



Springfield Community Digester Nutrient Concentration System Feasibility Report



Dane County, Wisconsin

I. Executive Summary

Dane County is home to 400 dairy farms and 50,000 dairy cows that produce not only many gallons of milk that results in a \$550 million per year dairy industry and 4,000 jobs, but over 2 billion pounds of manure each year that can harm area lakes and streams. The management of this manure is one of the most difficult, expensive, and potentially limiting problems facing the dairy industry today. Typically, the manure is stored in earthen ponds or lagoons and then land applied at a later date. The construction cost of the lagoons or other storage facilities require large capital investments for storage. The average hauling cost of manure is \$.015 per gallon which means that over \$3.5 million dollars annually is spent hauling and applying manure in Dane County. At the farm level this means that a 2,000 cow dairy hauls over 23,000,000 gallons of manure per year at a cost of \$345,000.

The manure is nutrient rich in nitrogen, phosphorus, potassium and other micro nutrients, providing fertilizer for crop production. The potential problem is the manure can sometimes be too nutrient rich and is applied at rates higher than crop production can utilize. The application rates run from 7,000-15,000 gallons per acre. Many times the over application of nutrients happens due to the expense of hauling further away from the livestock production facility causing a buildup of phosphorus in the soils in close proximity to the livestock operation. As studies have shown, when phosphorus levels in the soils exceed a certain point, the phosphorus has a greater likelihood of leaving the soil through run-off, soil erosion, heavy rains, and other events and entering the area waterways. Phosphorus is the biggest cause of pollution that turns the lakes green with algae.

When discussing manure management with dairy farms, their main concerns are typically the volume they need to handle and the phosphorus in the manure. On multi-generational farms, manure has been applied near the main farm for years, causing a buildup of phosphorus in the soils. As the farm grows and is required to follow a nutrient management plan that limits the amount of manure that can be applied due to the phosphorus levels of the soils, they need to haul the manure further from the main farm, increasing their operating costs. Given the tight margins and variability of the milk market, farms are looking for ways to cut costs, but proper manure management typically increases costs.

Some farms have considered installing digesters to help with manure management. Most digesters installed nationwide to date have not addressed the volume or phosphorus issues. They mainly focus on energy production with the farm benefits of odor reduction and possibly a source of bedding. Given the high capital cost of digestion systems, a relatively high energy value is required to justify the investment. Even with a high power purchase rate, systems require extensive maintenance and oversight to achieve the projected financial returns. Very few of the installed systems produce a positive cash flow for the farm.

In order to improve the financial returns of digestion systems, many system providers are turning to co-digestion of food processing by-products or substrates. This significantly increases the amount of energy produced from the system. The challenges with these systems are high utility interconnect costs due to larger generator sizing, the added volume and nutrients brought onto the farm, and the

operational issues that come with operating at much higher organic loading rates. Bringing in only one truckload per day of substrates increases the volume the farm must haul by 1.6 million gallons per year and increases the manure storage requirements by 800,000 gallons. Until digestion systems address the issues of volume reduction and nutrient management, their development will remain limited to high energy off-takes or odor issues.

Dane County officials and U.S. Biogas LLC (USB) have identified nutrient concentration systems (NCS) that process and successfully remove nearly 100% of the phosphorus from animal waste. This study addresses the feasibility of installing one of these cutting edge technologies as part of the new manure digester currently being built in the Town of Springfield, WI. This installation of an NCS would serve as a pilot project and will provide the commercial validation and experience needed to duplicate the system throughout the county, state, and nation.

II. The Project Objectives

The objectives of the project are: a.) improve the economic efficiencies of manure handling, b) reduce the adverse environmental impact of nutrient loading to ground and surface waters by making the redistribution of nutrients economically feasible, and c) evaluate the quality of water produced by combining the technologies and management practices to seek a water discharge permit.

The ultimate goal of the NCS is to capture 90-100% of the phosphorus in the effluent coming from the digesters. The NCS will remove 70-80% of the water in the manure. As stated earlier, the annual cost of hauling manure in Dane County is estimated to be over \$3.5 million per year. If all the manure was processed through the system, hauling costs would be reduced to just over \$1 million. By removing the water, segregating the phosphorus, and capturing it from the manure stream, cost savings in hauling will allow the farmer to apply the balance of the nutrients to the fields that require nutrients and the products created by the NCS can be blended to meet the crop uptake requirements. This would allow the soils that already have an excess of phosphorus to be drawn down over time by not applying phosphorus to these fields while allowing the farm to apply the phosphorus to fields that require it to meet the uptake needs to the crop, but not cause an excess build-up in the soils.

Nitrogen (N) in the manure enters the digester mainly in two forms: ammonium or organic N. Ammonium is formed from the reaction of the urease enzyme in the feces with the urea in the urine. Ammonium formation is fairly rapid, with about 95 % of the reaction complete in the first 12 hours, often before the manure is collected. Ammonium is not destroyed during the digestion process, but rather, organic N is converted to ammonium during protein degradation. Hence, the ammonium level in the digester effluent is typically higher than raw manure. A negligible amount of ammonia gas will escape with the biogas. It should be stressed that total nitrogen into the digester will equal the total nitrogen leaving the digester. This is different than most other manure management practices, which lose nitrogen through volatilization. As a result, the digester effluent ammonium content can be up to two times higher than in stored manure lowering the need for commercial fertilizer.

When digester effluent is field applied, much of the ammonium will be released as a gas (ammonia) unless it is incorporated into the soil. When incorporated, microorganisms can convert the ammonia to nitrite, which is then rapidly converted to nitrate, the nitrogen form most readily taken up by plants.

There is always some solids retention in a digester, especially in plug flow designs. In the digester, solid nutrients can settle. These settled solids make it look as though the nutrient concentration decreased as manure passed through the digester. Phosphorus (P) and potassium (K) measurements often illustrate this effect. The microorganisms in the digester do not consume P and K. Some P can be converted to ortho P (a soluble form) in the digester, but the total mass remains constant. The total P and K flowing into a digester equals the P and K in the effluent plus the amount that has settled out (<http://extension.psu.edu/natural-resources/energy/waste-to-energy/resources/biogas/projects/g-71>) .

Ultimately, the farm becomes a mini organic fertilizer plant. This allows for the reallocation of the phosphorus from where it is causing water quality issues and economically redistributes it to land that is in need of phosphorus for crop production. The nitrogen and potassium can be applied at more precise times when the crop needs the nutrients (i.e.: split applications or prior to planting) instead of applying manure when the crops are not able to utilize the nutrients.

Additional benefits to reducing the manure volumes include less wear and tear on town and county roads as the volume needed to apply nutrients has been reduced. This means fewer trucks on the roads and the loads within the weight limits of the roads. It also means the manure can be stored more cost effectively for longer periods of time ensuring the application of the nutrients takes place when the crops can utilize them and avoiding the time of the year that has the highest likelihood of a run-off event.

