NEWTRIENT™

APPLICATION FOR COMPONENT ADDITION TO NRCS

# NRCS Practice Standard 632

## For Acceptance of Vibratory Separation Screen Technology


**STUDY PREPARED BY:**

Mark Stoermann
Newtrient Technology Advancement Team


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**APPLICATION FOR COMPONENT ADDITION TO NRCS Practice Standard 632:**

***Vibratory Separation Screen Technology***

***REQUEST***

As various environmental, regulatory, and legal pressures mount regarding nutrient management on dairies, a multitude of new technologies are being marketed as solutions to these challenges. Dairies now face a diverse array of options, often receiving information solely from technology providers themselves. In response to the expressed needs of both the USDA's Natural Resources Conservation Service (NRCS) and dairy farmers, Washington State University, in collaboration with Newtrient, developed a standardized evaluation protocol, adapted from criteria found in Appendix A of the NRCS's Conservation Practice Standard (CPS) Waste Treatment (629). The intended purpose of this protocol is to enable reliable, unbiased assessments of nutrient removal technologies, supporting informed decision-making by farmers considering the adoption of these technologies on their dairies.

Newtrient has evaluated *Vibratory Separation Screen Technology* using the CPS 629 framework, and we are now requesting that this technology be included as a supplement under NRCS CPS 632 (Waste Separation Facility). This adjustment is appropriate as vibratory screens function primarily as separation systems, aligning more closely with the objectives of CPS 632. By adding this supplement to CPS 632, we aim to provide farmers and industry stakeholders with standardized guidelines and a proven approach to implementing vibratory separation screens for waste separation. This will expand the range of options available under NRCS CPS 632, allowing the development of cost-sharing opportunities with NRCS, thereby facilitating project assessment and financing—a critical aspect often limiting technology implementation.

***BRIEF DESCRIPTION OF COMPONENT CLASS***

Vibratory separation screen technology is employed for solid-liquid separation and sorting dry materials into various particle sizes. It utilizes vibratory motion to separate components based on size and density, oscillating a screen or sieve to move solids while allowing liquids to pass through the mesh. Widely used in agricultural settings, including dairy farming, these screens are valued for their efficiency, compact design, and versatility in handling different materials. They effectively separate solids from liquid waste streams, enabling resource recovery, reducing disposal volumes, improving liquid effluent quality, and offering cost-effective waste management solutions tailored to agricultural applications.

***DETAILED DESCRIPTION***

Vibratory separation technology is a sophisticated process utilized for separating, classifying, and dewatering materials by employing controlled vibratory motion. In the context of manure management, this technology effectively separates liquid from solid components within the manure stream. Vibratory screens are typically utilized for fine solids separation, but due to the flexibility in changing the mesh size, can be used for an array of particle sizes, including coarse solids. The process begins with the even distribution of manure onto the screen deck via a feeder. This screen deck is the core component of the separator, typically comprising one or multiple layers of screens with varying mesh sizes.

A vibrating motor or exciter, which has an eccentric weight to generate unbalanced force, induces the necessary vibratory motion. This motion can be linear, circular, or elliptical, depending on the separator's design and specific application needs. The screen deck is mounted on springs or rubber mounts that isolate the vibratory motion from the rest of the structure, ensuring that only the screen deck vibrates. As the manure is fed onto the vibrating screen deck, the vibratory motion causes the material to stratify based on size, shape, and density. The smaller liquid particles pass through the mesh openings, while the larger solid particles remain on the screen.

This stratification process is continuous, driven by the consistent vibratory motion, which keeps the manure in constant movement and prevents clogging. The separated liquid and solid components are then directed to different discharge points. Typically, the solid particles are collected from the end of the screen deck, while the liquid passes through the mesh and is collected underneath. Depending on the specific setup and the number of screen layers, intermediate fractions can also be collected at various points along the screen deck.

For manure processing, a vibratory separator can handle significant volumes, with capacities varying based on the model and configuration. Generally, industrial vibratory separators can process anywhere from one to ten tons of manure per hour, depending on the consistency and moisture content of the manure. To enhance efficiency, especially in applications involving fine particles or hazardous materials, a dust cover or enclosure may be used. This helps contain dust, protect the equipment from weather events, improve the working environment, and prevent contamination.

Operators can adjust the vibration intensity, screen angle, and other parameters via a control panel to optimize the separation process. Sensors and monitoring systems ensure consistent operation and track the separator's performance. Regular maintenance and monitoring, such as checking and adjusting screen tension, inspecting springs and mounts, and ensuring the motor and drive system are functioning correctly, is crucial to prevent downtime and extend the equipment's life.

In essence, vibratory separation technology leverages controlled vibratory motion to effectively separate liquid from solid components within a manure stream. This process enhances the efficiency and scalability of manure management, offering a versatile solution that can handle large volumes with minimal maintenance requirements.

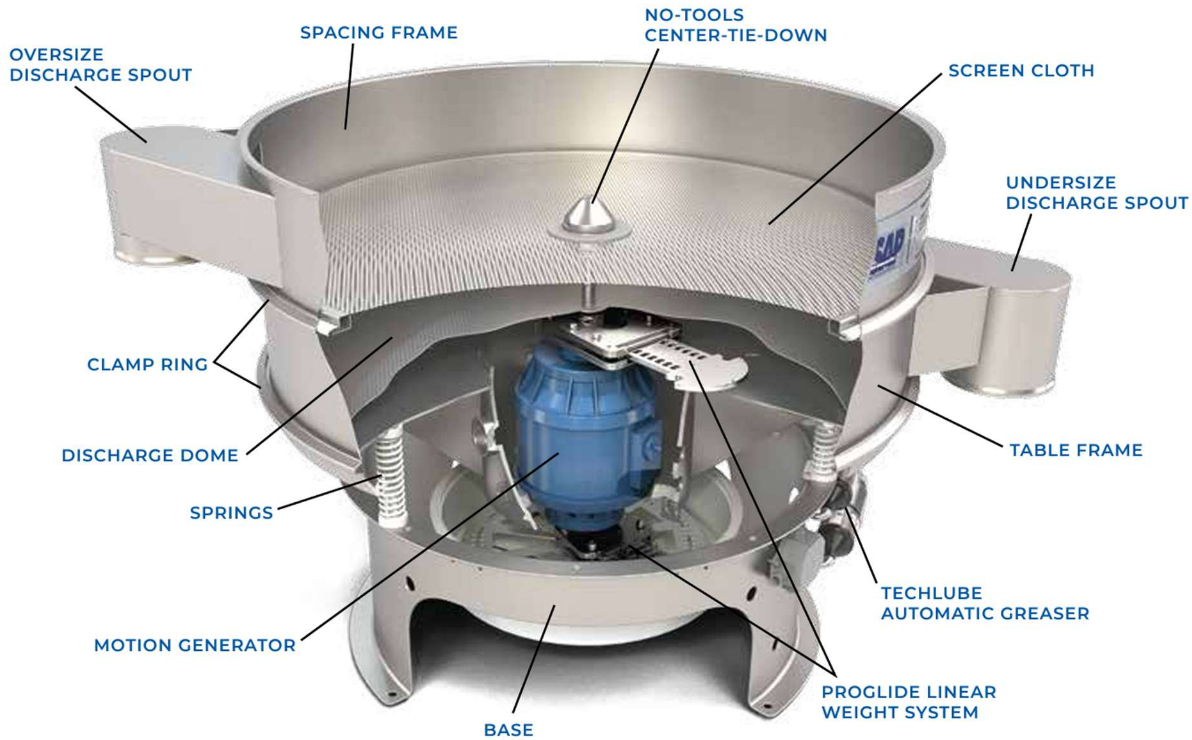



**Figure 1. SWECO Vibro-Energy Round Separators Interior View.**

The basic components of vibratory separators include (**Figure 1**):

