THE BIOSET PROCESS
CLASS 'AA' BIOSOLIDS TREATMENT THROUGH LIME STABILIZATION

INTRODUCTION:

Schwing Bioset technology provides an inexpensive, reliable, and EPA approved means for producing a readily usable and valuable Class 'AA' product.

Compared to other methods of producing Class 'AA' material, the Bioset process is inexpensive from both initial capital expenditures and ongoing, operation and maintenance costs. Studies have shown that, compared to composting, thermal drying, and digestion technologies, lime stabilization has unit costs as much as 60 percent lower than other alternatives (National Lime Association). The equipment is fully automated and requires very little operator time. As a Class 'AA' biosolid, the end product can be widely used and handled without many of the restrictions imposed on a Class 'B' product.

Some of the advantages are:

- EPA approval for Class 'A'
- Low Capital and Operational Costs
- Easy to Operate
- Easy to Maintain
- Consistent Results
- Valuable End Product

LIME TREATMENT OF BIOSOLIDS:

Quicklime and hydrated lime have been used to treat biological organic wastes for over a century. The treatment of biosolids by lime treatment is also specifically prescribed in U.S. EPA regulations (40 C.F.R. 503) as an acceptable means to produce a Class 'A' biosolid. As the EPA notes, "properly prepared biosolids provide a rich source of the essential fertilizer elements needed by plants to produce food." (U.S. EPA, "Biosolids Recycling: Beneficial Technology for a Better Environment," June 1994).

Adding lime to biosolids raises the temperature and pH of the material, effectively killing most pathogens and creating an environment that will not support future pathogen re-growth. Elevated pH also reduces the biosolids' propensity to attract vectors. This treatment converts the biosolids

into a product that is a highly beneficial fertilizing product and also helps balance the pH of acidic soils.

Lime stabilization is one of the most cost-effective alternatives to produce a safe, stable, and valuable product from biosolids. The mechanism of lime treatment of biological wastes is based on the following chemical reaction:

Lime Reaction (Slaking):

$CaO + H_2O \rightarrow Ca(OH)_2 + 63.9kJ$ Heat

- When quicklime (CaO) is added to dewatered sludge, the calcium oxide reacts with water and converts to calcium hydroxide ($Ca(OH)_2$).
- This is an exothermic reaction, generating a significant amount of heat. This heat release can increase the temperature of the biological waste to 70ºC (158F), which provides effective pasteurization.
- Calcium hydroxide ($Ca(OH)_2$) is an alkaline compound that can create pH levels as high as 12.4. At pH levels greater than 12, the cell membranes of harmful pathogens are destroyed. The high pH also provides a vector attraction barrier, preventing flies and other insects from infesting the treated biological waste. Because lime has low solubility in water, lime molecules persist in biosolids. This helps to maintain the pH above 12 and prevent re-growth of pathogens.

Along with pasteurization and increased pH of the biosolids, there are several other benefits provided by the lime reaction including:

- The high pH will precipitate most metals that are present in the biosolids and reduce their solubility and mobility.
- The solubility of calcium hydroxide provides free calcium ions, which react and form complex compounds with odorous sulfur species such as hydrogen sulfide and organic mercaptans. Thus the biological waste odors are destroyed.
- The addition of lime also increases the solids content of the biosolids, making it easier to handle and store.
- The reaction of lime with the sludge liberates ammonia. When contained within the reactor of the Bioset process, ammonia acts as a biocide that further kills pathogens. (Fitzmorris, K., et. al. “Developments in Stabilization and Disinfection in Alkaline Systems” 2004)

The Bioset process also calls for the addition of sulfamic acid. Sulfamic acid is a solid granule that is safe and easy to handle. It is metered into the biosolids with the lime at approximately 1/10% by weight of biosolids. The reaction of the sulfamic acid with lime produces an exothermic reaction that gives the material the critical temperature rise.