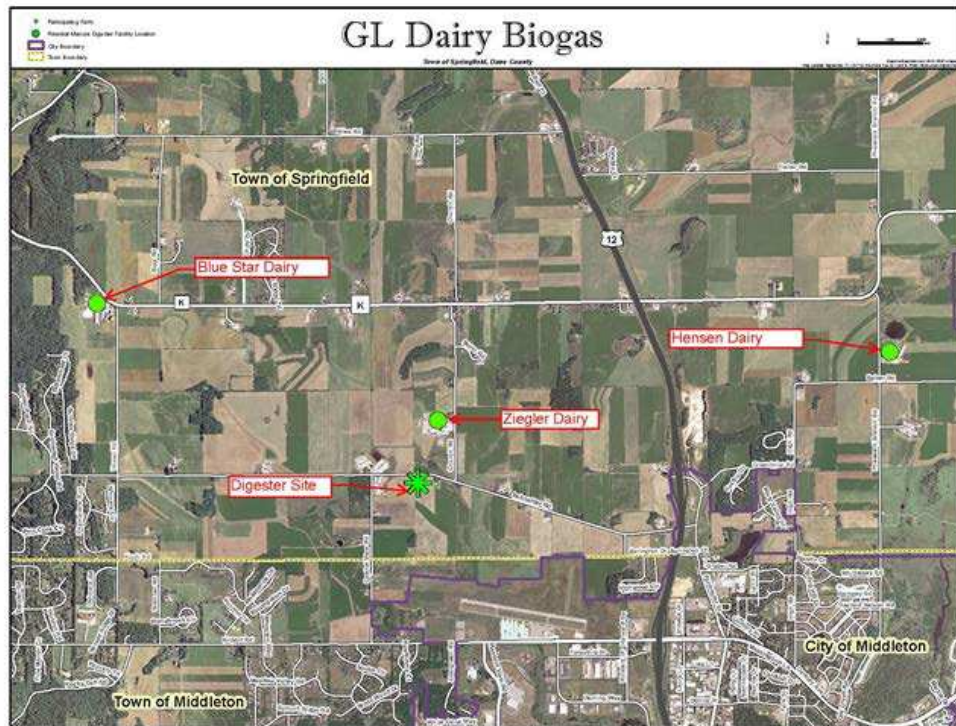
III. Base Project Description

The site is located on approximately 22 acres and is located in Dane County within the Town of Springfield off of Schneider Road. The Dane County Manure Handling Facility will accept manure from three farms: Hensen Brothers Dairy, Ziegler Dairy, and Blue Star Dairy. Manure from all three farms will be either pumped to the digester site or hauled by trucks to the processing facility.

The digester facility will be owned, designed, constructed, and operated by GL Dairy Biogas, LLC. The equipment that relates to phosphorus removal will be owned by the County and leased to GL Dairy Biogas, LLC. The digesters and the storage and treatment buildings for this project will be located on land owned by Dane County and will be leased to GL Dairy Biogas, LLC.

The manure from Ziegler Dairy will be pumped directly from the local reception pit at Ziegler's facility to the 150,000 gallon underground concrete raw manure storage tank at the facility.

The manure from both Hensen and Blue Star will be hauled daily to the site via semi tanker and delivered at the truck unloading depot upon entry to the site.



The site will also include a 40' x 20' solid manure receiving bunker that will be housed within the 71,000 square foot composting building to control odors. Bedding pack manure, frozen manure, and other organic by-products will be stored here and transported using an end loader to the solids feeding hopper. From here, the solids will be metered and mixed with liquid manure before being injected into the digesters.

There will also be one 100,000 gallon concrete organic waste tank located on site. This tank will be used to store organic substrates delivered to the site prior to processing in the digester. Additionally, one 25,000 gallon concrete tank will be used to store fats, oils, and greases (FOG) for supplementing biogas production within the facility. The FOG was selected to provide a feed stock with a high energy density, but relatively low nutrient content. This substrate is necessary to make the system economically viable. FOG produces about 8-10 times more biogas than manure of the same volume. Other substrates produce only 2-5 times more biogas than manure for the same volume. The substrate quantity will also be metered prior to feeding into the digesters. There will be a loading and unloading depot/containment area where trucks will be unloaded of liquid manure, organic waste products, and FOG, as well as loaded with centrate and digestate to bring back to the farms. Centrate is a combination of substrates and manure that has undergone anaerobic digestion and is the liquid fraction after having a portion of the suspended solids removed through a screw press and centrifuge system. Digestate is a combination of substrates and manure that has undergone anaerobic digestion. The centrate and digestate will either be loaded on trucks and returned to Blue Star and Hensen Dairies or will flow into the 16 million gallon on-site storage structure.

Centrate will be returned to Blue Star and Hensen Dairy using a semi tanker truck. Storage at Blue Star will be in an existing earthen storage lagoon. Storage at Hensen's will be in an existing concrete manure storage structure. Ziegler's centrate will be stored in the 11 million gallon portion of the concrete storage lagoon to be constructed at the facility with the digestate stored in the remaining 5 million gallon portion of the lagoon. The total lagoon size is 16 million gallons with a concrete dividing wall separating the centrate and digestate.

The digestion process is a continuous process with fresh manure always entering the digesters and the digested effluent constantly being removed from the digesters. Following the digestion process, the manure will be pumped to two screw press separators. This will separate the coarse solid material from liquids. The solids or fiber will then be placed into windrows inside the 71,000 square foot composting building where it will be composted for 35-45 days and aerated with a self-propelled compost row turner.

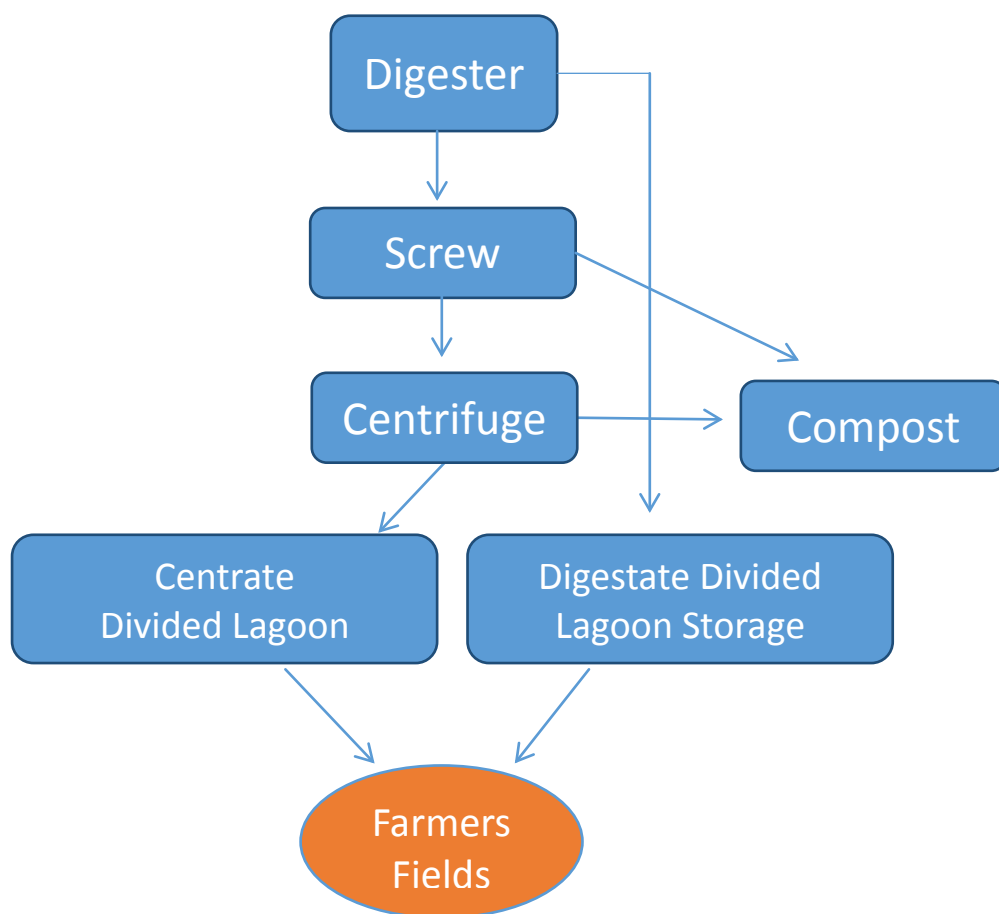
The liquids from the screw press will be processed by a centrifugal separator to remove the fine solids. Some of the solids or cake from the centrifuge will be composted and the balance will be stacked for truck load out.

