ENERGY EFFICIENCY STUDY
HIGH STRENGTH WASTEWATER PROCESSING
ROTHSCHILD AND PLOVER SITES
FOREMOST FARMS USA, INC.

FINAL REPORT

Prepared for:

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EXECUTIVE SUMMARY

The following is an energy efficiency study analysis to assess the feasibility of several methods recommended for managing high strength wastewaters at two (2) Foremost Farms USA, Inc. (FFU) facilities: one facility located in Rothschild, Wisconsin; and the second facility located in Plover, Wisconsin. Both sites generate a high strength wastewater that is presently managed by land application, and both facilities presently utilize on-site wastewater treatment facilities (WWTFs) to treat the majority of site process wastewaters and discharge the WWTF effluent, along with non-contact cooling water (NCCW), to surface water.

The Rothschild production facility performs liquid whey processing and lactose operations. These operations include membrane processing and drying operations for the production of whey by-products for pharmaceutical and other food manufacturers. The site also has material receipt and shipping operations at the facility. The Rothschild site manages most of its wastewater with an on-site wastewater treatment facility (WWTF) with discharge of effluent to the Wisconsin River under a WPDES permit.

The Plover production facility performs liquid whey operations. These operations include demineralization, condensing and drying operations. The Plover site manages most of its wastewater with an on-site wastewater treatment facility (WWTF) with discharge of effluent to the Wisconsin River under a WPDES permit.

INTRODUCTION

The objective of this study is to develop and analyze information to assist Foremost Farms USA in assessing alternatives for managing its high strength wastewater and potentially improving the operation of the WWTFs at its Rothschild and Plover sites.

High Strength Wastewater Characterization Data

Characterization data for the high strength wastewaters from the two (2) sites is tabulated in Table 1 below. This high strength wastewater is currently managed by land application at a cost of [redacted]/year for the Rothschild and Plover sites combined.

Biosolids from the on-site WWTFs are also a potential renewable energy source. The mass of biosolids can be reduced by anaerobic treatment in conjunction with high strength and process wastewaters. Such a strategy allows for increased energy production and reduced volumes of sludge for land disposal. Individual alternatives analyses shall include this provision.

Table 1
Foremost Farms, USA, Inc.
High Strength Wastewater Characterization

ITEM	ROTHSCHILD SITE	PLOVER SITE
High Strength Wastewater Production, gallons/day	[redacted]	[redacted]
Daily High Strength Land Application Costs	[redacted]/day	[redacted]/day
Chemical Oxygen Demand, mg/L	[redacted]	[redacted]
Chemical Oxygen Demand, lbs/day	57,500	25,500
Available Energy for Recovery, Therms/day	2,640	1,170
Potential Energy Revenue	$2,640/day	$1,170/day
Chlorides, mg/L	[redacted]	[redacted]
Chlorides, lbs/day	[redacted]	[redacted]
Phosphorus, mg/L	[redacted]	[redacted]
Phosphorus, lbs/day	[redacted]	[redacted]
Kjeldahl Nitrogen, mg/L	[redacted]	[redacted]
Kjehldahl Nitrogen, lbs/day	610	600

Note energy and excess nutrient calculations are based on 90 percent treatment efficiency of anaerobic pretreatment process. Potential energy value is based on $1.00/Therm.

Wastewater Treatment Facilities Descriptions

The Rothschild WWTF consists of the following major process operations:

- Influent Collection, Monitoring, Neutralization, and Distribution
- Enhanced Biological Phosphorous Removal
- Wastewater Processing with Activated Sludge System
- Clarifier Operation
- Dissolved Air Flotation Operation
- Primary Tank #2 / Clarifier #2 Effluent Polishing Operations
- Sludge Storage/Disposal Operation
- High Strength Waste Storage/Disposal Operation

The Plover WWTF consists of the following major process operations:

- Wastewater Receipt and Equalization;
- Enhanced Biological Phosphorus Removal;
- Wastewater Processing with Activated Sludge System – Aeration Basis 1&2;
- Waste Solids Thickening through Dissolved Air Floatation – Gravity Clarifier;
- Sludge Storage/Disposal Operations
- High Strength Waste Storage/Disposal Operation

WWTF Operating/Design Information at each site is tabulated in Table 2 below.

Table 2
Foremost Farms, USA, Inc.
WWTF Design/Operating Summary

	Rothschild		Plover	
Parameter	**Design Values**	**Operating Values**	**Design Values**	**Operating Values**
Flow, MGD (Average/Maximum)	0.345/0.691	0.193/0.360	0.511/0.606	0.298/0.544
COD, lbs/day (Average/Maximum)	3,000/6,000	1,650/8,136	19,400/48,600	12,700/33,000

Discharge Permit Information for both facilities is tabulated in Table 3 below.

Table 3
Foremost Farms, USA, Inc.
Site Discharge Permit Summary

	Rothschild				Plover			
Parameter	**Average Permit Limit**	**Maximum Permit Limit**	**Current Average /Month**	**Current Average /Month**	**Average Permit Limit**	**Maximum Permit Limit**	**Current Average /Month**	**Current Average /Month**
Effluent Receiving Body	Wisconsin River				Wisconsin River			
Permit Expiration Date	3/31/2009				12/31/2005			
Discharge in Regulated Outfall	Effluent NCCW				Effluent			
Average Design Discharge Flow, MGD	0.474							
Discharge Limits								
Biochemical Oxygen Demand, lbs/day	136	341	10.9	27.0	156	390	8.5	12.2
Total Suspended Solids, lbs/day	205	512	18.44	40	234	586	12.0	23.3
pH, range	6.0 to 9.0		7.16	7.6	6.0 to 9.0		6.74	7.10
Nitrogen Ammonia, mg/L-N			ND[1]	ND			5.13	9.65
Total Phosphorus, mg/L –P	1.0		0.547	0.66	5.0		4.3	8.2
Chlorides, mg/L	1,450 (Projected)		ND	ND	1,450 (Projected)		NO[2]	NO
Total Residual Chlorine, ug/l			NO	NO		38	NO	NO

[1]ND = No Data Available
[2]NO = No Occurrences

The following are conclusions regarding the characterization and WWTF information:

- The Rothschild site generates [redacted] gallons/day of high strength wastewater that is currently land applied at a cost of [redacted]/year. The high strength material represents 2,640 therms/day of potential recovered energy, with a value of $2,640/day @$1.00/therm ($963,600/year).
- Due to the relatively high chloride levels in both high strength wastewater streams, the high strength wastewaters would have to be blended with other process wastewaters to facilitate anaerobic treatment. At Rothschild, the wasted sludge from the aerobic system is to be treated in the anaerobic process to reduce the sludge volume for land disposal and to provide the chloride dilution factor.
- The Rothschild site WWTF discharges its effluent to the Wisconsin River, with its WPDES permit expiring on March 31, 2009. The permit discharge limitation for phosphorus is 1.0 milligrams per liter (mg/L). The site has a chloride limitation of approximately 1,400 mg/L. The WWTF has average reserve hydraulic capacity of 142,000 gallons/day; but, only reserve average oxygen transfer capacity of 1,350 pounds/day. Utilization of an anaerobic treatment operation at the site requires increasing the aeration capacity at the facility.
- The Plover site generates [redacted] gallons/day of high strength wastewater that is currently land applied at a cost of [redacted]/year. The high strength material represents 1,170 therms/day of potential recovered energy, with a value of $1,170/day ($427,000/year).
- The existing raw wastewater treated aerobically at the Plover WWTF is of a high strength which is compatible with anaerobic treatment in conjunction with high strength wastewaters. Bio-solids produced in the aerobic treatment process are also amenable to anaerobic processing. Anaerobic treatment of these combined waste streams at Plover accounts for 2,359 therms/day of potential recovered energy with a value of $2,359/day ($861,000/year). Additional sludge disposal and chemical cost savings are also projected.
- The Plover site WWTF discharges its effluent to the Wisconsin River, with its permit expiring December 31, 2005. It presently has a phosphorous discharge limitation of 5.0 mg/L which may be reduced to as low as 3 mg/L in the next permit. The existing WWTF is close to average hydraulic and organic capacity. However, utilization of an anaerobic treatment operation at the site will not require additional aeration capacity increase due to the WWTF's high existing capacity and the dramatic reduction of the current organic loading if it is first treated anaerobically.

METHOD

Based on the data analysis performed, the following alternatives have been identified and shall be analyzed for managing the high strength wastewaters and improving WWTF operations from the Foremost sites:

- **Alternative 1 – Rothschild High Strength Waste Treatment Process**
  - 1A: Rothschild Stream Only – Anaerobic Treatment w/Crystalactor®
  - 1B: Rothschild Stream Only – Anaerobic Treatment Only
  - 1C: Rothschild and Plover Combined – Anaerobic w/Crystalactor
  - 1D: Rothschild and Plover Combined – Anaerobic Only

- **Alternative 2 – Plover High Strength Waste Treatment Process**
    - 2A: Plover Stream Only – Anaerobic Treatment w/Crystalactor
    - 2B: Plover Stream Only – Anaerobic Treatment Only
    - 2C: Plover and Rothschild Combined – Anaerobic w/Crystalactor
    - 2D: Plover and Rothschild Combined – Anaerobic Only

- **Alternative 3 – Anaerobic Reactors on Each Site**
    - 3A: Anaerobic with Crystalactor at Each Site
    - 3B: Anaerobic Only at Each Site

This section provides process information in relation to the strategies for renewable energy production and improved wastewater management at the Rothschild and Plover sites.

Alternative 1: Rothschild High Strength Waste Treatment Facility Location
In this alternative, high strength wastewater would be treated at an anaerobic treatment operation built at the Rothschild production facility. Effluent from the anaerobic treatment operation would undergo further treatment at the existing Rothschild WWTF prior to surface water (river) discharge. Biogas recovered from the anaerobic treatment operation would be utilized by the Rothschild production facility, with a small portion being used to heat the anaerobic treatment operation. Several variations of this alternative are described as follows:

<u>1A – Rothschild Only Anaerobic/Crystalactor Process</u>

Under this strategy, an anaerobic treatment operation designed to treat only Rothschild high strength and other site generated process wastewaters would be constructed and operated at the Rothschild site. A Crystalactor process would be used to remove phosphorus from the anaerobic effluent in the onsite activated sludge aerobic wastewater treatment facility.

<u>1B - Rothschild Only Anaerobic Process</u>

Under this option, Rothschild high strength wastewater would undergo phosphorus removal, via a recovery process at the production facility, prior to being processed through an anaerobic treatment operation designed to treat only Rothschild high strength and other selected process wastewaters would be constructed and operated at the Rothschild site.

<u>1C - Combined Anaerobic/Crystalactor® Process</u>

Under this option, an anaerobic treatment operation designed to treat high strength wastewater from the Plover and Rothschild sites and other Rothschild process wastewaters would be constructed and operated at the Rothschild site. A Crystalactor phosphorus removal process would be provided similar to activated sludge with Alternative 1A above.

<u>1D - Combined Anaerobic Process</u>

Under this option, Rothschild and Plover high strength wastewaters would undergo phosphorus removal via a recovery process at the Rothschild production facility. The wastewaters would then be processed through an anaerobic treatment operation designed to also treat other Rothschild process wastewaters that would be constructed and operated at the Rothschild site.

Alternative 2 - Plover High Strength Waste Treatment Facility Location

In this alternative, high strength wastewater and site generated process wastewaters would be treated at an anaerobic treatment operation built at the Plover production facility. Effluent from the anaerobic treatment operation would undergo further treatment at the existing Plover WWTF prior to surface water (river) discharge. Biogas recovered from the anaerobic treatment operation would be utilized by the Plover production facility, with a small portion being used to heat the anaerobic treatment operation. Several variations of this alternative are described as follows:

<u>2A - Plover Only Anaerobic/Crystalactor Process</u>

Under this option, an anaerobic treatment operation designed to treat only Plover high strength and process wastewaters would be constructed and operated at the Plover site. A Crystalactor process would be used to remove phosphorus from the anaerobic effluent in the onsite activated sludge aerobic wastewater treatment facility.