MEETING EPA PART 503 REGULATIONS:

The EPA has established federal requirements for the safe treatment, beneficial use, and disposal of biosolids (40 CFR Part 503). For biosolids that are to be beneficially used, lime stabilization is one of the technologies identified to meet these requirements.

The Part 503 regulations establish two classes -- Class A and B -- that specify performance goals and the degree of treatment biosolids must receive before beneficial use or disposal:

- Class B biosolids contain higher pathogen concentrations than Class A, but have levels low enough for some beneficial uses, such as land application with restrictions.
- Class A biosolids contain extremely low pathogen concentrations and have few or no use restrictions.

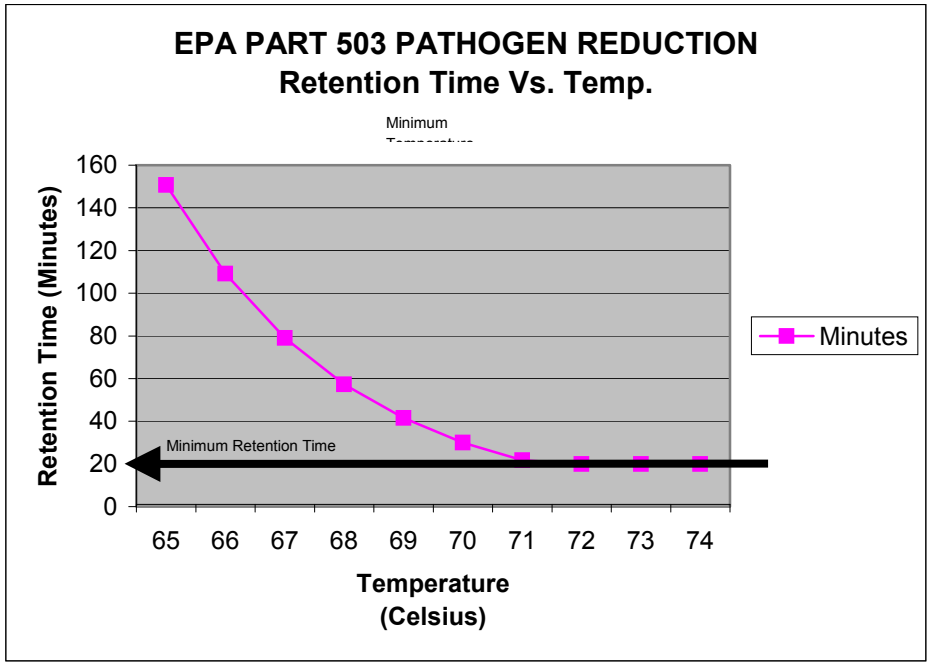
The Schwing Bioset system meets pathogen reduction by raising the temperature of the biosolids above fifty (50) degrees Celsius for a set time as defined in Part 503 Class A pathogen reduction alternative #1, see below.

> *503.32 Pathogens*
> *503.32(a)(3) Class A-Alternative 1*
> *(ii) The temperature of the sewage sludge that is used or disposed shall be maintained at a specific value for a period of time.*
> *503.32(a)(3)(ii)(A) When the percent solids of the sewage sludge is seven percent or higher; the temperature of the sewage sludge shall be fifty (50) degrees Celsius or higher; the time period shall be twenty minutes or longer; and temperature and time period shall be determined using equation (2), except when small particles of sewage sludge are heated by either warmed gases or an immiscible liquid.*
> *Eq. (2)* $$D = \frac{131{,}700{,}000}{10^{0.1400t}}$$

In addition to regulating pathogen concentrations, Part 503 regulations include requirements for reducing the tendency of biosolids to attract disease-carrying vectors such as rodents and insects. To meet vector attraction reduction requirements using lime, the pH must be raised to 12 or higher for 2 hours and subsequently maintained above pH 11.5 for another 22 hours without further alkali addition, see below.

> *503.33 Vector Attraction Reduction*
> *5033.33(b)(6) The pH of the sewage sludge shall be raised to 12 or higher by alkali addition and without the addition of more alkali, shall remain at 12 or high for 2 hours and then 11.5 or higher for an additional 22 hours.*

In practice, the Bioset process has seen stored material maintain a pH over 12 for over six months.



