The Pioneer Grant Program

The 2016 Pioneer Grant Program aims to reduce nutrient and/or sediment contaminant loads to the Maryland portion of the Chesapeake Bay and Maryland Coastal Bays from any nonpoint source: agriculture, urban or suburban stormwater, air, and septic by seeking proposals that focus on new techniques, information, or programs that increase the rate at which load reductions can occur.

Sassafras River Association

Phosphorus Removal from Dairy Manure in the Sassafras and Upper Chester Headwaters

2012-2013

Project Track: New Technology

Research Question: Can a crystalized struvite phosphorus removal system successfully reduce phosphorus by 60% in dairy waste lagoons prior to field application?

Research Results: The Jones Family Farm constructed a dual reactor system that was capable of handling 60,000 gallons of effluent per day. By developing a crystallized struvite phosphorus removal system they were able to achieve all proposed goals for this project.

Notable Information: Another major success of this project was the unprecedented ability to conduct precision blending and application of manure fertilizer through a multi-cell lagoon system which resulted in a net decrease in soil phosphorus saturation over time.

PROJECT PARTNERS

Jones Family Farm
Lester C. Jones & Sons, Inc.

Sassafras River Association

Multiform Harvest

red barn Consulting

Sassafras River Association

Phosphorus Removal from Dairy Manure in the Sassafras and Upper Chester Headwaters

2012-2013

Summary of Project

The Jones Family Farm is a large dairy and grain operation nestled in the headwaters of the Sassafras and upper Chester Rivers in Kent County, MD. The farm is currently milking 1300 cows with over 2400 total animals and 1000 acres of crop ground in a corn and small grain rotation. This dairy utilizes a recycled wastewater flush system for waste removal in the milking parlor and main enclosure areas. The water is pumped from lagoon storage, through the enclosures and then through a solid separation system, then finally back into the lined waste lagoon. The wastewater is periodically pumped from the lagoon through a center pivot irrigation system onto 520 acres of adjacent cropland to create additional storage space and to meet nitrogen requirements of growing crops. Unfortunately, phosphorus levels in the irrigated wastewater far exceed the crop uptake when applied to meet nitrogen requirements. Annual soil test analyses completed by Sean Jones and Willard Agri-Service have shown increasingly elevated soil P levels, which, unchecked, may reach a soil saturation point that will result in P leaching to adjacent headwater streams.

While the Jones Family Farm is legally allowed to apply dairy effluent to meet crop nitrogen requirements, based on P-site index analysis, the farm maintains a progressive and proactive approach to nutrient management and environmental stewardship. The farm approached Red Barn Consulting Inc. to investigate possible technologies that would reduce or remove P from wastewater prior to field application. A new technology called a crystallized struvite phosphorus removal system, developed through researchers at Washington State University and Multi-Form Harvest, Inc., was identified as a potential solution. The system, developed and perfected in the Pacific Northwest over the past 11 years, has recently been shown to achieve greater than 50% reductions of TP in swine and dairy lagoon waste. In the summer of 2011, the Jones Family Farm set up and operated a demonstration scale system to test the technology on-farm and develop protocol that would achieve the highest potential P removal efficiency. Samples were tested both on the farm with portable test kits, following stringent protocol, and through Multi-Form Harvest labs. Results were impressive with removal rates of 60% orthophosphate and 50% TP achieved by the end of the 2 ½ month trial.

Based on initial on-farm testing, lagoon waste analysis, and the current farm nutrient management plan, it was determined that Jones Family Farm would need to treat approximately 40,000 gallons of effluent daily to meet reduction goals that would support a slow decrease in soil P levels over time. It was decided to install a 60,000 gallon/day capacity system to account for additional capacity or future increases in reduction goals. The system, when installed, will treat up to 21,900,000 gallons annually if run at full capacity for 365 days per year, accounting for the majority of the 25,689,042 gallons spray irrigated annually on the adjacent cropland. Using a conservative estimate of 44% removal efficiency for TP, the system will achieve a reduction of 7,800 lbs TP annually from the wastewater irrigation, exceeding both the SWAP and Sassafras River TMDL goals. The Jones Family Farm has made a considerable investment to date, exceeding $540,000, to line and segregate the lagoon storage system into a three compartment facility which will facilitate segregation of treated and untreated wastewater. With separate pumping stations to supply the waste irrigation system, the farm will be capable of custom blending effluent to meet exact nutrient

requirements of crops, thereby drastically improving precision fertilizer application on 520 acres in close proximity to sensitive headwaters.