<u>2B - Plover Only Anaerobic Process</u>

Under this option, Plover high strength wastewater only would undergo phosphorus removal, via a recovery process at the Plover production facility, prior to being processed through an anaerobic treatment operation. The anaerobic process would be designed to treat Plover high strength and process wastewaters and would be constructed and operated at the Plover site.

<u>2C - Combined Anaerobic/Crystalactor Process</u>

Under this option, an anaerobic treatment operation designed to treat high strength wastewaters from both the Plover and Rothschild sites and the balance of the Plover process wastewaters would be constructed and operated at the Plover site. A Crystalactor phosphorus removal process would be provided similar to that included with Alternative 2A above.

<u>2D - Combined Anaerobic Process</u>

Under this option, Rothschild and Plover high strength wastewaters would undergo phosphorus removal, via a recovery process at the Plover production facility. The wastewaters would then be processed through an anaerobic treatment operation designed to also treat Plover process wastewaters that would be constructed and operated at the Plover site.

Alternative 3 – Anaerobic Reactors on Each Site

In this alternative, high strength wastewater would be treated at anaerobic treatment operations built at both the FFU Plover site and the FFU Rothschild site. Effluent from the anaerobic treatment operations at each site would undergo further treatment at the existing WWTFs prior to surface water (river) discharge. Biogas recovered from the anaerobic treatment operations would be utilized by each respective production facility, with a small portion being used to heat the anaerobic treatment operations.

3A – Anaerobic/Crystalactor Process (Combination of 1A & 2A)

Under this strategy, anaerobic treatment operations located at each site will be designed to treat high strength and other site generated process wastewaters. A Crystalactor process would be used to remove phosphorus from the anaerobic effluent in the onsite activated sludge aerobic wastewater treatment facility.

3B – Anaerobic Process (Combination of 1B & 2B)

Under this option, high strength wastewaters at each facility would undergo phosphorus removal via a recovery process built at each sites WWTF prior to being processed through an anaerobic treatment operation. The anaerobic process would be designed to treat high strength and process wastewaters and would be constructed and operated at each site.

RESULTS

1A – Rothschild Only Anaerobic/Crystalactor Process

The anaerobic treatment operation with the Crystalactor consists of the following unit operations:

- Phosphorus removal by use of the Crystalactor followed by the anaerobic process. The Crystalactor is a fluidized bed crystallization process that utilizes no mechanical parts, has high chemical efficiency, and produces self-dewatering treatment solids which are approximately 95 percent solids and 90 percent pure. Effluent with approximately 10 mg/L phosphorus would be produced;
- Anaerobic Treatment through a jet mixed anaerobic reactor;
- Solids / liquid separation of anaerobic mixed liquor with a membrane process; The membrane unit would produce effluent with virtually no suspended solids and sufficient hydraulic head for phosphorus and aerobic biological polishing operations;
- The anaerobic process is expected to remove 90-95% of the COD loading;
- The anaerobic effluent will add up to an additional 4,500 lbs-COD/day, on average, into the aerobic system;
- Aerobic biological treatment of Crystalactor and anaerobic effluent with the existing site WWTF prior to surface water discharge;
- The loading analysis is listed in the following Table 4;
- Waste solids from the existing WWTF would be digested in the anaerobic digester for volume reduction, chloride dilution and energy recovery;
- Gas recovery; with condensate knock-out for gas recovery operations (see Section 4.0 for energy analysis.);
- Solids thickening of waste anaerobic sludge (WAS) with a rotary drum thickener and utilization of the existing sludge silo for storage of thickened solids prior to land application;
- Gas utilized in dual fuel steam boiler.

☐ This alternative effectively utilizes the installed WWTF at the site and is recommended as a technically feasible alternative.

Table 4
Alternative 1A- Rothschild Loading Analysis
Rothschild Only - Anaerobic/Crystalactor

		Anaerobic Influent				Anaerobic / Crystalactor Effluent	
Site		**Flow (mgd)**	**COD (lbs/day)**	**P (lbs/day)**	**Cl (mg/L)**	**COD* (lbs/day)**	**P** (lbs/day)**
Rothschild	Wastewater	[redacted]	1,650	21	270	165	14
	HS	[redacted]	57,500	870	13,000	5,800	3
	Sludge	[redacted]	4,420	63	685	442	1
	NCCW	[redacted]					
Plover	Wastewater	[redacted]	0	0	0	0	0
	HS	[redacted]	0	0	0	0	0
	Sludge	[redacted]	0	0	0	0	0
	NCCW	[redacted]					
	Total WTP Effluent	**0.460**	**63,570**	**954**		**6,407*** **	**18**

** 90-95% COD Removal*
*** 10 mg-P/L at Crystalactor Effluent*
**** Note: Existing Rothschild WWTP design average >3,000 lbs-COD/day; peak ≥6,000 lbs-COD/day*

1B - Rothschild Only Anaerobic Process

The anaerobic treatment operation consists of the following unit operations:

- Phosphorus recovery from high strength wastewater in the factory;
- Anaerobic Treatment through a jet mixed anaerobic reactor;
- Solids / liquid separation of anaerobic mixed liquor with a membrane process; The membrane unit would produce effluent with virtually no suspended solids and with sufficient hydraulic head to accommodate phosphorus and aerobic biological polishing operations without additional pumping;
- The anaerobic system is expected to remove 90-95% of COD loading;
- The anaerobic effluent will add up to an additional 4,500 lbs/day of COD, on average, into the aerobic system;
- Aerobic biological treatment of the anaerobic treatment operation effluent with the existing site WWTF prior to surface water discharge. Waste solids from the existing WWTF would be digested in the anaerobic digester for volume reduction and energy recovery;
- Phosphorus removal of the combined wastewater would also be performed through the existing WWTF;
- Chemical (ferric, alum) is expected to be added for phosphorus removal. The loading analysis is listed in Table 5;
- Gas recovery; with condensate knock-out for gas recovery operations (see Section 4.0 for energy analysis.);
- Solids thickening of the WAS with a rotary drum thickener and utilization of the existing sludge silo for storage of thickened solids prior to land application;

- Gas utilized in dual fuel steam boiler.

☐ This alternative effectively utilizes the installed WWTF at the site for treatment of organic loads. Phosphorus must be removed from the high strength wastewaters at the factory if this alternative is to be recommended as a technically feasible alternative. The existing WWTP, with a 1.0 mg-P/L effluent limit, could not manage the mass of phosphorus in the high strength wastewater without phosphorus recovery in the factory.