PROCESS:

The Schwing Bioset process consists of blending the sludge cake with lime and sulfamic acid and allowing the reaction to occur under pressure to meet the requirements of the 503 regulations. To accomplish this, it is necessary to control the flow of the biosolids through the reactor, and dose them with quicklime and sulfamic acid, such that the retention time and temperature rise achieved within the reactor match the required temperature set forth by equation 2 in 503.32.

Additionally, this dosage of quicklime to raises the pH of the biosolids per 503.33 (above pH 12). The final lime and sulfamic acid dosages for a specific application are designed such that the EPA requirements are fulfilled, for both pathogen and vector attraction reduction, while also taking into consideration the local costs of chemicals, to strike the optimum balance between regulatory requirements and local economies.

EQUIPMENT:

Major components of a typical Bioset System are described below.

Lime Feed System: The Lime Feed System provides storage and accurate metering of lime into the Bioset System. A rotary valve controls the feed rate of lime from the storage silo. An enclosed screw conveyor transports lime into the Twin-Auger Mixer inlet hopper.

Acid Feed System: The Acid Feed System provides storage and accurate metering of sulfamic acid into the Bioset System. A variable speed conveyor feeds acid into the Twin-Auger Mixer inlet hopper.

Transfer Screw Conveyor: A screw conveyor transports sludge from the dewatering

equipment to the Twin-Auger Mixer. The conveyor discharge is bolted to the mixer feed hopper with a flanged connection. This prevents the release of lime dust from the Twin Auger Mixer inlet hopper.

Twin-Auger Mixer: The Twin-Auger Mixer allows for the blending of the sludge, lime, and acid into a homogenous mixture. It feeds this mixture into the Reactor Feed Pump. The inlet hopper is fully enclosed to contain odors and prevent the release of lime dust. A Schwing Bioset twin-screw feeder is used to insure reliable service and thorough blending of material.

Reactor Feed Pump: The Reactor Feed pump moves the sludge/lime/acid mixture through the Sludge Stabilization Reactor. A Schwing Bioset piston pump is used to insure reliable service.

Sludge Stabilization Reactor: The reactor is used to achieve the required time and temperature to meet the EPA regulations for Class "A" EQ biosolids. The reactor vessel is insulated to minimize heat loss from the material. Multiple temperature sensors mounted in various locations throughout the reactor vessel to provide accurate temperature readings.

Ammonia Scrubber: The Ammonia Scrubber captures and treats ammonia emissions at the reactor discharge. The recovered aqueous ammonia solution is typically returned to the plant headworks.

Hydraulic Power Unit: The Hydraulic Power Unit drives the Twin-Auger Mixer and the Reactor Feed Pump.

Main Control Panel: A single panel is provided to control and monitor all Bioset equipment. This panel is typically furnished with a PLC and touchscreen operator interface. The PLC collects data from temperature sensors and hopper level indicator. In automatic mode, operation rates of the lime screw, acid feeder, screw conveyor, mixer, and pump are adjusted accordingly with minimal operator interaction. The touch-screen interface allows for simplified monitoring and operation.

The Process and Equipment design of the Bioset Lime Stabilization system described above effectively addresses the design features requested by Martin County:

Mixing Design

Poor lime/sludge mixing is a problem observed with other lime stabilization systems, where portions of lime can be found in the discharge that have obviously been un-reacted. This can also be seen in legacy Bioset Inc. systems that used a progressive cavity pump with a single mixing auger. Latest generation Schwing Bioset systems use a twin auger mixer with counter-rotating, intermeshing augers. Mixing continues with turbulence induced in the piston pump control valve housing. The thoroughly blended product can be seen with a homogeneous consistency. The homogeneous product is evidence that all the biosolids are uniformly treated and unreacted lime is not wasted.