The land application of both centrate and digestate is critical for all three farms. These materials contain nutrients (nitrogen, phosphorus, and potassium) that are essential for crop growth. These materials are needed by the farms in order to ensure that an adequate and appropriate amount of nutrients are available for growing crops. If these nutrients are not returned, the participating farms will need to import nutrients from outside the watershed to meet crop needs. This contradicts the primary goal of the project which is the removal of nutrients, in particular phosphorus, from the watershed. For that reason, the system has been designed with the ability to produce both centrate and digestate and make it available to the farms to meet their difference in nutrient concentration requirements. The centrate contains a relatively lower amount of phosphorus and higher amount of nitrogen when compared to the digestate. In order to maximize nutrient uptake efficiency and minimize nutrient loss, 25% of the total volume of liquid returned to the farms will be digestate with the remaining 75% being centrate. Farms will then be able to use manure spreading equipment that they already have to deliver a more appropriate amount of nutrients to growing crops that are based on site specific conditions and soil fertility levels.

Upon start-up, 60% of the phosphorus contained within the centrate will be removed and captured in the solids along with 60% of the phosphorus from the substrates. The amount of phosphorus capture from the substrates will incrementally increase over the course of the next 5 years where in 2018 100% of the phosphorus in the substrates will be removed. The primary reason for this incremental increase is due to fluctuations in the volume of nutrients that will be sent to the digester (Ziegler Dairy expansion) and time needed to stabilize the digestion process. If a NCS proves viable, 90-100% of the total phosphorus would be removed upon installation of the system.

Product Flow Chart

Base Project



IV. Proposed Separation Systems For Nutrient Capture

Manure comprises both urine and feces. It consists of water, complex carbohydrates, and nutrients. These nutrients are nitrogen, phosphorus and potassium, as well as minor nutrients, trace elements and salts. Commercial fertilizers used for crop production also include the same basic nutrients as manure. The challenge as stated earlier is to separate the nutrients from the water to create an economically usable fertilizer product(s) and clean water.

In addition to large amounts of dissolved organic matter and nutrients, manure also contains suspended matter that can easily be removed using screening techniques. The base project includes two types of equipment to remove suspended solids. The liquid from the digester or digestate will flow first to the screw presses which will have a removal rate of 35-40% of the suspended solids. The digestate is processed into two streams by the screw presses: 1) solids which will be transported to the composting facility, and 2) liquid or pressate that flows to the centrifuge separator. The pressate is processed in the

next stage of separation which is a centrifugal separator to remove the fine solids yielding a total suspended solids capture rate of 60-70%. Some of the solids or cake from the centrifuge will be composted; the balance will be stacked for truck load out.

V. Alternative Advanced Separation Technologies

Membrane separation technology has been around for many years. Over the past twenty years membranes have been used on an industrial level. A membrane is simply a synthetic barrier, which prevents the transport of certain components based on various characteristics. Below is an example of a reverse osmosis (RO) unit.



Membranes are very diverse in their nature with the one unifying theme to separate. They can be manufactured to be electrically neutral, positive, negative or bipolar. These different characteristics enable membranes to perform many different separations from reverse osmosis to microfiltration.

There are four main categories of membrane filtration. These are determined by the pore size or molecular weight cut off:

Filtration Type	Particle Size Rejection	Molecular Weight Cut-off
Reverse Osmosis	≤ 0.001 micron	≥ 100 daltons
Nanofiltration	0.001 to 0.01 micron	100 to 1000 daltons
Ultrafiltration	0.01 to 0.1 micron	1000 to 500,000 daltons
Microfiltration	≥ 0.1 micron	$\geq 500,000$ daltons

The first category of membranes is for RO. These are the tightest membranes for separating materials. They are generally rated on the percentage of salts that they can remove from a feed stream. However, they can also be specified by molecular weight cutoff (see table above).

In the past, the limitations of conventional membrane systems have prevented widespread use because of rapid fouling due to colloidal scale formation. Colloidal fouling obstructs the pores of the membrane which greatly reduces the throughput and increases the frequency and amount of cleaning required. The source of colloids in RO feed waters is varied and often includes bacteria, clay, colloidal silica, and iron corrosion products.



RO elements fouled with resin and sand

To combat the fouling problem, several companies have developed new pretreatments using chemicals such as alum and ferric chloride or developed different membranes, and/or combined different technology solutions to solve the fouling problems.

VI. Market Research: Request for Proposal

USB sent out over 20 Requests for Proposals (RFP) regarding this study (**see Exhibit A**). The request included capital and installation cost, operational cost of the system including electrical usage, replacement parts, chemicals if applicable and labor. Of the 20 plus RFPs sent out, over 14 companies responded with proposals. We have included detailed information on the top four proposals.

VII. Top Four System Descriptions

Company A: Mechanical and Chemical Combined to RO

Manufacturer A utilizes a patented process using mechanical and chemical treatments for the removal of manure contaminants from the manure waste stream creating clean water. As the manure flows through this process, solids are sequentially removed from the influent stream.

1. Fine Solids Removal: A fine mesh screen is utilized to provide protection to the clarifier for any coarse solids that make it through the centrifuge. A feed box with this screen is utilized for dosing of alum and polymers to assist in separating the remaining suspended solids in the clarifier.
2. Suspended Solids Removal: For fine solids separation, a specially designed clarifier tank is employed. The tank design enables efficient solids removal with minimal power or additional chemicals/polymers. The suspended solids settle to the bottom of the tank and are returned to the feed end of the system for removal.
3. Fine Particle Separation: After the clarifier, the water is pumped through bag filters to remove any remaining suspended solids as a protection for the reverse osmosis system. Following this step, the phosphorus is removed from the manure stream, leaving the nitrogen and potassium water solution.
4. RO: In the final step, the nitrogen and potassium water solution is processed through a RO to separate the water from the remaining nutrients. This process concentrates the nitrogen and potassium into approximately 20-30% of its original volume. The other 70-80% is water that can be re-used for animal consumption, irrigated, or discharged to surface water or the local sanitary sewer system.

Company B: Mechanical and Chemical Combined to RO

Manufacturer B utilizes a patent pending process known as an Electrostatic Flocculating Reactor. This process uses mechanical and chemical treatments for the removal of manure contaminants from the manure waste stream creating dischargeable water.