Table 5
Alternative 1B – Rothschild Loading Analysis
Rothschild Only - Anaerobic

		Anaerobic Influent				**Anaerobic Effluent**	
Site		**Flow (mgd)**	**COD (lbs/day)**	**P (lbs/day)**	**Cl (mg/L)**	**COD* (lbs/day)**	**P** (lbs/day)**
Rothschild	Wastewater	[redacted]	1,650	21	270	165	18
	HS	[redacted]	57,500	3	13,000	5,800	3**
	Sludge	[redacted]	4,420	63	685	442	54
	NCCW	[redacted]					
Plover		[redacted]	0	0	0	0	0
	HS	[redacted]	0	0	0	0	0
	Sludge	[redacted]	0	0	0	0	0
	NCCW	[redacted]					
	Total	**0.460**	**63,570**	**87**		**6,407*****	**75**

** 90-95% COD Removal*
*** COD:P = 1000:2 in Anaerobic; factory recovery to <10-mg-P/L*
**** Note: Existing Rothschild WWTP design average >3,000 lbs-COD/day; peak ≥6,000 lbs-COD/day*

1C - Combined Anaerobic/Crystalactor Process

The anaerobic treatment operation on the combined Plover and Rothschild high strength wastestreams consists of the following unit operations:

- Anaerobic Treatment through a jet mixed anaerobic reactor;
- Solids / liquid separation of anaerobic mixed liquor with a membrane process; The membrane unit would produce effluent with virtually no suspended solids and sufficient hydraulic head for phosphorus and aerobic biological polishing operations;
- Phosphorus removal by use of the Crystalactor. Effluent with approximately 10 mg/L phosphorus would be produced;
- Aerobic biological treatment of Crystalactor effluent with the existing site WWTF prior to surface water discharge. The anaerobic effluent would add up to 7,700 lbs of COD loading per day to the existing aerobic WWTF. Additional aeration capacity would need to be installed in the existing WWTF to handle the increased organic loading from treating the high strength wastewater from both sites.
- Waste solids from the existing WWTF would be digested in the anaerobic digester for volume reduction and energy recovery. The loading analysis is listed in Table 6;

- Gas recovery; with condensate knock-out for gas recovery operations (see Section 4.0 for energy analysis.);
- Solids thickening of WAS with a rotary drum thickener and utilization of existing sludge silo for storage of thickened solids prior to land application;
- Gas utilized in dual fuel steam boiler.

☐ Site constraints and the increased organic loading rates to the existing WWTFs present implementation difficulties for this alternative. This alternative is not recommended for implementation.

Table 6
Alternative 1C – Rothschild Loading Analysis
Combined - Anaerobic/Crystalactor

		Anaerobic Influent				**Anaerobic Effluent**	
Site		**Flow (mgd)**	**COD (lbs/day)**	**P (lbs/day)**	**Cl (mg/L)**	**COD* (lbs/day)**	**P** (lbs/day)**
Rothschild	Wastewater	[redacted]	1,650	21	270	165	14
	HS	[redacted]	57,500	870	13,000	5,800	3
	Sludge	[redacted]	4,420	63	685	442	1
	NCCW	[redacted]					
Plover	Wastewater	[redacted]	0	0	0	0	0
	HS	[redacted]	32,000	626	3,400	3,200	5
	Sludge	[redacted]					
	NCCW	[redacted]					
	Total	**0.487**	**95,579**	**1,580**		**9,607*****	**23**

** 90-95% COD Removal*
*** 10 mg-P/L at Crystalactor Effluent*
**** Note: Existing Rothschild WWTP design average >3,000 lbs-COD/day; peak ≥6,000 lbs-COD/day*

<u>1D - Combined Anaerobic Process</u>

The anaerobic treatment operation on the combined Plover and Rothschild wastestreams consists of the following unit operations:

- Phosphorus recovery from high strength wastewater in the factory;
- Anaerobic Treatment through a jet mixed anaerobic reactor;
- Solids / liquid separation of anaerobic mixed liquor with a membrane process; The membrane unit would produce effluent with virtually no suspended solids and sufficient hydraulic head for phosphorus and aerobic biological polishing operations;
- Aerobic biological treatment of the anaerobic treatment operation effluent with the existing site WWTF prior to surface water discharge. The anaerobic effluent would add up to 7,700 lbs of COD loading per day to the existing aerobic WWTF. Additional aeration capacity would need to be installed in the existing WWTF to handle the increased organic loading from treating the high strength wastewater from both sites.
- Waste solids from the existing WWTF would be digested in the anaerobic digester for volume reduction and energy recovery. The loading analysis is listed in Table 6;
- Additional aeration capacity would be installed in the existing WWTF to handle the increased organic loading from treating the high strength wastewaters from both

sites. Waste solids from the existing WWTF would be digested in the anaerobic digester for volume reduction and energy recovery. Phosphorus removal from the combined wastewater would also be performed through the existing WWTF. The loading analysis is listed in Table 7;

- Gas recovery; with condensate knock-out for gas recovery operations (see Section 4.0 for energy analysis.);
- Solids thickening of the WAS with a rotary drum thickener and utilization of existing sludge silo for storage of thickened solids prior to land application;
- Gas utilized in dual fuel steam boiler.

☐ Site constraints and the increased organic loading rates to the existing WWTFs present implementation difficulties for this alternative. Phosphorus would need to be removed from high strength wastewater in the factory. This alternative is not recommended for implementation.