Dust Control

Historically, biosolids treatment processes that use lime have been plagued by dusty conditions that create unpleasant working conditions for plant staff. Even some of the original Bioset process installations supplied by the original Bioset, Inc. had these same issues. As a result a common reaction to a proposed lime stabilization system is a knee-jerk negative response. However, since Schwing America, and later Schwing Bioset, took over the marketing of the Bioset process technology, we have recognized that controlling fugitive lime dust is one of the most important issues for a successful installation. With this in mind we have taken great care to ensure that the handling of lime does not result in dusty conditions with Bioset process operation. Copied below are photos of equipment supplied by Schwing Bioset that show that all the connections into the mixing hopper are either hard-piped or sealed with a flexible boot. These connections ensure that lime dust cannot escape and a clean working environment is provided.




Odor Control

Another common knee-jerk reaction to biosolids treatment technologies that utilize lime is the associated odors. It is true that competitors' systems and legacy Bioset systems create overpowering amounts of unpleasant odors that have adverse impact on plant operations. Again, Schwing Bioset has addressed this issue by completely enclosing the system where the mixing is taking place (see photos above), and the Bioset reactor, a pressurized pipe, completely contains the odors until they are released at the reactor discharge. This single point location results in a strategic location to capture the odors. Schwing Bioset includes a pinch valve at the reactor discharge to flatten the sludge flowing out of the reactor to create additional surface area to allow the ammonia and other compounds to be released and subsequently captured and scrubbed under the collection hood. The resulting end product has an "odor" similar to wet concrete as a result of the lime content. This is not an offensive odor at all. In fact, it can be seen in the photos below that the Class AA product produced by the Bioset process is stored outdoors on the edge of town with residential homes in the background and other photos show people "inspecting" the material for odors. This is always the first comment prospective Customers make when touring a Bioset installation is how clean the system is and the obvious lack of odors.




Maintainability

A remarkable feature of the Bioset process is how little maintenance is required as there are very few moving components. Aside from the two feed augers that require normal drive and bearing maintenance the only other item that requires regular maintenance is the piston pump. The Bioset system uses piston pump technology as manufactured by Schwing Bioset. These pumps were originally developed for pumping concrete and have over the past 25 years been adapted to other industries. The basic pump models offered by Schwing Bioset are designed for pumping concrete, essentially a mix or rock and sand, at operating at pressures up to 1,500 psi - by anyone's account this is a severe duty application. When used in Bioset applications, by comparison, the duty is much less severe as biosolids will contain a small percentage of grit and the system will operate at less than 50 psi. As a result, the wear lives of the replaceable parts in the piston pump are capable of exceeding 5,000 hours of run time.

Energy Efficiency & Noise

The total connected horsepower of the Bioset system proposed is under 40 HP (30 kW), exclusive of dewatering equipment. The largest drive provided will operate the piston pump and

is only 20 hp. There is no need for any supplemental fuel source, the energy required for the process is primarily from the chemical reaction of sludge and lime.

At full load, this 20 HP motor would emit maximum 66 dBA at 10 foot distance; coupled with the sound containment of the building structure, the specified 65 dBA at 23 is easily attained.

Marketability of the Class AA material:

The Class AA biosolids produced by the Bioset process are marketed under the trade name Revinu.

Biosolids Distribution Services (BDS) (sister company of Schwing Bioset that provides operation and marketing services) has successfully provided operations of the Bioset Process including biosolids dewatering, transportation and marketing services to multiple Florida municipalities and we have multiple outlets in Florida close to Martin County. BDS has owned and operated equipment utilizing the Bioset process to produce "Class AA Exceptional Quality" biosolids in Florida applications. Additionally BDS has owned and operated equipment to dewater liquid biosolids prior to treatment to Class AA. BDS has worked closely with the FDEP and currently has multiple permitted land sites to dispose of Class AA biosolids. BDS has also obtained a fertilizer license to be able to market and distribute Class AA biosolids in the state of Florida.