The Project: This project will include the following activities and action items:
• Construct a dual reactor system, each tank handling 30,000 gallons per day
• The Jones Family Farm, with project oversight from Red Barn Consulting and Multi-Form Harvest, will continue to refine the timing and amounts of reagent injection, through continued analysis of lagoon waste P concentrations and effluent post-treatment
• Soil P levels on irrigated fields will be closely monitored through annual soil analyses and P site index conducted by Willard Agri-Service.
• Connection of a multi-cell, segregated lagoon storage system to existing center pivot irrigation system, allowing custom precision blending of fertilizer levels based on crop uptake requirements.
• Conduct outreach/ dissemination efforts to transfer knowledge to other Chesapeake Bay watershed farmers.

The Technology:
The crystallized struvite* P removal system was developed and perfected over the past decade in the Pacific Northwest through a partnership between Washington State University and Mulit-Form Harvest Inc. The system pre-treats dairy or swine waste with a strong acid that breaks the phosphorus-calcium bonds. The effluent is then forced through a fluidized bed of struvite, within a closed tank, where a caustic soda or other basic medium is injected which causes a rapid rise in pH, thereby forcing the free P atoms to precipitate and bond with the struvite particles. The treated effluent rises to the top of the tank, and is pumped off to a separate lagoon cell. As struvite crystals grow with bonded P atoms, the larger crystals fall to the bottom of the tank and enter a collection chamber where they are periodically collected, dried, and stored for export off-farm. Residual struvite is left in the chamber as "seed" for the next treatment. Markets exist or are being developed for the struvite product as mined phosphorus becomes less available and more expensive.
Several years of testing on multiple farms have been conducted to identify a pH depressor (to break phosphorus-calcium bonds) and a pH booster (to force precipitation of P) that would achieve optimal results while maintaining a cost efficiency that is sustainable on a commercial scale.

Progress to Date:
SRA and project partners have met all project goals. The Jones Family Farm completed the splitting and lining of the wastewater treatment lagoon that was critical for segregation of pre and post treatment wastewater. A custom designed and sized struvite reactor was constructed, delivered, installed, and calibrated early last spring and the Jones Farm has completed the installation of a shed facility for the control center and chemical storage. The remainder of the project period has been spent further learning and calibrating the system and finding a sustainable balance between reagent costs and P removal levels. The farm will be using treated effluent in their fertigation system this spring to meet crop needs, and will use significantly less phosphorus than previous years. SRA is currently working to coordinate a regional field day for dairy producers that may be interested in this technology and to explore the potential of a mobile unit that would service multiple farms. This is discussed further below.

Project Evaluation

The nature of this project was the implementation of a new and developing technology that holds significant promise to help meet the nutrient load reduction goals for the Sassafras River, as well as the Chesapeake Bay. While the technology has been implemented successfully on a few farms and several municipalities across the country, it is far from a cookie cutter project, as each reactor and

system is sized and designed to that specific application. A significant amount of time must be dedicated to learning, calibrating, and fine-tuning the system, and the operator must have a strong grasp of chemistry and mathematics. While, given the initial financial investment and knowledge base needed to successfully implement this technology, it will likely only be feasible for large operation. A mobile unit could possibly be constructed, however, that would be hauled from farm to farm. A dairy could wait until the primary lagoon is near maximum capacity and then have a custom processor treat and pump effluent to a second lagoon for field application.

The high rate of P removal achieved through this project is tremendously encouraging, and shows great potential for helping dairy farms in the Chesapeake Bay watershed to meet new regulations while maintaining a usable, free, organic source of nutrients for cropping systems. The project also promotes sustainability through use of farm-generated fertilizer, and the reclamation and reuse of harvested phosphorus (a finite, mined commodity) for alternative uses. Continued promotion and support of this technology would be advised as a next step in the advancement of precision agriculture, as treated effluent can be custom blended on-farm to meet crop uptake goals.

Transferability and Sustainability

One of the primary objectives of this project was to disseminate this technology to other dairy and swine farmers in the Chesapeake Bay watershed. SRA worked with the Jones Farm and several regional dairy associations to set up a regional field day to feature the phosphorus reactor (discussed in section below). SRA coordinated the event and promoted it through local media outlets, regional agricultural media, and social media. Significant interest has been expressed in this technology from other dairy producers, local Soil and Water Conservation Districts, and several NGO watershed organizations.