- **Screen/Sieve Deck**: The primary component where the separation process occurs. It consists of one or multiple screen layers with varying mesh sizes to allow particles of specific sizes to pass through.
- **Vibrating Motor or Exciter**: The source of vibration, which can be an electric motor with an eccentric weight or a mechanical exciter, generates the necessary vibratory motion to move and stratify the material on the screen deck.
- **Frame or Base**: A sturdy structure that supports the screen deck and motor. It provides stability and ensures the machine operates efficiently.
- **Spring System**: Springs or rubber mounts that isolate the vibratory motion from the frame and support the screen deck. They help absorb vibrations and prevent excessive movement that could lead to structural damage.
- **Feeder**: An inlet system that distributes the material evenly onto the screen deck. It ensures consistent feeding of material into the system for effective separation.

- **Discharge Chutes**: Outlets that guide the separated materials (oversized and undersized particles) to designated collection points or downstream processes.
- **Dust Cover or Enclosure**: An optional component used to contain dust, protect equipment from weather events, and prevent contamination. It is particularly useful in applications involving fine powders or hazardous materials.
- **Control Panel**: An interface for operating the separator, adjusting vibration intensity, and monitoring performance. It may include switches, dials, or digital controls.
- **Screen Tensioning System**: A mechanism to adjust and maintain the tension of the screen mesh. Proper tension is crucial for efficient separation and prolonged screen life.
- **Drive System**: The assembly that transmits power from the motor to the screen deck. It can include belts, pulleys, or direct drive mechanisms.

### *HOW PROPOSED SYSTEM ACCOMPLISHES PURPOSES OF THE STANDARD*

The proposed vibratory separation technology aligns with NRCS Waste Separation Facility (CPS 632) by efficiently separating solids from liquid waste streams in agricultural contexts, particularly in dairy farming. By utilizing vibratory motion, this technology allows liquids to pass through while retaining solids, facilitating subsequent manure treatment processes such as composting or anaerobic digestion. It effectively prevents solids accumulation in liquid storage facilities, thereby improving operational efficiency, enhancing air quality, and reducing maintenance requirements. Moreover, the technology enables easier recycling of liquids for irrigation and enhances the suitability of liquid waste for land application, supporting sustainable nutrient management practices in agriculture.

Newtrient (www.newtrient.com), a company sponsored by the dairy industry and committed to enhancing value and sustainability in manure management, has conducted a thorough assessment of technology systems and practices within the field, focusing on their impact on critical environmental metrics, specifically water quality. In support of this discussion, Appendix A offers brief insights on the significant impact of vibratory separation screen on key environmental indicators related to water quality, air quality, and other relevant factors aligned with the objectives of NRCS Standard 632. Also, Appendix B presents data from a specific commercial installation, offering visual representations and nutrient profiles that demonstrate the positive influence of integrating a vibratory separation system within a comprehensive manure management approach. Additionally, Appendix C contains the final report of the study conducted by the University of Delaware, focusing on the commercial installation of the system and providing further insights into the effectiveness and benefits of vibratory separation technology.

Reducing nutrient content, organic strength

Vibratory separation screens effectively reduce nutrient content and organic strength in liquid waste streams by employing vibratory motion to separate solid particles from liquid waste in agricultural settings like dairy farms. This process significantly lowers concentrations of nutrients such as nitrogen (N) and phosphorus (P) in the liquid fraction, while also diminishing the organic strength by removing solids containing organic matter. These screens play a crucial role in improving the quality of liquid effluent and reducing environmental impacts when the treated liquid is recycled or applied to land for irrigation, mitigating risks associated with excess nutrient application, leaching, and runoff, thereby supporting sustainable agricultural practices.

Reducing odor and gaseous emissions

The vibratory separation system can contribute to reducing odors and gaseous emissions in several ways. First, by effectively separating solids from liquid waste streams, it minimizes the organic matter content in the liquid fraction. Organic matter decomposition is a significant source of odorous compounds and gaseous emissions such as ammonia ($NH_3$) and volatile organic compounds (VOCs). By reducing the organic load in the liquid waste, the system inherently decreases the potential for odor generation.

Moreover, preparing manure through solid-liquid separation is beneficial for downstream processes like anaerobic digestion. Anaerobic digesters utilize organic matter to produce biogas, methane ($CH_4$), which can be captured and used as a renewable energy source. By removing coarse solids before digestion, the vibratory separation system optimizes the efficiency of anaerobic digestion, thereby enhancing biogas production while further reducing odors and gaseous emissions associated with untreated manure.

Additionally, the separation of solids allows for better management of nutrient distribution. By concentrating nutrients in the solid fraction, which can be more easily transported and applied to fields at appropriate times and rates, the system helps to minimize nutrient loss to the atmosphere as gases (such as $NH_3$) during storage and land application. This holistic approach not only improves odor control and reduces gaseous emissions but also enhances the overall environmental sustainability, particularly pertaining to air quality, of manure management practices in agriculture.

Facilitating desirable waste handling and storage

The vibratory separation system effectively manages the composition of liquid and solid fractions in manure. By separating solids from liquid waste streams, it reduces the organic load in the liquid portion, essential for minimizing odors and gaseous emissions during storage and handling. A reduction in solids content in the liquid fraction during storage and handling also decreased the need for laborious and time-consuming cleanouts of storages and downstream treatment technologies. This improved management of organic matter also enhances the stability and consistency of the liquid waste, making it more suitable for various downstream processes such as anaerobic digestion. Solids reduction in the waste stream can also improve the longevity of downstream processes, reducing abrasive wear on equipment, which would otherwise result in costly maintenance repairs and replacements.

Furthermore, concentrating nutrients in the solid fraction allows for more economical land application. The separated solids, rich in nutrients like N and P, can be transported and applied to fields further away from the dairy farm. This strategic distribution helps balance nutrient availability across fields and reduces costs associated with transporting and applying manure, supporting efficient agricultural practices and minimizing environmental impacts.