References:

City of Lakeland, Florida
Water Utilities
Tim Lokken (retired)
Manager of Wastewater Treatment
1825 Glendale Street
Lakeland, Florida 33803
(863) 834-6565

Service provided: The project started in 2004, during this time we produced on average 3 loads a day, 6 days a week. BDS was able to meet the demands of the City through many unexpected events including hurricanes and times of increased flows through the plant. This was an operations contract that included dewatering and treatment to Class AA standards, transportation and distribution of the finished product were included. Many satisfied customers were created during the life of this project. Multiple market opportunities for the finished product exist as a result of this successful venture with the City of Lakeland.

City of Hollywood, Florida
Department of Public Utilities
Deputy Director / Water
Steve Joseph, P.E. sjoseph@hollywoodfl.org
1621 N.14th Avenue, 2nd Floor
P.O. Box 229045
Hollywood, FL 33022
(954) 921-3522

Service provided: City owns and operates Bioset™ equipment, BDS provides transportation and distribution services for the finished product (marketed under the trade name Revinu). BDS is markets the Revinu material as a licensed Florida fertilizer. BDS has spent the last 4 years dedicated to creating a market for this material, because of this we currently do not have enough material to meet this demand. BDS internally has a beneficial re-use expert that allows us to help the end user with this material. We offer assistance with meeting the regulations set by the FDEP, land application, and helping the customer achieving their goals with the use of our product. We currently have multiple FDEP approved land sites to meet the demand from the City.

Currently, BDS provides transportation for 7 loads (average) a day of Class AA material from the City of Hollywood and 1 load a week of Class B cake to an approved landfill.

Revinu's Value in the Agricultural Market:

Revinu™
Lime-Enhanced Soil Conditioner

In today's market producers as well as consumers are looking for ways to cut cost while maintaining quality more than ever. With the rising cost of production and dropping retail values of the products being produced alternative production practices have changed from something that was a good idea to a necessity for many companies around the world. The trend of low cost production is seen in the Agriculture industry as apparent as any other field. Farmers and Ranchers across the world are looking for ways to maintain crop yields while effectively lowering the cost to do so. There are many levels in the operation of a farm or ranch but for the crop or pasture nutrition problem, the product Revinu is a large part of the answer. Revinu is a nutrient rich mixture of organic matter, calcium hydroxide, potassium, and slow release nitrogen that can be offered to the consumer at a much lower cost than traditional commercial fertilizers.

Revinu is composed of 40% calcium hydroxide (hydrated lime) which gives the product the ability to adjust pH in soil. Hydrated lime is also much more soluble than dolimitic limestone which means the reaction time for Revinu when applied to the soil is much more rapid. The break down period on dolomite could be as much as 60 days where Revinu will adjust pH in about 10 days. Revinu is a very complex product and soil condition is definitely a place it stands out when compared to other available products. Revinu is very comparable in price to other liming agents on the market today but Revinu is the only product available that will offer pH adjustment and nutrient value in one application. The Revinu product is one of the top liming agents available to the Agriculture industry and it offers the end users a great option for cost savings and more than adequate results in the field.

Another strong point for the Revinu product is the availability of nutrients in the material. Revinu has a registered fertilizer label with the State of Florida and a guaranteed analysis of 2-0.5-1. Because Revinu has less than ½ a percent of phosphorus it can be applied in phosphorus sensitive areas giving consumers in the areas an option that a short time ago was not available. Also over ½ of the available nitrogen in the product is organic slow release which gives the consumer a much longer feed time for the forage which the product was applied to. With commercial nitrogen you evaporate about a unit a day so by applying Revinu the consumer will have three times the amount of nitrogen breakdown for prolonged plant nutrition. The potassium in the product is a very expensive nutrient and although the pounds per ton in the Revinu product are not very high it is still a great asset to the material. Potassium is needed al all forages for root growth and proper seed germination. The Revinu product has enough Potassium to ensure a strong stand of plant life for a fraction of the cost at market price for potassium.