1. Primary treatment: Utilizes Pre-Reactor and Post-Reactor filtration devices to remove total suspended solids, biological oxygen demand, nutrients, and pathogens.
2. Secondary Treatment: Ultra filtration system is utilized to separate 100% of the suspended solids from the liquid. The phosphorus is removed from the manure stream, leaving nitrogen and potassium in the water solution. The solids will be fed back in the digesters or composted.
3. RO: In the final step, the nitrogen and potassium water solution is processed through a RO to separate the water from the remaining nutrients. This process concentrates the nitrogen and potassium into approximately 20-30% of its original volume. The other 70-80% is water that can

be re-used for animal consumption, irrigated, or discharged to surface water or to the local sanitary sewer system.

Company C: Mechanical to RO

Manufacturer C has developed a system utilizing a patented advanced separation technology. By applying their technology, the integrated system is able to separate high levels of suspended and dissolved solids.

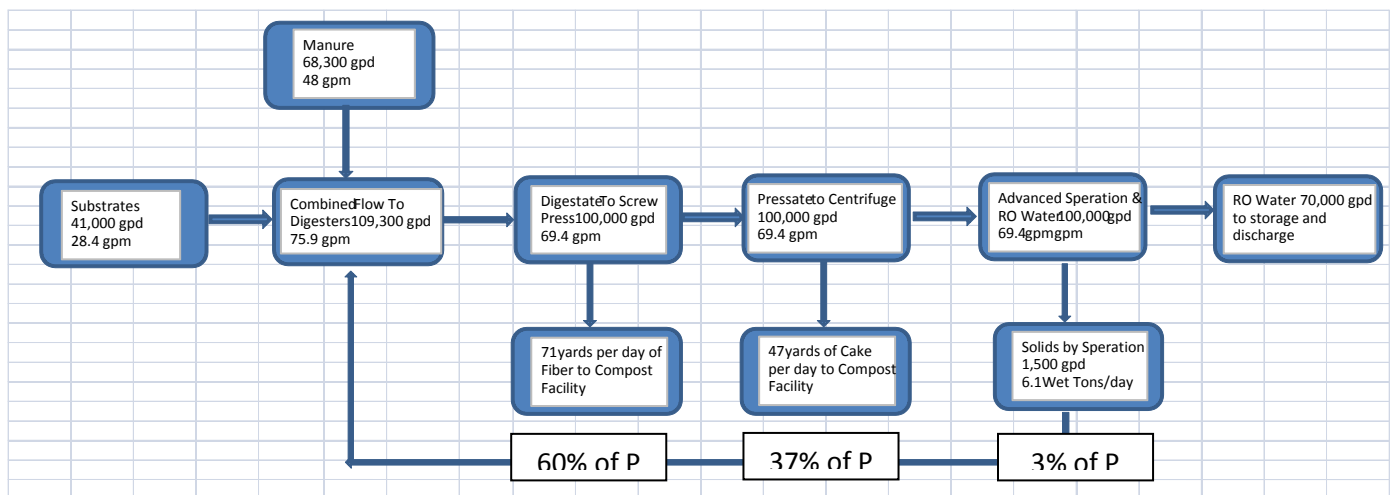
1. Fine Solids Removal: A bag filter is used for fine solids separation to capture anything that might make it through the centrifuge before sending product to the vibratory filtration machine.
2. Product is split into two streams: 1) concentrated manure slurry that is 20-25% of the original volume containing all the nutrients; 2) a clear filtrate with solids, metals, and sulfates removed.
3. RO: This final step processes the clear filtrate so that 45-80% of the water is clean enough for animal consumption, surface water discharge, irrigation water or discharged to the local sanitary sewer system.

Company D: Mechanical to RO

Manufacturer D utilizes a series of technologies integrated together to remove solids from manure and partition nutrients to achieve total liquid / solid separation and create nutrient-rich fertilizers and reusable water.

1. Fine Solids Removal: Fine mesh screen is utilized to capture any coarse solids that make it through the centrifuge.
2. Suspended Solids Removal: Ultra filtration system is utilized to separate 100% of the suspended solids from the liquid. Creating two streams, the system converts solids to a nutrient rich, concentrated liquid manure, and converts liquids to “tea water”, a low odor nutrient rich liquid ideal for irrigation with 98% plus phosphorus removed.
3. RO: The final step converts 30-35% of the liquid to clean water for animal consumption, surface water discharge, irrigation water or discharged to the local sanitary sewer system.

VIII. Project Product Flow Chart Adding NCS



IX. Capital Cost Comparison

Manufacturer	System Capital Cost	Supporting Infrastructure	Total Capital
B	\$ 850,000	\$ 247,808	\$ 1,097,808
A	\$ 1,160,000	\$ 247,808	\$ 1,407,808
D	\$ 1,544,724	\$ 247,808	\$ 1,792,532
C	\$ 2,073,596	\$ 247,808	\$ 2,321,404

X. Operational Cost Comparison

Manufacturer	Cost Per Gallon Treated	Gallons Treated Per Day	Total Operational Cost / Year
C	\$ 0.0070	100,000	\$ 255,500
B	\$ 0.0070	100,000	\$ 255,500
A	\$ 0.0090	100,000	\$ 328,500
D	\$.00683	100,000	\$ 249,295

XI. End Liquid Products Produced

Manufacturer	% Potable Water	Gallons Water Per Day	Nutrient Conc. Per Day	Super Conc. Per Day
C	70-80%	75,000	25,000	
B	70-80%	75,000	25,000	
A	70-80%	75,000	25,000	
D	25-35%	33,000	33,000	33,000

XII. Possible Methods of Using Clean Water (See Exhibits B-D Test Results)

- Direct discharge / Extensive test data required over extended period of time
- Indirect discharge / Extensive test data required over extended period of time
- Wetlands / Extensive test data required over extended period of time
- Dispose of clean water to the City of Middleton sewer system / Municipality would need to be willing to accept the water
- Reuse for animals at the Dairies / Dairies are willing to consider
- Land application / Current Wisconsin Department of Natural Resources (WDNR) standards treat discharge water as manure applying manure regulations

Given that the NCS system generates potable water directly discharging this water to the nearby Pheasant Branch Creek is ideal. The Pheasant Branch Creek is currently listed as a 303d impaired water for both total suspended sediment and phosphorus. It is also located within the Rock River TMDL. The digester facility is currently permitted as an Industrial Facility under the Wisconsin Pollution Discharge Elimination System (WPDES) and therefore would need to document an additional offset/credit within

the watershed. This credit would have to be equal to or greater than the amount discharged by the facility for both phosphorus and TSS. Based on lab analyses of the clean water and the amount of clean water discharged the amount of phosphorus and total suspended solids would be negligible.

Further insuring the safety of this discharge is the ability to store the clean water within the 16 million gallon storage lagoon. This allows for additional sampling prior to discharge to insure permit compliance. Should the nutrient concentration exceed the permit requirements the clean water could be land applied according to the conditions set forth in the Land Spreading Agreement.

XIII. Best Utilization of the Processed Nutrients From the System

Because of the advance separation process all of the nutrients from the system will be utilized by the three participating farms.