<u>Producing value added byproducts that facilitate manure and waste utilization</u>

The system effectively concentrates nutrients like N and P in the solid fraction by separating solids from liquid waste streams. These nutrient-rich solids are ideal for composting or direct use as organic fertilizers, bolstering soil fertility and enhancing crop yields. Additionally, the separation process decreases the organic load in the liquid fraction, enabling it to undergo anaerobic digestion to generate biogas, primarily methane. This biogas serves as a renewable energy source that can be utilized onsite or fed into the grid, promoting energy independence and sustainable agricultural practices.

### ***RANGE OF VOLUMETRIC AND MASS FLOW CAPACITIES AS WELL AS HYDRAULIC RETENTION TIME***

The following section provides an overview of key parameters related to the performance of vibratory separation systems in manure management:

- *Volumetric Flow*: The volumetric flow rate refers to the rate at which material (such as liquid or slurry) passes through the separator. It is typically measured in liters per hour (L/h) or cubic meters per hour ($m^3$/h) and indicates the volume of material processed over a specific time period. Flow rate is crucial for determining the throughput capacity of the separator and is influenced by factors like the size of the screen deck, vibration frequency, and material properties. For vibratory separation screens used in industrial or agricultural settings, typical volumetric flow rates can range from several hundred liters per hour to thousands of liters per hour. Manufacturers often specify the maximum flow rates their equipment can handle under optimal conditions, which can be adjusted based on the specific needs and characteristics of the material being processed.

  During the Kilby Dairy vibratory system evaluation (Appendix B), the average inflow rate of liquid manure into the SWECO vibratory screens from an 870-cow dairy was 2.41±

0.52 liters per second (L/s), which translates to approximately 8,676 L/h. This measurement is based on the average collected during the 16-week sampling period, ensuring a consistent flow rate over time.

- *Mass Flow*: Mass flow capacity refers to the amount of material processed by the separator in terms of mass per unit of time. It takes into account not only the volumetric flow rate but also the density of the material being processed. Mass flow capacity is measured in kilograms per hour (kg/h) or metric tons per hour (t/h), depending on the scale of operation. It provides a measure of the separator's capability to handle and separate materials based on their mass. For dairy manure processing, vibratory separators can handle mass flow capacities ranging from approximately 500 kg/h to 5,000 kg/h (0.5 to 5 t/h). The actual capacity depends on factors such as the moisture content of the manure, the efficiency of separation desired (e.g., solids removal), and the specific design of the vibratory separator.
- *Hydraulic Retention Times (HRT):* HRT is the average time that a discrete volume of material spends inside the separator. It is calculated as the volume of the separator divided by the volumetric flow rate of the material passing through it. HRT is important in processes where contact time between material and separation media (such as screens or filters) affects the efficiency of separation or treatment. In vibratory separators, HRT helps determine how long particles remain in contact with the screen surface, influencing separation efficiency. HRT in vibratory separators for dairy manure processing typically ranges from 5 minutes to 30 minutes. This range allows sufficient time for the manure to interact with the vibrating screens or sieves, facilitating effective separation of solids from liquids. HRT can be adjusted based on operational parameters and the desired level of separation efficiency. Factors such as screen mesh size, vibration intensity, and flow rate influence the effective HRT.

### *DESIRED FEEDSTOCK CHARACTERISTICS*

To ensure optimal performance, the desired characteristics of feedstock entering a vibratory separator apply to various types, including raw manure. Here are the key desired characteristics for efficient separation of solids from liquids while maintaining processing efficiency:

- **Consistency and Homogeneity**: Feedstock should have a consistent composition and be well-mixed to ensure uniform flow through the separator. This consistency facilitates predictable separation outcomes and prevents uneven distribution of solids and liquids, and consequently nutrients, across the screen deck.
- **Particle Size Distribution**: A relatively uniform particle size distribution enhances separation efficiency. Ideally, ultrafine particles should remain suspended in the liquid

phase, while coarse and fine particles or solids, depending on mesh size, settle or are retained on the screen surface.
- **Moisture Content**: The optimal moisture content in the feedstock helps maintain flowability and promotes effective separation. Excessively dry materials may lead to poor suspension of solids, while overly wet feedstock can increase viscosity, hindering separation efficiency.
- **Density and Viscosity**: The density and viscosity affect feedstock behavior during processing. Lower viscosity promotes easier movement through the separator, facilitating efficient separation. However, higher viscosity may require operational adjustments to maintain performance.
- **Nutrient Content and Consistency**: Feedstock with consistent nutrient content (e.g., N, P) ensures predictable outcomes for downstream nutrient recovery processes, which is especially important in agricultural applications focused on nutrient management.
- **Free from Large Foreign Objects**: The feedstock should be free from large foreign objects, such as rocks, sticks, or metal debris, to prevent damage to equipment components and avoid disrupting the separation process.
- **pH and Chemical Composition**: While not as critical as other factors, pH levels and chemical composition should be within acceptable ranges to avoid adverse reactions or corrosion within the separator equipment.

### *EXPECTED SYSTEM PERFORMANCE*

Vibratory separator technology offers efficient solid-liquid separation capabilities, crucial for enhancing waste management and resource utilization in agricultural settings. The system's performance can be evaluated based on its ability to alter the physical form and handling characteristics of dairy manure, influence nutrient fate and availability for agricultural use, contribute to pathogen reduction, and mitigate impacts on air and water quality.

- *Changes in form or handling characteristics*
    - Vibratory separation significantly alters the form and handling characteristics of dairy manure by effectively separating solids from liquid streams. This process results in a more manageable and versatile end product: liquid effluent with reduced solids content and drier, nutrient-rich, solid fractions that are easier to handle and store. The separation of solids allows for enhanced nutrient management and application flexibility, as the liquid portion becomes more conducive to irrigation and nutrient distribution, while the solid fraction can be processed into value-added products like compost or bedding material. Moreover, by reducing the moisture content in the solids, the system minimizes storage requirements and potential environmental impacts associated with nutrient runoff, leaching, and odorous emissions.

- *Nutrient fate or end use projections*
    - Vibratory separation systems are designed to effectively partition nutrients within manure, thereby enhancing the overall efficiency of nutrient management in agricultural settings. By separating the solid and liquid fractions, these systems concentrate key nutrients such as N and P in the solid fraction. The separation process also helps reduce the organic load in the liquid fraction, which can be repurposed for various uses, including irrigation and further treatment processes. This reduction in nutrient concentration in the liquid fraction helps minimize the risk of nutrient leaching and runoff, contributing to better water quality management. Additionally, by facilitating the removal and concentration of P in the solids, the system helps mitigate the potential for P accumulation in soils, which is a common challenge in manure management.