Table 7
Alternative 1D – Rothschild Loading Analysis
Combined - Anaerobic

		Anaerobic Influent				Anaerobic Effluent	
Site		**Flow (mgd)**	**COD (lbs/day)**	**P (lbs/day)**	**Cl (mg/L)**	**COD* (lbs/day)**	**P** (lbs/day)**
Rothschild	Wastewater	[redacted]	1,650	21	270	165	18
	HS		57,500	3	13,000	5,800	3**
	Sludge		4,420	63	685	442	54
	NCCW						
Plover	Wastewater		0	0	0	0	0
	HS		32,000	60	3,400	3,200	60**
	Sludge						
	NCCW						
	Total	**0.487**	**95,570**	**147**		**9,607*** **	**135**

** 90-95% COD removal*
*** COD : p = 1,000 : 2*
**** Note: Existing Rothschild WWTP design average >3,000 lbs-COD/day; peak ≥6,000 lbs-COD/day*

2A - Plover Only Anaerobic/Crystalactor Process

The anaerobic treatment operation for only Plover high strength and process wastewaters with Crystalactor at the Plover site consists of the following unit operations:

- Anaerobic Treatment through a jet mixed anaerobic reactor;
- Solids / liquid separation of the anaerobic mixed liquor with a membrane process; The membrane unit would produce effluent with virtually no suspended solids and sufficient hydraulic head for phosphorus and aerobic biological polishing operations;
- Phosphorus removal by use of the Crystalactor. The Crystalactor is a fluidized bed crystallization process that utilizes no mechanical parts, has high chemical efficiency, and produces self-dewatering treatment solids which is approximately 95 percent solids and ninety percent pure. Effluent with approximately 10 mg/L phosphorus would be produced;

- Aerobic biological treatment of anaerobic/Crystalactor effluent with the existing site WWTF prior to surface water discharge. Additional aeration capacity would <u>not</u> need to be installed in the existing WWTF to handle the **<u>decreased</u>** organic loading from treating the process and high strength wastewaters. Organic loading to the existing WWTF would be decreased by **<u>14,260 lbs-COD/day</u>** or nearly **<u>75%</u>**.
- The reduced mass of waste solids from the existing WWTF would be digested in the anaerobic digester for volume reduction and energy recovery. The loading analysis is listed in Table 8;
- Gas recovery; with condensate knock-out for gas recovery operations (see Section 4.0 for energy analysis.);
- Solids thickening of the WAS with a rotary drum thickener and utilization of existing sludge silo for storage of thickened solids prior to land application;
- Gas utilized in a dual fuel steam boiler.

☐ This alternative decreases the organic and phosphorus loadings to the existing WWTF. Operation costs should be reduced. This alternative is recommended as technically feasible.

Table 8
Alternative 2A - Plover Loading Analysis
Anaerobic/Crystalactor

		Anaerobic Influent				**Anaerobic / Crystalactor Effluent**	
Site		**Flow (mgd)**	**COD (lbs/day)**	**P (lbs/day)**	**CL (mg/L)**	**COD* (lbs/day)**	**P** (lbs/day)**
Rothschild	Wastewater	[redacted]	0	0	0	0	0
	HS	[redacted]	0	0	0	0	0
	Sludge	[redacted]	0	0	0	0	0
	NCCW	[redacted]					
Plover	Wastewater	[redacted]	19,400	500	1,200	1,940	42
	HS	[redacted]	32,000	626	3,400	3,200	2
	Sludge	[redacted]					
	NCCW	[redacted]					
	Total	**0.951**	**51,400**	**1,126**		**5,140*** **	**44**

** 90-95% COD removal*
*** 10 mg-P/L at Crystalactor Effluent*
**** Existing Plover WWTP design average =19,400 lbs-COD/day; peak ≥ 48,600 lbs-COD/day*

<u>2B - Plover Only Anaerobic Process</u>

The anaerobic treatment operation for only Plover high strength and process wastewaters at the Plover site consists of the following unit operations:

- Phosphorus would be removed from Plover high strength wastewaters only via a recovery process at the Plover production facility;
- Anaerobic Treatment through a jet mixed anaerobic reactor;

- Solids / liquid separation of the anaerobic mixed liquor with a membrane process; The membrane unit would produce effluent with virtually no suspended solids and sufficient hydraulic head for phosphorus and aerobic biological polishing operations;
- Aerobic biological treatment of the anaerobic treatment operation effluent with the existing site WWTF prior to surface water discharge. No additional aeration capacity would be necessary in the existing WWTF to handle the organic loading which will have been <u>**decreased**</u> by nearly <u>**75%**</u> by anaerobically pretreating the high strength and process wastewaters;
- The reduced mass of waste solids from the existing WWTF would be digested in the anaerobic digester for volume reduction and energy recovery. Phosphorus removal of the combined wastewater would continue to be performed through the existing WWTF. The loading analysis is listed in Table 9;
- Gas recovery; with condensate knock-out for gas recovery operations;
- Solids thickening of the WAS with a rotary drum thickener and utilization of existing sludge silo for storage of thickened solids prior to land application;
- Gas utilized in a dual fuel steam boiler.

☐ This alternative decreases the organic and phosphorus loadings to the existing WWTF. Operation costs should be reduced. This alternative is recommended as technically feasible.

☐ The existing WWTF shall continue to use ferric precipitation to remove phosphorus. The chemical and sludge removal costs for this operation shall remain unchanged.

Table 9
Alternative 2B - Plover Loading Analysis
Anaerobic

		Anaerobic Influent				**Anaerobic Effluent**	
Site		**Flow (mgd)**	**COD (lbs/day)**	**P (lbs/day)**	**Cl (mg/L)**	**COD* (lbs/day)**	**P** (lbs/day)**
Rothschild	Wastewater	[redacted]	0	0	0	0	0
	HS	[redacted]	0	0	0	0	0
	Sludge	[redacted]	0	0	0	0	0
	NCCW	[redacted]					
Plover	Wastewater	[redacted]	19,400	500	1,200	1,940	461
	HS	[redacted]	32,000	60	3,400	3,200	60
	Sludge	[redacted]					
	NCCW	[redacted]					
	Total	**0.951**	**51,400**	**560**		**5,140*** **	**521**

** 90-95% COD removal*
*** COD : p = 1,000 : 2*
**** Existing Plover WWTP design average =19,400 lbs-COD/day; peak ≥ 48,600 lbs-COD/day*

<u>2C - Combined Anaerobic/Crystalactor Process</u>

The anaerobic treatment operation w/Crystalactor on the combined Rothschild and Plover high strength wastestreams and the Plover process wastewaters consist of the following unit operations:

- Anaerobic Treatment through a jet mixed anaerobic reactor;
- Solids / liquid separation of the anaerobic mixed liquor with a membrane process; The membrane unit would produce effluent with virtually no suspended solids and sufficient hydraulic head for phosphorus and aerobic biological polishing operations;
- Phosphorus removal by use of the Crystalactor. Effluent with approximately 10 mg/L phosphate phosphorus would be produced;
- Aerobic biological treatment of the anaerobic/Crystalactor effluent with the existing site WWTF prior to surface water discharge. Organic loading to the existing WWTF would be **<u>reduced</u>** by approximately 7,600 lbs-COD/day or **<u>40%</u>**. No Additional aeration capacity would be necessary in the existing WWTF to handle the **decreased** organic loading from treating the high strength wastewater.
- The reduced mass of waste solids from the existing WWTF would be digested in the anaerobic digester for volume reduction and energy recovery. The loading analysis is listed in Table 10;
- Gas recovery; with condensate knock-out for gas recovery operations (see Section 4.0 for energy analysis.);
- Solids thickening of the WAS with a rotary drum thickener and utilization of existing sludge silo for storage of thickened solids prior to land application;
- Gas utilized in dual fuel steam boiler.

☐ This alternative makes greater use of the existing WWTF. Trucking of high strength wastewaters from Rothschild is a detriment. This alternative is feasible from a technical point of view.

Table 10
Alternative 2C – Plover Loading Analysis
Combined - Anaerobic/Crystalactor

		Anaerobic Influent				**Anaerobic / Crystalactor Effluent**	
Site		**Flow (mgd)**	**COD (lbs/day)**	**P (lbs/day)**	**Cl (mg/L)**	**COD* (lbs/day)**	**P** (lbs/day)**
Rothschild	Wastewater	[redacted]	0	0	0	0	0
	HS	[redacted]	57,500	870	13,000	5,800	3
	Sludge	[redacted]	4,420	63	685	442	1
	NCCW	[redacted]					
Plover	Wastewater	[redacted]	19,400	500	1,200	1,940	42
	HS Sludge	[redacted]	32,000	626	3,400	3,200	5
	NCCW	[redacted]					
	Total	**0.990**	**113,320**	**2,059**		**11,382*** **	**51**

** 90-95% COD removal*
*** 10 mg-p/L at Crystalactor Effluent*
**** Existing Plover WWTP design average =19,400 lbs-COD/day; peak ≥ 48,600 lbs-COD/day*

<u>2D - Combined Anaerobic Process</u>

The anaerobic treatment operation on the combined Rothschild and Plover high strength wastestreams and the Plover process wastewaters consist of the following unit operations:

- Phosphorus would be removed from the high strength wastewaters at the factory(s) prior to being delivered to the proposed WWTF.
- Anaerobic Treatment through a jet mixed anaerobic reactor;
- Solids / liquid separation of the anaerobic mixed liquor with a membrane process; The membrane unit would produce effluent with virtually no suspended solids and sufficient hydraulic head for phosphorus and aerobic biological polishing operations;
- Aerobic biological treatment of the anaerobic treatment operation effluent with the existing site WWTF prior to surface water discharge. Organic loading to the existing WWTF would be **reduced** by approximately 8,000 lbs-COD/day or **40%**. No additional aeration capacity would be required in the existing WWTF to handle the **decreased** organic loading from treating the high strength wastewater.
- The reduced mass of waste solids from the existing WWTF would be digested in the anaerobic digester for volume reduction and energy recovery. Phosphorus removal of the combined wastewater would also be performed through the existing WWTF. The loading analysis is listed in Table 11;
- Gas recovery; with condensate knock-out for gas recovery operations (see Section 4.0 for energy analysis.);
- Solids thickening of the WAS with a rotary drum thickener and utilization of existing sludge silo for storage of thickened solids prior to land application;
- Gas utilized in dual fuel steam boiler.

☐ This alternative makes greater use of the existing WWTF. Trucking of high strength wastewaters from Rothschild is a detriment. The alternative is feasible from a technical point of view.

☐ The existing ferric phosphorus precipitation process shall continue to be used to remove a similar mass of phosphorus to that which is currently achieved. The cost and complications of the existing phosphorus removal process would continue.

Table 11
Alternative 2D – Plover Loading Analysis
Combined - Anaerobic

		Anaerobic Influent				**Anaerobic Effluent**	
Site		**Flow (mgd)**	**COD (lbs/day)**	**P (lbs/day)**	**CL (mg/L)**	**COD* (lbs/day)**	**P** (lbs/day)**
Rothschild	Wastewater	[redacted]	0	0	0	0	0
	HS		57,500	3	13,000	5,800	3
	Sludge		4,420	60	685	442	54
	NCCW						
Plover	Wastewater		19,400	500	1,200	1,940	461
	HS		32,000	60	3,400	3,200	60
	Sludge						
	NCCW						
	Total	**0.990**	**113,320**	**623**		**11.382*** **	**579**

** 90-95% COD removal*
*** 10 mg-p/L at Crystalactor Effluent*
**** Existing Plover WWTP design average =19,400 lbs-COD/day; peak ≥ 48,600 lbs-COD/day*

3A - Anaerobic/Crystalactor Process (Combination of 1A & 2A)

Building an anaerobic treatment operation with Crystalactor at each of the manufacturing facilities for FFU Plover and FFU Rothschild for treatment of high strength wastestreams and process wastewaters respectively consist of the following operations at each site:

- Anaerobic Treatment through a jet mixed anaerobic reactor;
- Solids / liquid separation of the anaerobic mixed liquor with membrane processes; The membrane units would produce effluent with virtually no suspended solids and sufficient hydraulic head for phosphorus and aerobic biological polishing operations;
- Phosphorus removal by use of the Crystalactor. Effluent with approximately 10 mg/L phosphate phosphorus would be produced;
- Aerobic biological treatment of the anaerobic treatment operation effluent with the existing site WWTFs prior to surface water discharge. No additional aeration capacity would be required in the existing WWTFs to handle the residual organic loading from anaerobically treating the high strength and process wastewater.
- The reduced mass of waste solids from the existing WWTFs would be digested in the anaerobic digester for volume reduction and energy recovery. Phosphorus removal of the combined wastewater would also be performed through the existing WWTFs. The loading analysis is listed in Table 12;
- Gas recovery; with condensate knock-out for gas recovery operations (see Section 4.0 for energy analysis.);
- Solids thickening of the WAS with a rotary drum thickener and utilization of existing sludge silo for storage of thickened solids prior to land application;
- Gas utilized in dual fuel steam boiler.