Also Revinu is made up of 35% to 55% organic humus which is another stand alone quality. The humus in the material acts as a top soil replenishing the natural bacteria that are essential for optimal plant growth and root strength. Year after year the top layer of soil is eroded away by the wind and natural elements and very little action is taken by the land owners to replace what is lost strictly due to cost. Now with Revinu there is an option that is available. By land Appling Revinu the customer is adding back layers of organic material that have been lost over the years. The fill that is provided by the Revinu product is great for restoring what has been lost and establishing a proper base for exceptional forage growth.

New products are getting much more attention in today's market than in the past. Farmers and Ranchers alike are much more willing to try something new in hopes of saving money. Revinu is great product for that reason and a few others, not only will Revinu save that consumer money but it will do exactly what is needed by the consumer for ample product production. By using Revinu the customer can be assured that they are receiving a product that will perform along side any other product that is available. Revinu has a slightly different make up than other products so application rate may be a little different, but when applied properly Revinu will cover all aspects of proper pasture nutrition. Revinu will also offer pH adjustment and nutritional value in one application which no other product can do. Revinu is a great product for anybody in the

Agriculture or any other forage growing industry. By using Revinu the customer can cut cost without chancing the quality or integrity of the product.

As a Liming Agent

-Due to a pH range of 11.5 to 12.3 Revinu has the same effects on soil conditioning and pH adjustment as any other product on the market.

-As a liming agent Revinu is one the top products on the market. When applied at 1 ton per acre Revinu will raise a landowner's pH by about ¾ of a point, this number is very consistent with a Dolomite type product.

-The use of Revinu will eliminate the need for any liming agent application.

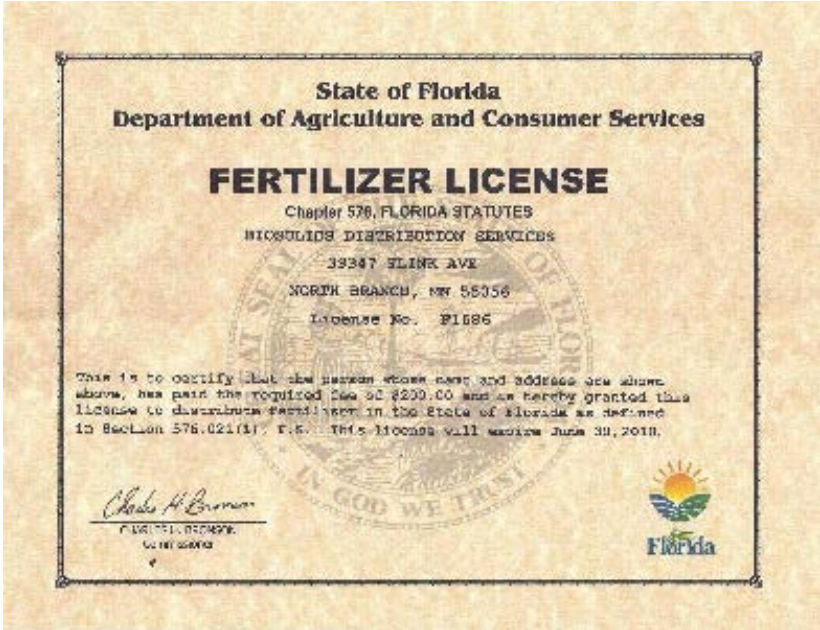
-Due to the high pH of the product leaching nitrates and phosphates can be reduced in the soil.

-With Revinu the consumer receives N-P-K value that is not available in any other liming agent on the market.

-The product also contains 27% Calcium Hydroxide which is also rare in the liming industry. What this does is allow the product to react faster and provide the forage with all the nutrients from 40% hydrated lime in a much faster time frame.

-The reaction time on commercial limestone is around 60 days; because of the Calcium Hydroxide Revinu has a reaction time of less than 15 days.

