvage Value	0
Interest Investment	0.05	Interest Investment	0.05	Interest Investment	0.05
Average Investment	7000	Average Investment	0	Average Investment	6000
Annual Interest charge	350	Annual Interest charge	0	Annual Interest charge	300
Depreciation	1750	Depreciation	0	Depreciation	2000

Total Annual Fixed Costs **$16,400**

Annual Operating Costs

Operating costs of manure system, over annual period, dollars

			Livestock Facility Removal	Manure Systems	Field Application
Repairs/Maintenance, including parts and service fees			0	1200	2000
Utilities			0	0	0
Gas			0	0	0
Hired Labor			0	0	0
Management Labor	$20/hr	346 hrs	0	6920	0
Owner Labor & Management			0	0	0
Fuel	included in Other below		0	0	0
Supplies			0	0	0
Consulting			0	0	0
Insurance			0	400	0
Taxes			0	0	0
Other	Tractor 25 dollars/ hr. (includes all costs), 346 hours		0	0	8650
		TOTAL of Columns	0	8520	10650

Total Annual Manure System Operating Costs **$19,170**

Operating costs of other systems impacted by manure system, such as crop enterprise, dairy enterprise, or overall business
Negative is a benefit

Bedding	0
Feed usage	0
Fertilizer	1500
Herbicides	0
Crop Rotations	0
Tillage operations	0
Other Improved soils	0

Total Annual Operating Costs, Other Systems **1500** Added to Total

Revenue Generation due to manure system

gas	0
electricity	0
solids	0
liquids	0
related farm products	0

Total Annual Revenue Generation due to Manure **0** Subtracted from Total

Total Annual Operating Costs **$20,670**

Total Annual Costs, All Areas **$37,070**

Table A-17. Manure Systems Analysis, Fixed Film AD System with Liquid Storage Cost, Farber Farm.

Initial Investments and Fixed Cost Calculation — Real Interest Rate 0.05

Fixed Costs	Manure Facility
Initial Investment	76800
Useful Life	15
Salvage Value	12100
Interest Investment	0.05
Average Investment	44450
Annual Interest charge	2223
Depreciation	4313

Fixed costs	Manure Facility Equipment
Initial Investment	63100
Useful Life	5
Salvage Value	14330
Interest Investment	0.05
Average Investment	38715
Annual Interest charge	1936
Depreciation	9754

Fixed costs	Concrete Storage
Initial Investment	160000
Useful Life	20
Salvage Value	0
Interest Investment	0.05
Average Investment	80000
Annual Interest charge	4000
Depreciation	8000

Fixed Costs	Spreaders, Liquid
Initial Investment	14000
Useful Life	10
Salvage Value	0
Interest Investment	0.05
Average Investment	7000
Annual Interest charge	350
Depreciation	1400

Fixed costs	Spreader, Solid, 1/3 of 8000
Initial Investment	2640
Useful Life	8
Salvage Value	0
Interest Investment	0.05
Average Investment	1320
Annual Interest charge	66
Depreciation	330

Fixed costs	Existing Equipment, pump
Initial Investment	12000
Useful Life	10
Salvage Value	0
Interest Investment	0.05
Average Investment	6000
Annual Interest charge	300
Depreciation	1200

Fixed costs	Small tractor, 30%, $30000
Initial Investment	10000
Useful Life	10
Salvage Value	0
Interest Investment	0.05
Average Investment	5000
Annual Interest charge	250
Depreciation	1000

Total Annual Fixed Costs **$35,122**

Annual Operating Costs

Operating costs of manure system, over annual period, dollars

		Livestock Facility Removal	Manure Systems	Field Application
Repairs/Maintenance, including parts and service fees		0	5600	1000
Utilities		2500	0	0
Gas		0	0	0
Hired Labor		0	0	0
Management Labor	$20/hr @ 462 hrs.	0	9240	0
Owner Labor & Management		0	0	0
Fuel	1.31 gal/hr, 180 hr, $1.40	0	330	0
Supplies		0	0	0
Consulting		0	0	0
Insurance		0	400	0
Taxes		0	0	0
Other	Tractor Rent, 25 dollars/hour (all inclusive), 264 hrs	0	0	6600
	TOTAL of Columns	2500	15570	7600

Total Annual Manure System Operating Costs **$25,670**

Operating costs of other systems impacted by manure system, such as crop enterprise, dairy enterprise, or overall business

Negative is a benefit

Bedding		0
Feed usage	Improve hay yield - more timely application of manure	-4500
Fertilizer		-1000
Herbicides		0
Crop Rotations		0
Tillage operations		0
Other	Improved soils	-1000

Total Annual Operating Costs, Other Systems **-$6,500** Added to Total

Revenue Generation due to manure system

gas		0
electricity		0
solids	solids sales	20000
liquids		0
related farm products		0

Total Annual Revenue Generation due to Manure **$20,000** Subtracted from Total

Total Annual Operating Costs **-$830**

Total Annual Costs, All Areas **$34,292**

Table A-18. Testing Methods for Chemical and Biological Properties.

Sampling / Monitoring Parameter	Test Method
Total Solids (TS)	EPA 160.3
Total Volatile Solids (TVS)	EPA 160.4
Total Phosphorous (TP)	EPA 365.3
Ortho Phosphorous (OP)	EPA 365.3
Total Kjeldahl Nitrogen (TKN)	EPA 351.4
Ammonia-Nitrogen (NH_3-N)	SM18 4500F
Organic N (ON)	By subtraction (TKN-NH_3-N)
Total Potassium (K)	EPA SW 846 6010
Total Copper (Cu)	SW846 6010
Fecal Coliform (F. Coli.)	SM18 9221E
Johne's Disease (MAP)	See footnote below
Volatile Acid (as Acetic Acid) (VA)*	SM18 5560C
Dissolved COD (DCOD)	SM18 5220B
Chemical Oxygen Demand (COD)	SM18 5220B
pH	SW846 9045

***** analyzed for acetic acid only

Laboratory tests were conducted by CES [Certified Environmental Services, Inc.], Syracuse, NY. Approved by the NYS Department of Health

* Assumes the density of raw manure and separated liquid to be 8.34 lbs/gal

APPENDIX B

Disclaimer

This report was prepared by the Watershed Agriculture Council in the course of performing work contracted for the New York State Energy Research and Development Authority (NYSERDA). However, any opinions, findings, conclusions or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of NYSERDA.

PUBLICATIONS

Weeks, S.A. 2002. Fixed-Film Digestion of Separated Diary Manure: Compost Drying of Separated Manure Solids: Progress Report. ASAE Annual Meeting Paper No. 024154. Chicago, IL: ASAE.

Weeks, S.A. 2003. Anaerobic Fixed-Film Digester System fro Dairy Manure. Northeast Agricultural & Biological Engineering Conference Paper No. 03-023. Storrs, CT: NABEC.