      The vibratory separation system at Kilby Dairy effectively partitions nutrients within the manure, concentrating total Kjeldahl nitrogen (TKN), ammonium N, and organic N in the solid fraction. TKN concentrations were highest in the screw press solids, with an average of 0.39% (±0.07). P concentrations were significant in the inflow, SWECO liquids, and screw press solids, with more pronounced separation beginning in April, reducing the risk of P accumulation in soils. Potassium (K) levels remained stable across all manure streams, indicating limited impact on K distribution.
- *Macro-nutrient reductions or transformations*

  See '*Nutrient fate or end use projections'* above.
- *Pathogen reductions or eliminations*
    - While vibratory separation systems do not directly reduce pathogen loads, they play a critical role in preparing manure for further treatments that do. These systems separate solid and liquid fractions, which can facilitate efficient subsequent treatments such as composting and anaerobic digestion. These processes are effective in significantly reducing pathogen levels through high temperatures and microbial activity. Although vibratory separation does not concentrate pathogens, it does reduce the organic load in the liquid fraction, potentially lowering the risk of pathogen proliferation during storage or land application.
- *Air emissions*
    - Vibratory separation systems can have an indirect impact on reducing air emissions from manure management. By efficiently separating solids from liquids, these systems reduce the organic load in the liquid fraction, which can

lower the potential for VOCs and $NH_3$emissions during storage and handling. The separated solids, which are more stable, can be further processed through methods such as composting or anaerobic digestion. Composting reduces odors and VOCs by stabilizing organic matter, while anaerobic digestion captures methane—a potent greenhouse gas—that can be used as a renewable energy source. Consequently, the vibratory separation process enhances the overall efficiency of subsequent treatments, contributing to a reduction in air emissions and supporting more sustainable manure management practices.

- *Water quality*
  - Water quality from manure management are effectively addressed through vibratory separation systems. By separating solid components from liquid manure, these systems significantly reduce the organic load and nutrient content in the liquid fraction, as previously discussed. This process helps prevent nutrients such as N and from leaching into groundwater or both N and P causing runoff into surface water, thereby mitigating environmental impacts and improving water quality. Concentrating nutrients in the solid fraction allows for precise application of manure-derived fertilizers on agricultural fields, minimizing nutrient runoff and leaching and supporting soil health. The resulting liquid effluent, with reduced solids and nutrient levels, can be further treated or reused in agricultural practices, promoting sustainable water management practices overall.

***PROCESS MONITORING AND CONTROL SYSTEM REQUIRMENTS***

Process monitoring and control systems are crucial for optimizing the performance of vibratory separation technology. These systems enable real-time monitoring and control of key parameters specific to vibration separation operations, ensuring efficient and effective separation of solids and liquids.

- *Required monitoring*— Monitoring is crucial for ensuring the efficient operation and performance of vibratory separation technology in various applications. Key parameters that typically require monitoring include flow rates of incoming manure and separated fractions, particle size, moisture content in solids, nutrient concentrations (such as N, P, and K), and system uptime/downtime. Monitoring these parameters allows operators to optimize system performance, track nutrient partitioning efficiency, and ensure compliance with environmental regulations. Regular monitoring also facilitates proactive maintenance and troubleshooting, enhancing overall operational reliability and effectiveness.

- *Required control*— Effective control mechanisms are essential for managing vibratory separation systems to maintain consistent performance and optimize resource utilization. Controls typically involve regulating feedstock flow rates, adjusting vibration intensity or frequency to optimize separation efficiency, and managing system start-up and shutdown procedures. Automated controls are often employed to maintain optimal operational conditions, such as maintaining specific moisture levels in separated solids or adjusting screen settings based on feedstock characteristics. Reliable control systems ensure stable operation, minimize energy consumption, and maximize the quality of separated fractions for downstream processing or reuse.

- *Equipment included for monitoring*— Monitoring equipment for vibratory separation systems typically includes flow meters to measure incoming and outgoing flow rates, moisture sensors or probes to assess moisture content in solids, and nutrient analyzers for determining nutrient concentrations in separated fractions. Additionally, sensors may be used to monitor vibration intensity or frequency, ensuring consistent separation performance. Data loggers or monitoring software are employed to collect and analyze real-time data, providing insights into system performance trends and facilitating informed decision-making for operational adjustments and maintenance scheduling.
- *Equipment included for controlling*— Control equipment for vibratory separation systems includes programmable logic controllers (PLCs) or microprocessor-based controllers to automate system operations. These controllers manage feedstock flow rates, adjust vibration parameters, and coordinate ancillary equipment such as pumps and valves. Variable frequency drives (VFDs) or motor controllers are used to regulate vibration motors, optimizing separation efficiency and energy consumption. Human-machine interfaces (HMIs) or supervisory control and data acquisition (SCADA) systems provide operators with real-time status updates and allow for remote monitoring and control. Together, these control components ensure precise operation and responsiveness to varying feedstock conditions, enhancing overall system reliability and performance.

## *TYPICAL OPERATIONS/MAINTENANCE PLAN WITH MONITORING REQUIREMENTS AND REPLACEMENT SCHEDULE*

A typical operations and maintenance plan for vibratory separation technology in manure management includes regular monitoring requirements and a replacement schedule to ensure reliable and efficient operation of the system.

Monitoring Requirements:

1. Screen Condition: Inspect the screen daily to check for any breakage or wear. A damaged screen can reduce separation efficiency and compromise the quality of the output. Replacing or repairing screens promptly will ensure consistent operation.

2. Flow Rates: Continuous monitoring of inflow rates of manure and outflow rates of separated fractions (liquids and solids) ensures that the system is processing materials at optimal throughput levels.
3. Nutrient Concentrations: Regular monitoring of nutrient concentrations in both liquid and solid fractions (e.g., total N, P, K) ensures that the separation process is effectively concentrating nutrients in the desired fraction for subsequent use.
4. Vibration Intensity: Monitoring the intensity of vibratory motion ensures consistent and effective separation of solids from liquids, optimizing separation efficiency and minimizing energy consumption.
5. Equipment Status: Real-time monitoring of equipment status, including motor operation, conveyor speeds, and screen condition, helps identify potential mechanical issues early and ensures continuous operation, reducing the potential for shutdowns.
6. Environmental Emissions: Monitoring air emissions (e.g., dust particles) and water quality (e.g., effluent discharge) from the system ensures compliance with environmental regulations and minimizes impacts on surrounding ecosystems.
7. Energy Consumption: Tracking energy consumption of motors and other electrical components helps identify opportunities for energy efficiency improvements and cost savings.
8. Data Logging and Reporting: Comprehensive data logging and reporting capabilities are essential for documenting system performance, analyzing trends over time, and demonstrating compliance with regulatory requirements.

Replacement Schedule:

1. Screen/Sieve Deck: Screens should be inspected regularly for wear and tear, particularly the screen mesh. Depending on usage and material abrasiveness, screens may need replacement every 3 to 6 months.
2. Springs: Inspect springs annually for signs of wear, fatigue, or deformation. Replace as needed to maintain optimal vibration isolation and system performance.
3. Motors and Exciters: Motors and exciters should be inspected annually for wear, bearing condition, and electrical performance. Replace if the bearings are worn or if there is excessive heat buildup indicating motor stress.
4. Drive Belts and Pulleys: Belts and pulleys should be inspected quarterly for wear, tension, and alignment. Replace belts that show signs of cracking, stretching, or wear beyond manufacturer specifications.