- a. As stated earlier all of the N&K will be concentrated into a liquid waste stream approximately 30% of the original volume.
- b. 60% of the P will be in the fiber product which will be processed and sold as a soil amendment.
- c. The remaining P in the cake product will be utilized in one of two ways, land applied by the farms for crop production or incorporated into the fiber product.
- d. Utilizing all of the nutrients will lower the overall amount of commercial fertilizer applied in Dane County.
- e. No additional off take agreements will be needed.

XIV. Permit Requirements

The WDNR has been contacted regarding the project. Their concerns are water quality and potential impact to the watershed. USB will continue to work with DNR personnel submitting test data for review and feedback. Pathogens will be tested on irrigated, clean water to confirm there is no potential for human impact.

- a. Base project requirements already in place
 - i. Town of Springfield
 1. Rezoning with certified survey approval
 2. Conditional use permit
 3. Building permit
 4. Road Crossing Permit
 - ii. Dane County
 1. Chapter 14 manure storage permit
 2. Storm water and shore land erosion control permit (Main Project Site)
 3. Storm water and shore land erosion control permit (Hensen Dairy)
 4. Storm water and shore land erosion control permit (Blue Star Dairy)
 5. Rezoning with certified survey approval
 6. Conditional Use permit
 7. Septic System Permit

8. State of Wisconsin:
 - iii. WDNR
 1. WPDES Permit
 2. NR 216 Storm water/Construction Site Erosion
 3. Construction Air Pollution Control Permit and Operating Air Pollution Control
 4. Chapter 30 Permit (Hensen Dairy)
 5. Well Construction Permit
 - iv. Wisconsin Department of Commerce
 1. Building Permit
 2. Electrical Permit
- b. Any changes in the Plans and Specifications for any Proposed Facilities or Systems requires a submittal of three copies of plans and specifications at least 90 days prior to constructing or modifying existing system. The existing permits will need to be modified to include spray irrigation of the clean water if needed. A traveling gun irrigation system could be utilized to provide the maximum portability and flexibility for Ziegler Dairy's multiple field locations and irregular shaped fields (see illustrations below).



XV. Operational Flow of an NCS System Added to the Current Project Under Current Permit Compliance

- a. The NCS will be positioned in its own processing building on the project site (**see Exhibits E & F**). Centrate will be pumped from the centrifuge to the NCS processing building. Primary treatment will removal 100% of the total suspended solids and any BOD and pathogens left after the digestion process. These fine solids will be sent back to the digesters or composted.
- b. In the final step, the nitrogen and potassium water solution is processed through a RO to separate the water from the remaining nutrients. This process concentrates the nitrogen and potassium into approximately 20-30% of its original volume or 20,000-30,000 gallons/day of fertilizer. The other 70-80% is water that can be re-used for animal consumption, irrigated, or discharged to surface water or to the local sanitary sewer system. Currently, the fertilizer will be pumped to the 4 million gallon section of the lagoon for Ziegler Dairy's use or hauled to Blue Star and Hensen Dairies for storage and later land application under their current Nutrient Management Plans. Current permit requires manure storage capacity of 180 days of 19,674,000gallons. Combining

all the project participants' storage capacity totals 22,795,700 gallons or a surplus of over 3,000,000 gallons. Please see table below for manure storage details.

Product	Daily Volume	180 Day Storage Requirement
Dairy Manure	68,300	12,294,000
Substrate	41,000	7,380,000
Total	106,000	19,674,000

Farm	Gallons of Storage Capability
Ziegler / Project	15,000,000
Hensen	5,000,000
Blue Star	2,795,700
Total	22,795,700

c. When the NCS is installed the storage requirements will drop 70-80%.

	Daily Volume of Nutrient Concentration @ 70% Reduction	180 Day Storage Requirement	Current Project Capacity
Total Project	31,800	5,724,000	
Participate Breakdown			
Ziegler Share	19,080	3,434,400	4,000,000
Hensen Share	6,741	1,213,488	5,000,000
Blue Star Share	6,042	1,087,560	2,795,700
Total Project			11,795,700

	Daily Volume of Clean Water Produced in Gallons	180 Day Storage Requirement	Current Project Capacity (Including Hensen & Blue Star)
Ziegler / Project	70,000	12,600,000	11,000,000
Hensen			4,217,000
Blue Star			2,093,700
Total		12,600,000	17,310,700

The clean water will be pumped to the large section of the lagoon and irrigated onto Ziegler's adjacent crop production fields (See graphic below, *Permit modification required*).



XVI. Economic Feasibility / Financial Modeling

As stated earlier in the Executive Summary, management manure is one of the most difficult, expensive, and potentially limiting problems facing the dairy industry today. Typically, the manure is stored in earthen ponds or lagoons and then land applied at a later date. The construction cost of the lagoons or other storage facilities require large capital investments for storage.

The average hauling cost of manure per the Springfield project participants is \$0.0168/gallon on a weighted average basis (see chart below). That makes current hauling costs for the participants \$418,816 per year. By installing an NCS system, for example from manufacturer B, hauling costs can be decreased by an estimated \$230,641 per year.

Hauling Cost By Type of Application	\$ / Gallon
Hose Pump From Lagoon Nearby Fields	\$ 0.0086
Hose & Inject up to 2.5 Miles	\$ 0.0140
Truck With Tanker To Inject up to 3.5 Miles	\$ 0.0185
Current Weighted Average For Land Application	\$ 0.0168

The off-farm organic wastes being processed in the digesters also bring in additional nitrogen and potassium. The retail values of these nutrients are estimated at nearly \$400,000 per year. The project participants agree that a fair value for these nutrients would be 65% of retail market.

With a total installed capital cost of \$1,100,000 the NCS creates an internal rate of return (IRR) of 17.6% over a 10-year term or a simple payback of 4.5 years (details in table on following page).

Total Capital Cost	\$ 1,100,000
Dane County Investment	\$ -
	\$ 1,100,000
Gallons of Manure To System Per Day	\$ 68,300
Annual Gallons of Manure	\$ 24,929,500
Average Hauling Cost	\$ 0.0168
Current Annual Hauling Cost	\$ 418,816
Gallons of Substrate To The System Per Day	\$ 41,000
	\$ 14,965,000
Total Gallons To The System	\$ 39,894,500
Percentage Reduction from Digester	12%
Gallons of Reduction From Digestion	\$ 4,787,340
Net After Digestion	\$ 35,107,160
NCS Gallons Treated	\$ 35,107,160
NCS Operational Cost Per Gallon	\$ 0.0070
Total Operational Cost	\$ 245,750
Volume Reduction	80%
	\$ 28,085,728
Water Disposal	\$ 0.0025
	\$ 70,214
Gallons Left To Haul	\$ 7,021,432
	\$ 0
	\$ 117,960
New Hauling Cost	\$ 188,174
Hauling Cost Savings	\$ 230,641
Nitrogen LBS Per Gal. In Substrate	0.0268
Potassium LBS Per Gal. In Substrate	0.020
Total N LBS	\$ 401,062
Total K LBS	\$ 299,300
Retail Price of N	\$ 0.65
Retail Price of K	\$ 0.45
	\$ 260,690
	\$ 134,685
Total	\$ 395,375
Percentage of Retail Value	65.0%
Fertilizer Value	\$ 256,994

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Hauling Cost Savings		\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641
Fertilizer Value of Substrates		\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994
Total Revenue		\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635
Cost											
Operations & Maintenance		\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750
Net	\$ (1,100,000)	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885
IRR	17.67%										
Simple Payback	4.5										

By utilizing Dane County funding of \$300,000 with a total installed capital cost of \$1,100,000, the NCS creates an IRR of 27.59% over a ten-year term or a simple payback of 3.3 years.