-Revinu has been licensed by the FL DEP as a fertilizer


State of Florida
Department of Agriculture and Consumer Services

FERTILIZER LICENSE

Chapter 576, FLORIDA STATUTES

BIOSOLIDS DISTRIBUTION SERVICES

39347 SLINK AVE

NORTH BRANCH, MN 55056

License No. F1686

This is to certify that the person whose name and address are shown above, has paid the required fee of $200.00 and is hereby granted this license to distribute fertilizer in the State of Florida as defined in Section 576.021(1), F.S. This license will expire June 30, 2018.

Florida

Conclusion:

Lime Stabilization is a proven method for treating sewage sludge that has been approved by the EPA. The Bioset process further refines the technique of lime addition to optimize the chemical requirements and system efficiencies. The end product is safe and has many uses including fertilizer and as a soil stabilizer. These facts make the Bioset process the most versatile and attractive method for biosolids treatment on the market today. Copied below are two further endorsement letters for the Class AA Revinu product produced by the Bioset process:

Barnes Turfgrass Consulting Service, Inc.
225 Manatee Road
Winter Haven, FL 33884
Off. & Fax 863-324-2380
btcsfla@aol.com

January 18, 2009

To Whom It May Concern:

As our soil environment is being adversely affected by our water quality from deep wells, surface lakes and treatment plants that have become higher in salts, bicarbonates and chlorides the addition of the Revinu Lime-Enhanced Soil Conditioner is going to a positive input in combating these poor water conditions.

The adding of organic nutrients enhanced with high calcium to our soils will help in not only off-setting the negative effects of soluble salts, bicarbonates, and chlorides but will aid in enhancing and encouraging microbe populations that help in maintaining good soil microbiology, fertilizer breakdown, and organic matter decomposition.

The other factor that will be so important to golf courses, sod farms, and athletic fields is the economic impact of being able to apply good nutrition but also getting the liming benefits of the high calcium content of Revinu for almost the same cost of dolomitic limestone. It has always been suggested and recommended to apply lime annually to help keep soil pH stable from acid-forming fertilizers and nutrient leaching from rainfall and irrigation. The cost of Revinu will allow many golf courses, sod farms, and athletic fields the ability to apply good organic nutrition and lime for much less cost than conventional fertilizers and dolomite applied in separate applications. Revinu applied at one ton per acre gives the turf over 1 pound of nitrogen per 1,000 square feet that is composed of both water-soluble and water-soluble forms of nitrogen that limits excess run-off from rain or heavy irrigation and gives slow release of the nitrogen over several months. It also provides almost the same liming capacity at that rate of dolomite or high-cal lime.

I would recommend to anyone to anyone trying to maintain healthy turf to explore how to incorporate this new, economic product into their fertilizer program.

Respectively submitted,

David E. Barnes
Consulting Agronomist

RELIABLE SPREADER, INC.
Telephone 863-453-4459
Fax 863-453-4874
P.O. Box 905
3200 CR 64 EAST
AVON PARK, FLORIDA 33825

To whom it may concern:

Reliable Spreader Inc. is a custom commercial fertilizer application provider. We have been serving the Ag, Citrus and Turf Grass industries for 19 years. Please accept this statement as a reference to our experience with the Biosolids Distribution Services LLC. product Revinu. We have had the opportunity to apply the product multiple times for several customers in both a "wet" form and a "dried and screened" form. Either way, the application went very well and our customers were very satisfied.

To apply the product in the "wet" form, a "high volume spreader" or manure spreader is required. To apply the product in the "dried and screened" form, any standard spreader can be used.

Revinu has been a great asset to our business and to our customers because of its multifaceted benefits. Not only is it a fertilizer source but also it has liming benefits and is organic in nature, which is a real bonus for Florida's sandy soil. We are in our second year applying the product and are now doing "repeat business" with some of last years customers. They are pleased, and our only regret is that at times we are unable to provide service because of a shortage of material.

With kind regards,

R Jay Todd Jr.

FERTILIZER * LIME * ORGANIC FERTILIZER
LIQUID FERTILIZER
PASTURE * HAY FIELD * GROVE * SOD * GOLF COURSE