5. Bearings: Bearings supporting the screen and motor shafts should be inspected bi-annually. Replace bearings showing signs of wear, noise, or insufficient lubrication.
6. Control Panels and Electrical Components: Inspect electrical components annually for proper operation, signs of overheating, and electrical connections. Replace damaged components or upgrade as needed to ensure safety and reliability.
7. Structural Components (Frame and Base): Inspect the frame and base annually for structural integrity, welds, and corrosion. Repair or replace components showing signs of fatigue or damage.
8. Screen Tensioning System: Tensioning mechanisms should be checked monthly for proper tension and wear on tensioning hardware. Replace worn or damaged tensioning components promptly to maintain screen performance.
9. Wear Liners and Protection Components: Check wear liners and protective components quarterly for wear and damage. Replace liners and protective components as needed to prevent excessive wear on critical parts.
10. Seals and Gaskets: Inspect seals and gaskets annually for leaks and wear. Replace seals and gaskets showing signs of deterioration to prevent material leakage and contamination.

The operations and maintenance plan should be tailored to the specific vibratory system model and manufacturer recommendations. Adherence to the plan, along with regular monitoring, thorough record keeping of monitoring and maintenance tasks, and timely replacement of worn components, will help maximize the longevity, efficiency, and performance of the system. Regular maintenance and monitoring allow for early detection of potential issues, reducing downtime and improving overall operational reliability.

### *CHEMICAL INFORMATION*

In general, vibratory systems used for separating manure typically do not involve the use of chemicals in the separation process itself. However, in some specialized applications or for specific objectives, chemicals may be used upstream or downstream of the vibratory separator. For instance:

- **Pre-treatment:** Chemicals might be used upstream to adjust pH levels or enhance flocculation, causing small particles in the liquid waste stream to join together to create larger particles, which can aid in separation efficiency.
- **Post-treatment:** After separation, chemicals might be added to the liquid or solid fractions for further processing or conditioning. For example, additives may be used to stabilize solids or adjust nutrient profiles for specific agricultural applications.

The use of chemicals in conjunction with vibratory separators depends on the specific requirements of the separation process and the desired outcomes for the separated fractions by the user. It's essential to consider environmental regulations and best practices when incorporating chemicals into manure management processes to minimize impacts on water quality and soil health.

### *ESTIMATED INSTALLATION AND OPERATION COST*

Industry averages provide a general estimate of the expenses involved in acquiring and installing vibratory separation technology. It is important to note that these costs are subject to variation based on specific project requirements and market conditions.

#### Equipment and Installation Capital Costs

For a mid-sized dairy operation, total capital costs can range from $18,000 to $200,000 when all components, installation, and ancillary costs are considered. Larger or more complex operations may see costs at the higher end of this range.

These costs can fluctuate based on factors such as the scale of the operation, specific vendor pricing, regional labor rates, and the level of customization required for the system.

#### Operation and Maintenance Costs (O&M)

As of 2025, the average operations and maintenance costs for the SWECO HX Series Round Separator are estimated to be $3,000 annually. Data on the electrical and labor costs specific to the SWECO separation system is unavailable. However, the following information pertains to the operation and maintenance costs of vibratory separation screens in general, unless otherwise noted:

- ***Electrical—*** The electrical costs can range from $2,000 to $5,000 per year depending on the energy efficiency of the equipment and the frequency of use.
- ***Labor—*** On average, a vibratory system may require 3-7 hours per week of labor for routine monitoring, operation, and minor maintenance, depending on the system's complexity and level of automation.
- ***Maintenance Replacement—*** Maintenance and replacement costs can average between $3,000 to $10,000 per year depending on the wear and tear of components, the frequency of maintenance, and the cost of replacement parts. For the SWECO HX Series Round Separator, screen and gasket replacement are included as well as a lubrication kit to ensure smooth operation. Additionally, the motor may need to be replaced for the SWECO unit on a 5-year cycle, costing an estimated $3,300.

*EXAMPLE WARRANTY*

**General Warranty Overview for Vibratory Separator Systems**

A warranty for a vibratory separator system generally includes coverage for defects in materials and workmanship, ensuring that the equipment operates as intended. Here's what you can typically expect:

- **Coverage Includes:**
    - **Defects in Materials and Workmanship:** The warranty usually covers repairs or replacements for parts that fail due to manufacturing defects.
    - **Performance Assurance:** Some warranties guarantee that the separator will meet specified performance criteria, such as separation efficiency or processing capacity.
    - **Extended Warranty Options:** Manufacturers may offer the option to purchase extended coverage beyond the standard warranty period for continued protection.
- **Coverage Excludes:**
    - **Normal Wear and Tear:** Parts subject to regular use, like screens and belts, are typically not covered.
    - **Damage from Misuse or Neglect:** Issues arising from improper installation, misuse, or failure to follow maintenance guidelines are typically excluded.
    - **Environmental Damage:** Damage caused by factors such as fire, flooding, or severe weather is generally not covered.
    - **Routine Maintenance Costs:** Regular maintenance, calibration, and adjustments are not included.

For specific details, always review the warranty terms provided by the manufacturer.

*RECOMMENDED RECORD KEEPING*

Effective record keeping is crucial for maintaining the performance and reliability of vibratory separator systems. Proper documentation helps ensure that the equipment operates efficiently, complies with warranty requirements, and supports effective troubleshooting and maintenance. Below is a guide to recommended record keeping practices:

1. **Purchase and Installation Records:**
    a. **Purchase Documentation:** Keep a copy of the original purchase invoice, including the date of purchase, serial number, and details of the system.

   b. **Installation Records:** Document the installation process, including the date, any site modifications, and the name of the installer or service provider.

2. **Maintenance and Service Logs:**
   a. **Routine Maintenance:** Record all routine maintenance activities, such as cleaning, adjustments, monitoring, and inspections. Note the date, type of service performed, and the person who conducted the maintenance.
   b. **Repairs and Replacements:** Log any repairs or replacements made to the system, including the date, nature of the repair, parts replaced, and the technician or service provider involved.
   c. **Service Agreements:** Keep copies of any service agreements or contracts with maintenance providers, including the scope of work and service schedules.

3. **Operational Records:**
   a. **Operational Hours:** Track the hours of operation for the separator to help schedule maintenance and identify any potential issues related to usage.
   b. **Performance Data:** Record performance metrics such as separation efficiency, throughput rates, and any deviations from expected performance. This data helps monitor the system's effectiveness and identify potential problems early.

4. **Warranty and Warranty Claims:**
   a. **Warranty Documentation:** Maintain a copy of the warranty agreement, including coverage details, expiration dates, and any extended warranty options purchased.
   b. **Warranty Claims:** Document any warranty claims made, including the date, nature of the issue, communication with the manufacturer, and the resolution or outcome.