While SRA expects a significant impact to water quality through operation of this reactor on the Jones Farm, the promotion of this technology as a mobile service may be the key to making it a feasible option for smaller and mid-size dairies. SRA plans to look into the economic and technical feasibility of this option and measure farmer interest in the service. This technology could possibly be a major factor in sustainability of dairy farms under new phosphorus management guidelines, and is worth continued investigation and promotional effort from SRA.

Monitoring and Maintenance

The Jones Farm continues to monitor this project intensively to determine optimal levels of reagent inputs to achieve the desired reductions at an economically sustainable level. The farm has been able to achieve much higher reductions than the original project goals stated (over 70%). The farm needs approximately 35% reduction to meet P removal goals and continues to dial in the system to maximize efficiency.

Work is ongoing to gain experience and work the inevitable glitches out of the system. Extreme cold weather, high solid content in the effluent, and other issues have arisen to challenge the success of the project but have been solved through the dedication and ingenuity of the farm owner.

Community Involvement and Outreach Activities

As noted above, SRA held a successful field day for regional dairy producers and interested technical service providers. Attendees included dairy producers, dairy industry, conservation funders, Soil Conservation Districts and NRCS, Chesapeake Bay Foundation, University of Maryland, University of Delaware, and many interested agricultural professionals. The Kent County News,

Delmarva Farmer, Cecil Whig, and a regional dairy newsletter were present to cover the event. A presentation was given by farm owner, Sean Jones, and a tour was given of the project. Significant interest was generated and a farm in the mid-shore region is considering the technology for their operation. .

SRA has promoted the project through its media outlets, including monthly newsletters, website features, and social media updates. The project has been featured in the SRA newsletter update multiple times, reaching approximately 700 residents or part-time residents of the Sassafras River watershed. Additionally, the project was recently featured on the Maryland Public Television series Maryland Farm and Harvest. http://video.mpt.tv/video/2365146566/ . The project will be featured in the 2015 MD NPS report to the EPA as well.

As mentioned in a previous report, a Washington College class participated in a tour stop at the farm this fall as part of its Chesapeake Semester and discussed the reactor and its place in the operation with owner Sean Jones and SRA Ag Outreach Coordinator, Josh Thompson. The group included 12 students, 1 WC professor, and 1 WC Center for the Environment and Society staff member.

Partnerships

Sean Jones is the co-owner and manager of Jones Family Farm in Massey, MD. Sean is on-site project manager and will operate or manage the operation of the reactor and distribution of treated effluent on a daily basis.

Multiform Harvest Inc. is a private company based in Seattle, Washington, which has developed a patented technology that recovers excess phosphorus and nitrogen from wastewater and converts it into a premium, slow-release fertilizer. The technology allows wastewater treatment plants to meet nutrient discharge limits more cost-effectively than other technologies, and provides a sustainable, domestic supply of a diminishing world resource – phosphorus

Keith Bowers Ph.D. is the president and founder of Multi-Form Harvest, and is personally managing the production of this reactor and system. Keith maintains close contact with the Jones Family Farm to ensure proper sizing, setup, and operation.

Mike Twining is the General Manager of Willard Agri-Service Delmarva, certified nutrient consultant and crop consultant, and highly respected leader in the production agriculture field in Delaware and Maryland. Mike is responsible for all nutrient management planning and will adjust plans to accurately account for new effluent concentrations.

Red Barn Consulting, Inc. (RBC) is an agricultural engineering and permitting company that services over 1000 clients across the Commonwealths of Pennsylvania and Virginia and the states of New York, Ohio, Maryland, North Carolina and Texas. Red Barn will be working closely with project managers and will be responsible for:

- Facility design and layout
- Schematic estimating and construction budgets
- Financial feasibility modeling and assistanc
- Project supervision and construction management

Karen Miller is the District Manager for the Kent Soil and Water Conservation District in Kent County, MD. The Kent SCD will be involved in review for erosion and sediment control. They will

also play an integral role in promoting the technology across the County and facilitating farm tours featuring the system.

Accounting of Expenditures

CBT Funds: $99,900
Jones Family Farm: $747,674
Total Funds: $847,574