Total Capital Cost	\$ 1,100,000
Dane County Investment	\$ 300,000
	\$ 800,000
Gallons of Manure To System Per Day	\$ 68,300
Annual Gallons of Manure	\$ 24,929,500
Average Hauling Cost	\$ 0.0168
Current Annual Hauling Cost	\$ 418,816
Gallons of Substrate To The System Per Day	\$ 41,000
	\$ 14,965,000
Total Gallons To The System	\$ 39,894,500
Percentage Reduction from Digester	12%
Gallons of Reduction From Digestion	\$ 4,787,340
Net After Digestion	\$ 35,107,160
NCS Gallons Treated	\$ 35,107,160
NCS Operational Cost Per Gallon	\$ 0.0070
Total Operational Cost	\$ 245,750
Volume Reduction	80%
	\$ 28,085,728
Water Disposal	\$ 0.0025
	\$ 70,214
Gallons Left To Haul	\$ 7,021,432
	\$ 0
	\$ 117,960
New Hauling Cost	\$ 188,174
Hauling Cost Savings	\$ 230,641
Nitrogen LBS Per Gal. In Substrate	0.0268
Potassium LBS Per Gal. In Substrate	0.020
Total N LBS	\$ 401,062
Total K LBS	\$ 299,300
Retail Price of N	\$ 0.65
Retail Price of K	\$ 0.45
	\$ 260,690
	\$ 134,685
Total	\$ 395,375
Percentage of Retail Value	65.0%
Fertilizer Value	\$ 256,994

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Hauling Cost Savings		\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641	\$ 230,641
Fertilizer Value of Substrates		\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994	\$ 256,994
Total Revenue		\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635	\$ 487,635
Cost											
Operations & Maintenance		\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750	\$ 245,750
Net	\$ (800,000)	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885	\$ 241,885
IRR	27.59%										
Simple Payback	3.3										

The economies are of course considerably improved with the investment from Dane County which in turn increases the dairies interest in being an investor by lowering the risk.

XIII. Recommendations and Next Steps

USB has discussed the operational aspects of the NCS system with the participating farms. The possibility of participants taking an ownership interest has also been discussed and was received with unanimous interest in exploring the opportunity. Some of the participants have also indicated an interest in paying a processing fee versus investing capital. The Dane County investment in the project could provide either solution or a combination of solutions. The Dane County investment would expedite the implementation of the NCS system making an operational date in the 3rd quarter 2014 possible.

- a. Ownership structures considered
 - i. Cooperative
 - ii. Limited Liability Company (LLC)
 - iii. Third Party Investment & Ownership
- b. The participating farms feel that that structuring the project as an LLC offers the best benefit.
 - i. Created for a special purpose
 - ii. Allows for multi-members
 - iii. Members should have the same common goals (production agriculture)
 - iv. Pass through entity for tax purposes
- c. Project objectives once operational
 - i. Verification of operational cost
 - ii. Clean water sampling program to provide the needed data for this project and others to qualify for a discharge permit
 - iii. Identify best management practices of crop rotations and irrigation to reduce soil nutrient levels
- d. Producer benefits
 - i. Decreased hauling cost = increased profitability
 - ii. Improved yields due to better nutrient management = increased profitability
 - iii. Lowering the pressure on manure storage needs and possible manure overflows
- e. Short-Term Community benefit
 - i. Ability for the project to handle additional manure from other dairies on an emergency basis due to the excess storage capacities of the project participants
- f. Overall Community benefits
 - i. Protects & improves water quality
 - ii. Lowers the excessive wear to public roads by decreasing truck traffic
 - iii. Protects and facilitates sustainable growth for the dairy industry

Upon implementation this project will provide a new platform for optimizing livestock production and nutrient management. The economic validation of advanced separation and reverse osmosis technology in the livestock business will automatically start the commercialization process.

Exhibit A

Request for Proposal

Request for Proposal

US Biogas, a systems integrator of organic waste solutions is developing a turnkey dairy and organic waste product anaerobic digester project. The project requires that 90% of the Phosphorous be removed to meet regulatory requirements. As a result US Biogas is requesting a proposal for a turnkey solution that will be capable of removing the required amount of Phosphorous from the digester effluent waste stream.

The proposal must include; capital and installation cost of equipment, operational cost of the system including electrical usage, replacement parts/materials, labor costs, and chemical costs if applicable. Also required is a detailed profile and description of all of the end products produced by the system and an evaluation of market potential for this product.

Please find below the sample composition of the waste stream at two points; digester effluent, and centrifuge effluent:

Digester Effluent		Centrifuge Effluent	
Flow Rate (GPD)	107,000	Flow Rate (GPD)	100,000
TS (%DM)	5%	TS (%DM)	2.6%
TKN (lbs/1000 G)	26.73	TSS (%DM)	1.6%
P2O5 (lbs/1000 G)	20.68	TDS (%DM)	1.0%
K2O (lbs/1000 G)	24.18	TKN (lbs/1000 G)	24.23
S (lbs/1000 G)	4.49	P2O5 (lbs/1000 G)	7.66
pH	8.0	K2O (lbs/1000 G)	20.74
Temp (F)	100	S (lbs/1000 G)	4.44
		pH	8.0
		Temp (F)	95
		NH3	0.3%
		Cl-	0.1%
		Hardness CaCO3	0.35%

The effluent from the above defined waste stream is composed of dairy manure and other organic waste products.

Please direct all inquiries to Dan Meccariello meccariello@usbiogasllc.com

Exhibit B

Clean Water Lab Test Report

Report Number

13-212-2226



Page 1 of 1

13611 B Street • Omaha, Nebraska 68144-3693 • (402) 334-7770 • FAX (402) 334-9121 • www.midwestlabs.com

Lab Number: 2162567

Description:

Sample Id: 2013-38

Report Date: Jul 31, 2013

Received Date: Jul 26, 2013

Sampled Date:

P.O. Number:

Account Number: 19891

Parameters	Analysis as Received	Nutrients lbs/acre inch	Nutrients lbs/1000 gals
Ammonium Nitrogen(N)	16 ppm	3.6	0.14
Organic Nitrogen(N)	13 ppm	2.9	0.11
Total Nitrogen(N)	29 ppm	6.5	0.25
Phosphorus(P2O5)	1 ppm	0.2	0.0
Potassium(K2O)	8 ppm	1.7	0.1
Sulfur(S)	0.0 ppm	0.0	0.01
Calcium(Ca)	0.5 ppm	0.1	0.01
Magnesium(Mg)	0.3 ppm	0.1	0.01
Sodium(Na)	11.5 ppm	2.6	0.10
Copper(Cu)	n.d. ppm	0.00	0.01
Iron(Fe)	n.d. ppm	0.01	0.01
Manganese(Mn)	n.d. ppm	0.00	0.01
Zinc(Zn)	n.d. ppm	0.00	0.01
pH	6.50		
Conductance	.170 mS/cm		
Total suspended solids	3.0 mg/L		

n.d. = Non Detected

Research suggests that when Lagoon Water is applied by irrigation, conductance values of 6 mS/cm or less should be safe for corn and soybeans at all growth stages; conductance values up to 12 mS/cm should be safe for soybeans and corn by late July.