☐ This alternative effectively utilizes the installed WWTF at the site and is recommended as a technically feasible alternative.

Table 12
Alternative 3A –Loading Analysis for Independent
Anaerobic Digester Treatment at Each Site (Plover and Rothschild)
Followed by Crystalactor Phosphorus Removal Technology

		Anaerobic Influent				**Anaerobic / Crystalactor Effluent**	
Site		**Flow (mgd)**	**COD (lbs/day)**	**P (lbs/day)**	**Cl (mg/L)**	**COD* (lbs/day)**	**P** (lbs/day)**
Rothschild	Wastewater	[redacted]	1,650	21	270	165	14
	HS	[redacted]	57,500	3	13,000	5,800	3
	Sludge	[redacted]	4,420	63	685	442	1
	NCCW	[redacted]					
	Total WTP Rothschild Effluent	**0.460**	**63,570**	**87**		**6,407*** **	**18**

** 90-95% COD Removal*
*** 10 mg-P/L at Crystalactor Effluent*
**** Existing Plover WWTP design average =19,400 lbs-COD/day; peak ≥ 48,600 lbs-COD/day*

		Anaerobic Influent				Anaerobic / Crystalactor Effluent	
Site		**Flow (mgd)**	**COD (lbs/day)**	**P (lbs/day)**	**CL (mg/L)**	**COD* (lbs/day)**	**P** (lbs/day)**
Plover	Wastewater	[redacted]	19,400	500	1,200	1,940	42
	HS		32,000	60	3,400	3,200	2
	Sludge						
	NCCW						
	Total WTP Plover Effluent	**0.951**	**51,400**	**1,126**		**5,140*** **	**44**

** 90-95% COD removal*
*** 10 mg-P/L at Crystalactor Effluent*
**** Existing Plover WWTP design average =19,400 lbs-COD/day; peak ≥48,600 lbs-COD/day*

<u>3B - Anaerobic Process (Combination of 1B & 2B)</u>

Building an anaerobic treatment operation at each of the manufacturing facilities for FFU Plover and FFU Rothschild for treatment of high strength wastestreams and process wastewaters respectively consist of the following operations at each site:

- Phosphorus recovery from high strength wastewater in the factory;
- Anaerobic Treatment through a jet mixed anaerobic reactor;
- Solids / liquid separation of the anaerobic mixed liquor with a membrane process; The membrane unit would produce effluent with virtually no suspended solids and sufficient hydraulic head for phosphorus and aerobic biological polishing operations;
- Aerobic biological treatment of the anaerobic treatment operation effluent with the existing site WWTFs prior to surface water discharge. No additional aeration capacity would be required in the existing WWTFs to handle the organic loading from anaerobically treating the high strength wastewater.
- The reduced mass of waste solids from the existing WWTFs would be digested in the anaerobic digester for volume reduction and energy recovery. Phosphorus removal of the combined wastewater would also be performed through the existing WWTFs. The loading analysis is listed in Table 13;
- Gas recovery; with condensate knock-out for gas recovery operations (see Section 4.0 for energy analysis.);
- Solids thickening of the WAS with a rotary drum thickener and utilization of existing sludge silo for storage of thickened solids prior to land application;
- Gas utilized in dual fuel steam boiler.

☐ This alternative effectively utilizes the installed WWTF at the site and is recommended as a technically feasible alternative so long as phosphorus is recovered from the high strength wastewaters in the factory.

☐ This alternative effectively utilizes the installed WWTF at the site for treatment of organic loads. Phosphorus must be removed from the high strength wastewaters at the factory if this alternative is to be recommended as a technically feasible alternative. The existing WWTP, with a 1.0 mg-P/L effluent limit, could not manage the mass of phosphorus in the high strength wastewater without phosphorus recovery in the factory.

Table 13
Alternative 3B – Loading Analysis for Independent Anaerobic Digester Treatment at Each Site (Plover and Rothschild)

		Anaerobic Influent				Anaerobic Effluent	
Site		Flow (mgd)	COD (lbs/day)	P (lbs/day)	Cl (mg/L)	COD* (lbs/day)	P** (lbs/day)
Rothschild	Wastewater	[redacted]	165	21	270	165	18
	HS	[redacted]	57,500	870	13,000	5,800	3
	Sludge	[redacted]	4,420	63	685	442	54
	NCCW	[redacted]					
	Total	**0.460**	**63,570**	**954**		**6,407*** **	**75**

** 90-95% COD Removal*
*** COD:P = 1000:2 in Anaerobic*
**** Note: Existing Rothschild WWTP design average >3,000 lbs-COD/day; peak ≥6,000 lbs-COD/day*

		Anaerobic Influent				Anaerobic Effluent	
Site		Flow (mgd)	COD (lbs/day)	P (lbs/day)	Cl (mg/L)	COD* (lbs/day)	P** (lbs/day)
Plover	Wastewater	[redacted]	19,400	500	1,200	1,940	461
	HS	[redacted]	32,000	626	3,400	3,200	60
	Sludge	[redacted]					
	NCCW	[redacted]					
	Total	**0.951**	**51,400**	**1,126**		**5,140*** **	**521**

** 90-95% COD removal*
*** COD : p = 1,000 : 2*
**** Existing Plover WWTP design average =19,400 lbs-COD/day; peak ≥ 48,600 lbs-COD/day*

DISCUSSION

The possibilities reviewed, within each scenario, were done so in significant detail due to the potential variances in capital expenditures, the impact of this project on one or both manufacturing sites, and to determine the potential energy and overall technical and financial advantages of each option. Table 14 below, outlines the scenarios as studied by Foremost Farms and compares Alternatives 1 (A-D), 2 (A-D) and 3 relative to the renewable energy potential.