5. **Compliance and Safety Records:**
   a. **Regulatory Compliance:** Keep records of any inspections or certifications required to meet local regulations or industry standards.
   b. **Safety Checks:** Document safety checks and inspections to ensure the system operates safely and adheres to safety protocols.

6. **Training and Usage Records:**
   a. **Training:** Record details of any training provided to staff on the operation and maintenance of the vibratory separator. Include the date, participants, and content covered.

b. **Usage Guidelines:** Maintain records of any usage guidelines or best practices provided to operators to ensure proper use and prevent damage.

7. **Documentation Storage:**
   a. **Organized Filing:** Store all records in an organized manner, either digitally or in physical files, to ensure easy access and retrieval when needed.
   b. **Backup:** Regularly back up digital records to prevent data loss due to hardware failure or other issues.

By maintaining comprehensive and organized records, the longevity and efficiency of a vibratory separator system are enhanced. This approach streamlines maintenance and warranty processes, ensures compliance with regulatory requirements, and supports effective troubleshooting and decision-making. Ultimately, it contributes to the overall success of the operations.

***ALTERNATIVES FOR THE USE OF BYPRODUCTS***

Efficient management of byproducts from dairy manure separation can enhance sustainability and add value to dairy operations. Here are several effective alternatives for utilizing these byproducts:

1. **Animal Bedding:** Separated solids from dairy manure can be repurposed as bedding material for livestock. This byproduct helps to absorb moisture and control odors, providing a comfortable and hygienic environment for the animals.

2. **Composting:** Organic byproducts from the separation process can be incorporated into composting systems. Composting these materials results in high-quality compost that enriches soil, improves soil structure, and supports plant growth. This practice also helps in reducing the volume of waste and promoting nutrient recycling.

3. **Soil Amendment:** The separated solids can be used directly as soil amendments. These materials are rich in nutrients and can enhance soil fertility, improve moisture retention, and support healthy plant growth. This use contributes to sustainable agricultural practices and helps in closing the nutrient loop.

4. **Biogas Production:** The organic fraction of separated dairy manure can be utilized in anaerobic digesters to produce biogas. This renewable energy source can be used to generate electricity or heat, while the digestate produced can be used as a high-quality fertilizer.

5. **Fertilizer Production:** The byproducts from dairy manure separation can be processed into commercial fertilizers. These fertilizers, enriched with essential nutrients, can be

applied to crops and pastures, enhancing soil nutrient levels and improving crop yields.

6. **Erosion Control:** Processed byproducts can be used in erosion control applications, such as stabilizing soil on construction sites or along waterways. They help reduce soil erosion and support soil conservation efforts.

### *INDEPENDENT VARIFIABLE DATA DEMONSTRATING RESULTS/CREDENTIALS*

Appendix B is a summary of data obtained during a Newtrient-managed third-party review of a SWECO Vibratory Screen at Kilby Dairy Farm in Rising Sun, MD. The information was from a 16-week analysis of the system and it was performed by the University of Delaware College of Agriculture and Natural Resources—the work has not been peer-reviewed.

Appendix C is the complete University of Delaware report detailing the third-party review at Kilby Dairy Farm in Rising Sun, MD.

### *CONTACT INFORMATION—VENDOR*

While not an absolute conclusive list, the list below identifies vendors that are active in the application of this class of technology on manure projects within the US.

1. **SWECO – HX Series Round Separator**
   **Address**: 8029 Dixie Highway, Florence, KY 41042
   **Phone**: 859-283-8400
   **Website**: https://sweco.com/
   **Contact**: info@sweco.com
   **Company Information**: SWECO, a business unit of M-I L.L.C., is a manufacturer of customized industrial separation equipment. They manufacture round, rectangular, and pharmaceutical separators plus several lines of complementary separation products; centrifuges, grinding mills, finishing mills, and a wide variety of aftermarket screens and parts.

2. **Russell Finex, Inc. – Finex Separator**
   **Address**: 625 Eagleton Downs Drive, Pineville, NC 28134
   **Phone**: 704-588-9808
   **Website**: https://www.russellfinex.com/
   **Contact**: inquiriesrfi@russellfinex.com
   **Company Information**: Established in 1934, we lead the world in fine mesh separation technology. Russell Finex is a customer centric, solution-based company. We design and manufacture market-leading vibratory sieves, separators, ultrasonic mesh deblinding systems, and liquid filters. We do this for virtually every industry around the world.

3. **Kason Corporation – Vibratory Screeners, Sifters, & Separators**
   **Address**: 67-71 East Willow St., Millburn, NJ 07041-1416
   **Phone**: 973-467-8140
   **Website**: https://www.kason.com/
   **Company Information**: Whether you need a high-capacity circular vibratory screener or a circular vibratory separator that works with challenging materials, here at Kason Corporation, we have got you covered. For over 50 years, we have been supplying industrial, food, dairy, and pharmaceutical organizations with the highest-performing screening and separating solutions available on the market. We design and manufacture circular vibratory screeners and separators that utilize the latest technology and offer exceptional quality, performance, and dependability across simple and challenging applications.

4. **VibraScreener Inc.**
   **Address:** 1016 Montana Drive, Charlotte, NC 28216
   **Phone:** 800-779-4613
   **Website**: http://www.vibrascreener.com
   **Contact**: sales@vibrascreener.com
   **Company Information**: VibraScreener™ is a recognized industry leader in the development and service of industrial screening equipment and technology. We have engineered our industrial sieves and screens to be higher quality, more reliable and more cost-effective than any other sifter machines or other industrial screeners on the market today. We are committed to continually developing industrial sieves and vibrating screens that help you stay productive, keep operating costs low and downtime to a minimum, and maintain a safe working environment for all of your team members.

5. **Gerard Daniel Worldwide**
   **Address:** 150 Factory Street, Hanover, PA 17331
   **Phone:** 800-232-3332
   **Website**: https://www.gerarddaniel.com/
   **Company Information**: Our goal is to deliver directly to your production line the high-quality, repeatable filtration or separation solution you need, at the lowest cost of supply. We achieve this by using our global supply chain and expertise, our extensive manufacturing, and production facilities, the experience of our Design Engineers, and our skill in supply chain management.

### *CONTACT INFORMATION—USER*

Commercial facilities presently operating in the U.S. with this class of technology are identified below. The list is a best effort but may not be completely inclusive of all installations.

Vibratory Separation Screen Technology

***OTHER CONSIDERATIONS***

The NRCS documentation specifies that a third-party review shall contain 15 specific items that comprise the report above, but as part of working with the farm(s) and the technology provider during the 16-week evaluation period there are often other important and valuable learnings that may be helpful for NRCS and others as they consider this technology. Below is a list of Other Considerations that should be included in the evaluation of this technology:

1. **Weather-Related Variability**: Environmental factors, such as ambient temperature and humidity, can influence the moisture content of the separated solids, potentially impacting their handling and drying efficiency. Rain and other weather conditions can also introduce variability in the moisture levels of incoming manure, which may affect separation efficiency and the moisture content of screened solids. Monitoring environmental conditions can help in adjusting the system's operation to maintain consistent output quality.