Heather Rammig
Heather Rammig
Client Service Representative
heather@midwestlabs.com (402) 334-9121

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Exhibit C

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Clean Water Lab Test Report

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Report Number

13-212-2231



Page 1 of 1

12611 B Street • Omaha, Nebraska 68144-3693 • (402) 334-7770 • FAX (402) 334-9121 • www.midwestlabs.com

Lab Number: 2162572

Description:

Sample Id: 2013-43

Report Date: Jul 31, 2013

Received Date: Jul 26, 2013

Sampled Date:

P.O. Number:

Account Number: 19891

Parameters	Analysis as Received	Nutrients lbs/acre inch	Nutrients lbs/1000 gals
Ammonium Nitrogen(N)	37 ppm	8.3	0.31
Organic Nitrogen(N)	14 ppm	3.2	0.12
Total Nitrogen(N)	51 ppm	11.5	0.43
Phosphorus(P2O5)	1 ppm	0.2	0.0
Potassium(K2O)	24 ppm	5.3	0.2
Sulfur(S)	0.0 ppm	0.0	0.01
Calcium(Ca)	0.5 ppm	0.1	0.01
Magnesium(Mg)	0.2 ppm	0.0	0.01
Sodium(Na)	12.7 ppm	2.9	0.11
Copper(Cu)	n.d. ppm	0.00	0.01
Iron(Fe)	n.d. ppm	0.01	0.01
Manganese(Mn)	n.d. ppm	0.00	0.01
Zinc(Zn)	n.d. ppm	0.01	0.01
pH	7.19		
Conductance	.441 mS/cm		
Total suspended solids	1.0 mg/L		

n.d = Non Detected

Research suggests that when Lagoon Water is applied by irrigation, conductance values of 6 mS/cm or less should be safe for corn and soybeans at all growth stages; conductance values up to 12 mS/cm should be safe for soybeans and corn by late July.

Heather Ramig
Heather Ramig
Client Service Representative
heather@midwestlabs.com (402) 334-9991

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Exhibit D

Published Livestock Drinking Water Standards

	Alabama Extension Dairy and Beef		Colorado State		North Dakota State		Missouri- Columbia		University of Wisconsin		Average Limit		RO Sample Averages
	Limit		Limit		Limit		Limit		Limit				
Coliform Bacteria	50-100	ml			50	mg/L	50	mg/L			50		
Fecal Coliform Bacteria							1	/100 mL			1		
Total Bacteria	1000	ml					200	/100 mL			600	ml	
Nitrate + Nitrite Nitrogen	100	mg/l	100	mg/L	500	mg/L	100		25	ppm	165	ppm	40
Nitrite Nitrogen	10	mg/l	10	mg/L	100	mg/L	10		10	ppm	28	ppm	
Fluoride	2	mg/l	2	mg/L	2	mg/L	2		2	ppm	2	ppm	
Total Dissolved Solids	3000	mg/l	10,000	mg/L	3,000	mg/L	10,000	mg/L		ppm	6,500	ppm	
Salinity			3,000	mg/L			3,000	mg/L	1,000	ppm	3,000	ppm	
Sulphate	500	mg/l			500	mg/L	250	mg/L	250	ppm	250-500	ppm	
pH	6-8				6-8		6.8-7.5		6.0-9.0		6-8		6.8
Metals:													
Aluminum			5	mg/L			5	mg/L	5	ppm	5	ppm	
Arsenic	0.2	mg/l	0.2	mg/L	1	mg/L	0.2	mg/L	0.2	ppm	0.2	ppm	
Barium					10	mg/L					10	ppm	
Boron			5	mg/L			5	mg/L			5	ppm	
Cadmium	0.05	mg/l	0.05	mg/L			0.05	mg/L	0.05	ppm	0.05	ppm	
Chromium	1	mg/l	1	mg/L			1	mg/L	1	ppm	1	ppm	
Cobalt	1	mg/l	1	mg/L			1	mg/L	1	ppm	1	ppm	
Copper	0.5	mg/l	0.5	mg/L			0.5	mg/L	0.5	ppm	0.5	ppm	n.d.
Iron									0.3	ppm	0.3	ppm	n.d.
Lead	0.1	mg/l	0.1	mg/L			0.05	mg/L	0.1	ppm	0.1	ppm	
Mercury	0.01	mg/l	0.01	mg/L			0.01	mg/L	0.01	ppm	0.01	ppm	
Molybdenum					0.3	mg/L					0.3	ppm	
Nickel	1	mg/l							1	ppm	1	ppm	
Selenium			0.05	mg/L	0.1	mg/L	0.1	mg/L	0.05	ppm	0.05-0.1	ppm	
Vanadium	0.1	mg/l	0.1	mg/L		mg/L	0.1	mg/L	0.01	ppm	0.1	ppm	
Zinc	25	mg/l	24	mg/L		mg/L	24	mg/L	25	ppm	25	ppm	n.d.
Calcium									200	ppm	200	ppm	0.5
Chloride									250	ppm	250	ppm	
n.d.= Non Detected													