Table 14
Alternative Comparison Summary
Renewable Energy Value Tabulation

			Anaerobic Process					Anaerobic Energy Summary						
ALT. ID	**Description**	**Process Notes**	COD #/day	Load-ing Kg/M^3	Reactor Volume (gallons)	Tanks Rqd. (1MG max)	Tank Dia. 40' Max SWD.	% COD Reduction	Biogas @ 8.5 CF/#COD CF/Day	Mbtu/ Day @ 600 Btu/CF	Mbtu/ Hr	Approx. Boiler HP Equivalent	Gas Value @$1.00/ Therm $/day	Gas Value $/yr
1A	**Rothschild Only Anaerobic/ Crystalactor**	Full flow AD with MBR SLS with WAS to AD. Biogas to steam boiler. Crystalactor to process MBR Permeate	63,570	6	1,268,862	1	73	90%	486,311	292	12.16	300	$ 2,918	$ 1,065,020
1B	**Rothschild Only Anaerobic**	Full flow AD with MBR SLS with WAS to AD. Biogas to steam boiler. P removal w/ FeCl	63,570	6	1,268,862	1	73	90%	486,311	292	12.16	300	$ 2,918	$ 1,065,020
1C	**Rothschild Combined w/ Plover HS Crystalactor**	Full Flow AD with MBR SLS and Plover HS with WAS to AD. Crystalactor to process MBR permeate. Biogas to steam boiler.	95,570	6	1,907,585	2	64	90%	731,111	439	18.28	400	$ 4,387	$ 1,601,132
1D	**Rothschild Combined w/ Plover HS**	Full Flow AD with MBR SLS and Plover HS with WAS to AD. Biogas to steam boiler. P removal w/ FeCl	95,570	6	1,907,585	2	64	90%	731,111	439	18.28	400	$ 4,387	$ 1,601,132
2A	**Plover Only Anaerobic/ Crystalactor**	HS AD with MBR and LS Dilution for Cl Control. WAS to AD. Biogas to steam boiler. Crystalactor to process MBR permeate	51,400	6	1,025,948	1	66	90%	393,210	236	9.83	300	$ 2,359	$ 861,130
2B	**Plover Only Anaerobic**	Full flow AD with DAF SLS with WAS to AD. Biogas to steam boiler. P removal w/ FeCl at DAF and aerobic process	51,400	6	1,025,948	1	66	90%	393,210	236	9.83	300	$ 2,359	$ 861,130
2C	**Plover Combined w/ Rothschild HS-Crystalactor**	Full flow AD with DAF SLS and Rothschild HS. WAS to AD. Biogas to steam boiler. Crystalactor to process DAF Effluent. FeCl to polish aerobic effluent.	113,320	6	2,261,876	2	69	90%	866,898	520	21.67	500	$ 5,201	$ 1,898,507
2D	**Plover Combined w/ Rothschild HS**	Full flow AD with DAF SLS and Rothschild HS. WAS to AD. Biogas to steam boiler. Crystalactor to process DAF Effluent. FeCl to polish aerobic effluent.	113,320	6	2,261,876	2	69	90%	866,898	520	21.67	500	$ 5,201	$ 1,898,507
3	**Alt 1A + 2A**	Full flow AD with DAF SLS. WAS to AD. Biogas to steam boiler. Crystalactor to process DAF effluent. FeCl to polish aerobic effluent.	114,970	6	2294810	2	70	90%	879,521	528	21.99	500	$ 5,277	$ 1,926,150

= Confidential Information

As shown in Table 14 above, several opportunities exist for renewable energy creation using anaerobic treatment at each site. However, combining the wastestreams at either of the sites does not result in any measurable advantage. A portion of the energy created is consumed in the transport of high strength wastewaters from one site to another. As such, Alternatives 1C and 1D, and Alternatives 2C and 2D are not recommended for implementation.

FFU has chosen to further investigate Alternative 3 as the best long-term solution and is prepared to proceed with further detailed study of this option. By utilizing the gas values outlined in Table 13 for Alternatives 1A and 2A, and streamlining what was learned during this feasibility study, we are able to further develop Alternative 3 to result in an estimated gas value of $1,926,150/year.

Review of Table 14 assists in reviewing the gas value portion of the study. However, what is not clearly defined on a single comparison chart is the overall financial impact of these alternatives upon the ongoing operating costs at each site. On Tables 4 through 13, we have effectively detailed each Alternative, characterizing the wastewaters treated; potential, hauling or treatment costs; operational and capital expenditures; and calculated these costs and benefits to derive a total expenditure and a return on investment (ROI). We further defined these numbers should FFU choose to participate in an operational lease program. By doing so, each site would lease the equipment over a period of years without the need to spend capital. These cost comparisons are presented in Tables 15A thru 15E (not available for publication). The resultant financial situation would be that the moneys being spent on the current operations would net out at a lower number than the actual lease payments. As a result, FFU would be in an increased net profit situation annually while investing in their long term solution. A summary of financial impacts of alternatives is shown in Table 16.

Table 16
Summary of Financial Impacts of Alternative Options

	ALTERNATIVE 1				ALTERNATIVE 2				ALTERNATIVE 3	
	1A	1B	1C	1D	2A	2B	2C	2D	3A	3B
1. Capital Cost	$3,292,595	$2,911,964	$4,104,555	$3,205,749	$3,677,569	$3,216,089	$4,261,779	$3,764,800	$6,840,842	$5,917,881
2. Annual O&M Cost	$648,947	$585,007	$875,081	$816,033	$853,417	$697,422	$1,145,029	$1,005,007	$1,332,403	$1,130,577
3. Gas Value	($1,065,020)	($1,065,020)	($1,601,132)	($1,601,132)	($861,130)	($861,130)	($1,898,507)	($1,898,507)	($1,926,150)	($1,926,150)
4. Net Annual Operating Cost with Gas Value	($416,073)	($480,013)	($726,051)	($655,901)	($7,713)	($163,708)	($753,478)	($893,500)	($593,747)	($795,573)
5. Simple ROI years	3.69	3.04	3.41	2.54	4.86	3.52	3.17	2.54	3.73	2.91
6. Net Change in Annual Costs After Lease Payments	($249,897)	($388,224)	($401,191)	($635,895)	($38,726)	($284,910)	($510,565)	($747,713)	($497,191)	$879,393)

This concludes our study, partially funded by Wisconsin's Focus on Energy. We appreciate the opportunity to provide this analysis for energy savings and look forward to implementing these findings on this or a future project.