2. **Compatibility with Manure Composition**: Dairy farms using a mix of bedding materials, such as sand and sawdust, should consider how these inputs might affect the screen's performance. High levels of sand, for example, can increase abrasion on screening surfaces, leading to wear and tear, and should be removed before entering the vibratory screen to reduce risks of abrasion. Variability in bedding materials may require adjustments to screen settings or periodic changes to ensure efficient separation and minimal system strain.

3. **Energy and Operational Costs**: The energy demands of vibratory screens, which run for extended periods, contribute to overall operational costs. Farms should assess energy consumption against the system's benefits, such as reduced transportation costs for solids and improved water quality for field applications. Optimizing screen operation times and reviewing system energy consumption are key to balancing operational costs with performance outcomes.

4. **Integration with Other Waste Management Systems**: Vibratory screens often work best as part of a larger waste management process, such as in combination with screw presses or anaerobic digesters. Pre-separation of solids can enhance the efficiency of subsequent processing steps, like digestion, by removing larger particles that might reduce digester efficiency. Considering how the vibratory screens integrate with other processes is important to maximize the overall efficiency and resource recovery of the entire manure management system.

5. **Scalability and Future Growth**: As farms grow, manure output also increases. Vibratory screens should be assessed for scalability to ensure they can handle potential increases in manure volume. In some cases, adding additional screens or upgrading existing equipment may be necessary to keep pace with growth, particularly for farms anticipating increases in herd size.

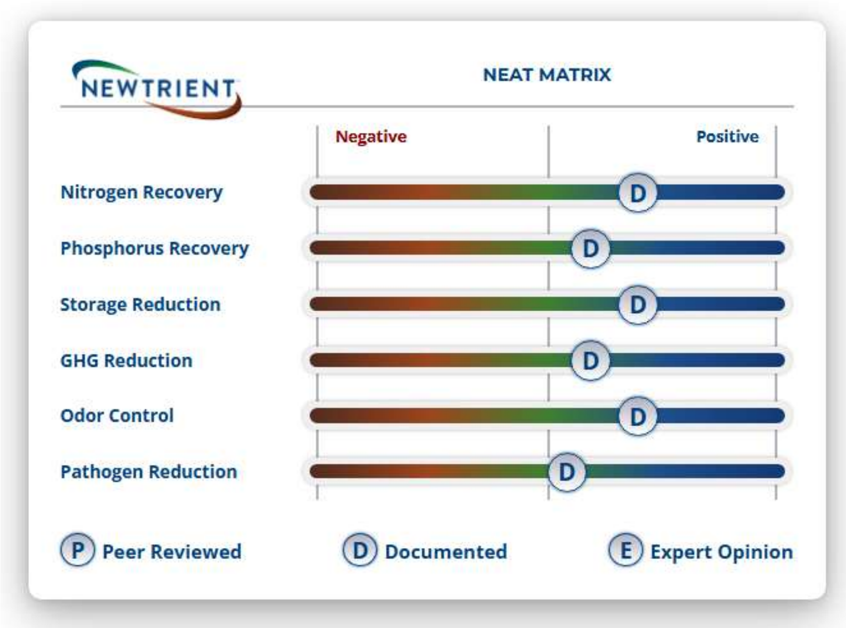
***Conclusion***

Incorporating vibratory screening technology into manure management systems can offer significant benefits for dairy operations, particularly those looking to enhance resource efficiency, reduce nutrient runoff, and manage solids more effectively. Vibratory screens enable farms to separate solid and liquid manure components, improving water quality for reuse on fields and creating nutrient-dense compost that can be utilized on-site or sold off-farm. By implementing this technology, farms can also achieve operational efficiencies that reduce transportation costs, streamline nutrient application, and potentially decrease the environmental impact of manure handling, application, and storage.

However, the successful integration of vibratory screening requires careful consideration of factors such as maintenance needs, energy consumption, labor, and compatibility with other manure management processes. By addressing these aspects and evaluating the system's scalability for future growth, farms can maximize the value of their investment in screening technology. This approach not only enhances daily operations but also aligns with broader sustainability goals, supporting both the farm's productivity and its commitment to environmental stewardship.

*Appendix A*

*NEWTRIENT CRITICAL INDICATOR ANALYSIS – VIBRATORY SEPARATION SCREEN*




**Overall Summary**

Vibratory screen technologies are used on dairy farms across the U.S. for their reduced footprint, flexible screen size and ability to effectively remove coarse solids from manure, producing a fibrous byproduct suitable for composting, or soil amendment. These systems are often deployed as a preliminary separation method ahead of other technologies, such as centrifuges and ultrafiltration membranes. Their operation typically requires a modest amount of maintenance and operator oversight, making them attractive for routine use. While vibratory screens contribute to reductions in storage volume, odor, and GHG emissions, as well as improvements in N and P recovery, their impact in each of these areas is generally limited. Importantly, they do not significantly reduce total nutrient loads in the manure stream but rather help redistribute nutrients to support downstream treatment and management.

## *Appendix B*

## *Third-Party Review of SWECO Vibratory Screens at Kilby Dairy Farm – Rising Sun, MD (Report Summary)*

**University Partner**
Dr. Amy Shober
Dr. Tanya Gressley
University of Delaware
College of Agriculture and Natural Resources
531 South College Avenue
Newark, DE 19716, USA

**JUNE 2024**

### BACKGROUND

Manure management practices are a critical aspect of sustainable dairy farming. As dairy farms expand in both size and productivity, the handling of manure becomes increasingly complex, particularly regarding nutrient management and minimizing environmental impacts. One promising solution to these challenges is the use of advanced manure separation technologies, such as the SWECO Vibratory Separator. This system uses vibrative motions to separate manure into liquid and solid fractions, improving the management and utilization of waste products.

The separation of solids and liquids in manure serves multiple purposes. It not only aids in managing waste, but it also holds potential to enhance nutrient cycling on farms. By reducing the volume of solids in the liquid waste stream, this technology makes it easier to repurpose solids for materials like bedding or compost. Meanwhile, the liquid fraction can be managed for agricultural applications such as irrigation or as feedstock for anaerobic digestion. These processes can enhance both the environmental sustainability and efficiency of manure management systems on dairy farms.

Despite the promising potential of manure separation technologies, there is limited research on their effectiveness on large-scale commercial dairy operations. A deeper understanding of their performance under real-world conditions is crucial for optimizing manure management practices and furthering sustainability efforts in the dairy industry.