Over All Project Site

Exhibit E

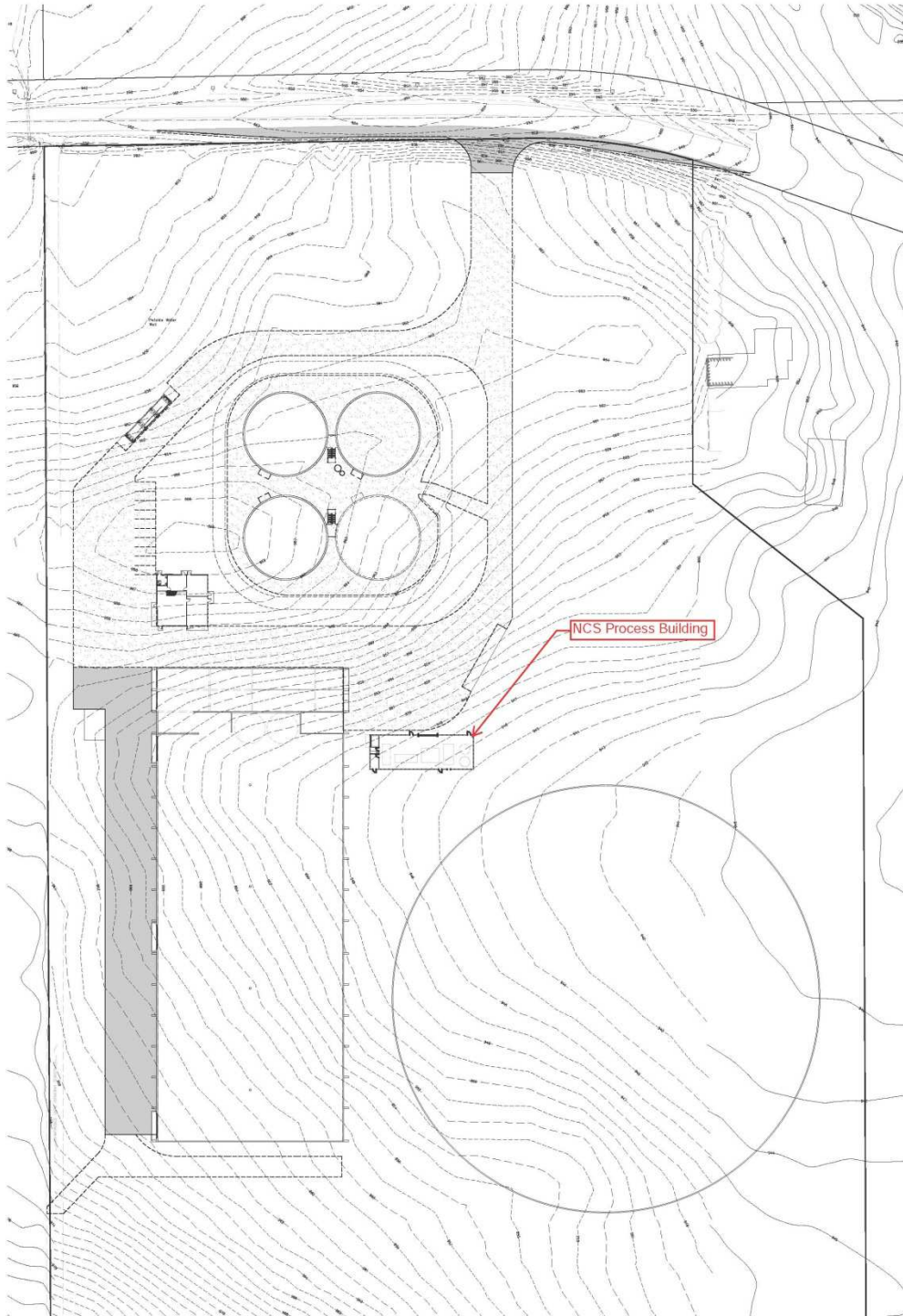
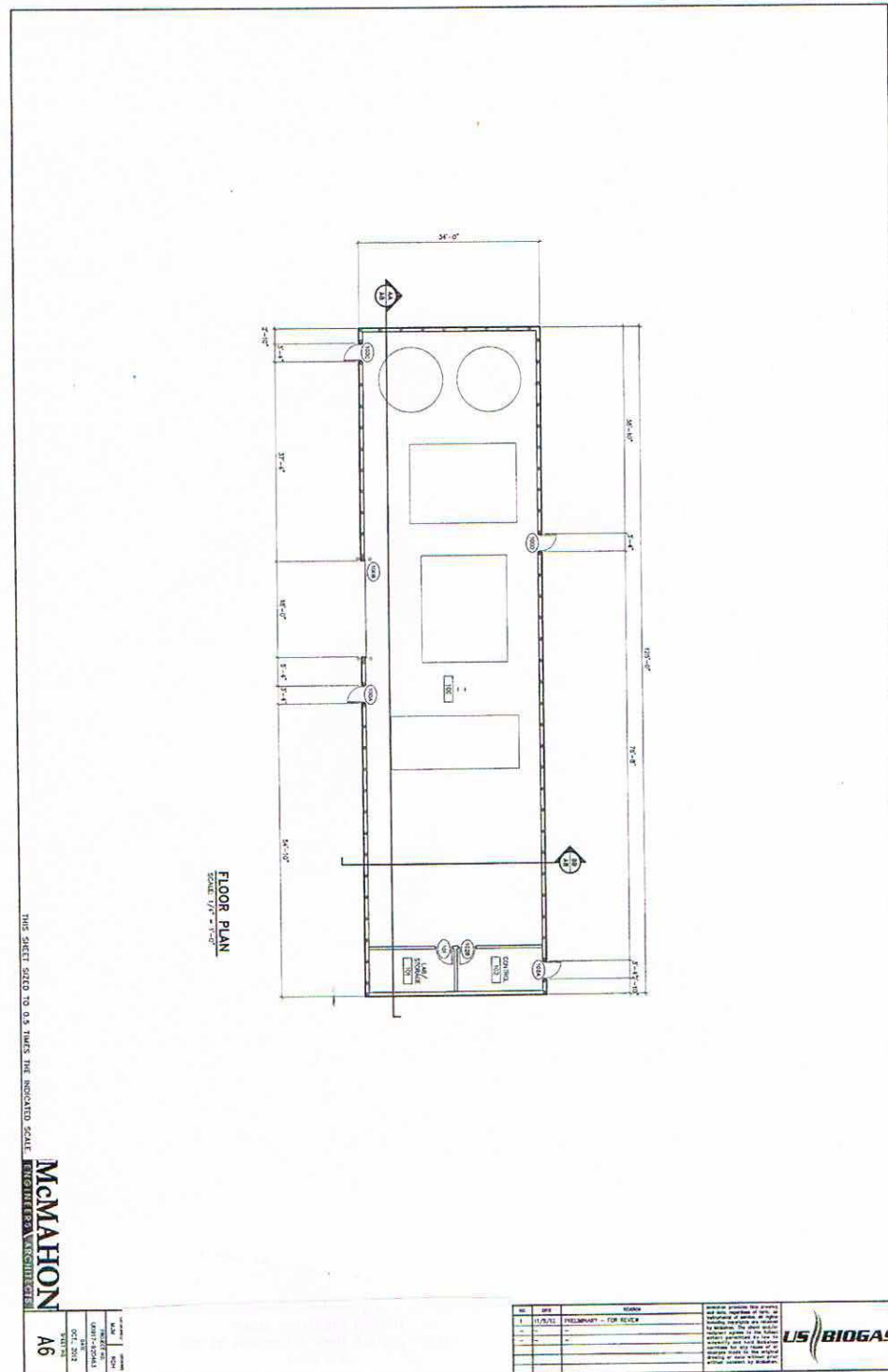


Exhibit F

Preliminary Drawing of NCS Process Building



Sequenced Mechanical Separation of Dairy Manure: On Farm Impacts of Membrane Separation; Tim Shepherd PRO-DAIRY Program, Department of Animal Science Cornell University
<http://www.ansci.cornell.edu/prodairy/nedpa/proceedings/2010/nedpa2010.14.Shepherd.pdf>

Treatment of Liquid Effluents from Dairy Cattle and Pigs using Reverse Osmosis; Lars Thorneby, Kenneth Persson, Gun Tragardh <http://www.prairieswine.com/pdf/3326.pdf>

Membrane Filtration of Manure Wastewater; Greg Johnson, Dr. Brad Culkin Ph.D, Larry Stowell
http://www.vsep.com/pdf/Membrane_filtration_of_manure.pdf

The Potential Contribution of Separation Technologies to the Management of Livestock Manure; C.H. Burton <http://www.prairieswine.com/pdf/39111.pdf>

Opportunities for Nutrient Recovery in Handling of Animal Residuals Eberhard Morgenroth
<http://www.livestocktrail.illinois.edu/uploads/sowm/papers/p101-110.pdf>

Recovery and Use of Nutrients, Energy and Organic Matter from Animal Waste- Rethinking Manure Recycling
http://www.reusewaste.eu/Nyheder/2012/~/_media/ReUseWaste/Ramiran/JENSEN_LARS_article_Ramiran15.ashx

Mechanical Solid-Liquid Separation of Livestock Manure Literature Review; Marcy Ford & Ron Fleming
http://mie.esab.upc.es/ms/informacio/residus_ramaders/Separator%20manure.pdf