### INTRODUCTION

Vibratory separation screen technologies like the SWECO Vibratory Separator have become a focal point of research due to their potential to enhance manure management and sustainability on dairy farms. These systems separate manure into solid and liquid fractions through vibrational movements, facilitating improved nutrient recycling, reduced manure volume, and diminished environmental impacts. Liquid effluent can be utilized for applications like irrigation or anaerobic digestion, while the solid fraction manure can be repurposed as compost or bedding, reducing the need for purchased bedding materials, commercial fertilizers, and disposal methods like landfilling. Efficient manure management is essential for reducing nutrient runoff and leaching, particularly nitrogen and phosphorus, which contribute to water pollution and eutrophication. Proper treatment and handling of manure is crucial to mitigating these environmental risks.

However, while manure separation technologies show promise, further studies are needed to explore their application in large-scale, commercial dairy operations. This study aims to evaluate the effectiveness of the SWECO Vibratory Separator in real-world conditions, focusing on its ability to improve manure management, reduce environmental impact – particularly in regard to water quality – and support sustainable practices in the dairy industry.

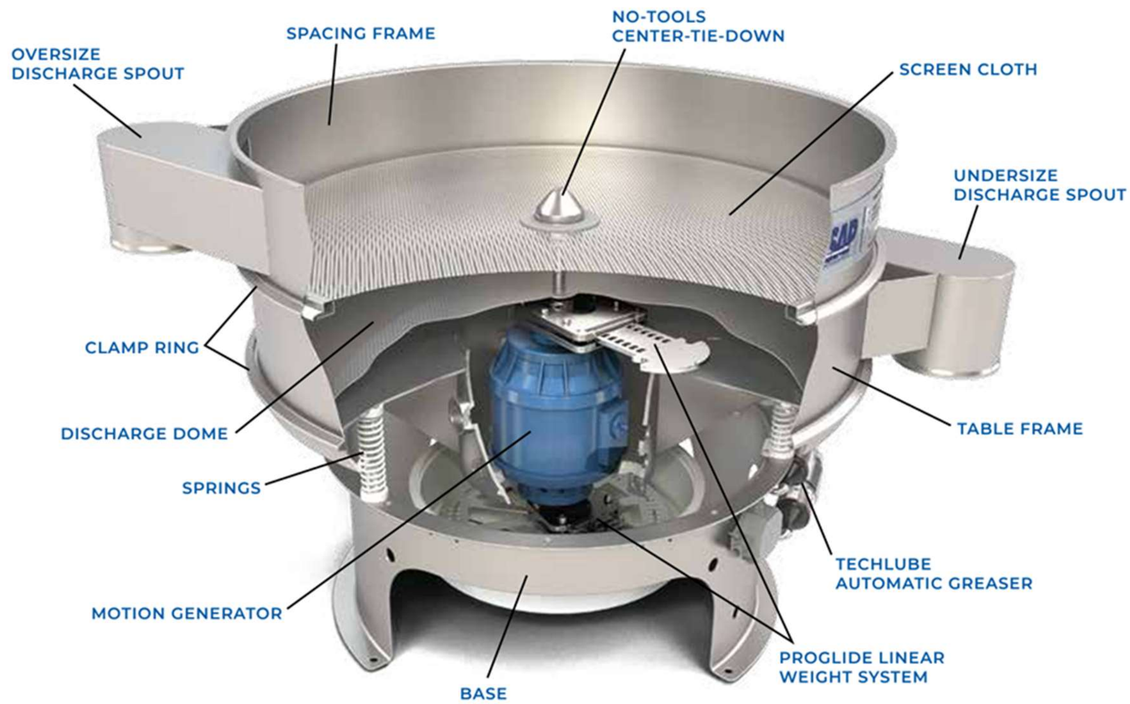



Figure 1: SWECO Vibro-Energy Round Separator Interior View.
*Source: [https://sweco.com/addinfo/Round-Separator.pdf](https://sweco.com/addinfo/Round-Separator.pdf)*

## THE PROCESS

1. **Vibration Mechanism**

   - At the core of the SWECO Separator is a motion-generator shaft equipped with two eccentric weights:
     - The **upper weight** creates horizontal vibrations, propelling materials across the screen cloth toward the edges.
     - The **lower weight** tilts the machine, introducing vertical and tangential vibrations to enhance separation.

2. **Material Movement Across the Screen**

- As the separator vibrates, materials fed onto the screen cloth are sorted based on size and weight:
    - **Liquids** and ultrafine solids pass through the mesh screen, leaving behind coarse and/or fine solid materials.
    - **Solids** move outward to the edges of the screen for collection.

3. **Adjustable Settings for Optimization**

- The operator can control the speed and spiral motion of the material flow, customizing the separation process for:
    - Different material characteristics (e.g., wet or dry, coarse or fine).
    - Desired throughput and separation efficiency.

4. **Continuous and Efficient Operation**

- The vibration mechanism ensures continuous material flow without clogging, maximizing performance efficiency in separating solids and liquids.
- The separator accommodates a variety of materials, making it versatile and adaptable to diverse dairy operations.

## METHODOLOGY

This evaluation was conducted as a single-stage study to assess the SWECO Vibratory Separator's ability to separate solids and liquids from manure at Kilby Dairy, an 870-cow commercial dairy farm in Rising Sun, MD. Sampling and flow rate measurements were performed over 16 weeks, from February 6 to May 24, 2023.

Manure was sourced from various locations on the farm (e.g., milking parlor, cow barn, sand lane, ramp tank) and pumped through piping into the separating barn. The SWECO vibratory screens separated solids and liquids, with larger particles falling through a chute into a screw press and liquid effluent flowing to a post-liquid weir tank. Effluent from the weir tank was subsequently directed to an anaerobic digester. Samples were collected at five points in the system: raw manure inflow, SWECO liquids, SWECO solids, screw press liquids, and screw press solids.

### Sample Collection and Flow Rate Measurement

Sampling was conducted three times weekly, and flow rates were measured at designated collection points as follows:

- **Raw Manure Inflow**: The inflow rate was measured by manually sealing the pipe, filling a 13-liter bucket three times, and averaging the collection times. A composite sample was created from subsamples of each bucket.
- **SWECO Liquids**: Liquid effluent passing through the screens was collected using a 32-ounce ladle. The flow rate was calculated by subtracting the SWECO solids rate from the inflow rate.
- **SWECO Solids**: Solids retained by the screens were collected into a bag for 30 seconds. The volume was recorded, and a subsample was taken for analysis.
- **Screw Press Liquids**: Liquids pressed out of SWECO solids were collected with a ladle from beneath the screw press.
- **Screw Press Solids**: Dewatered solids were sampled directly from the conveyor belt exiting the screw press.

Samples were collected consistently from one of the two SWECO units equipped with a shut-off valve and removable feeder cone, alternating between chutes to ensure representative data.

**Data Analysis**

All samples were analyzed for moisture, solids, organic matter, nitrogen, and select minerals at A&L Great Lakes Laboratory. Outliers exceeding three standard deviations were excluded from the dataset.

Throughout the sampling period, weather conditions (temperature, humidity, and precipitation) were recorded using a smartphone app. Operational notes, including system downtime and maintenance, were documented to account for variability in the system's performance.

A total of 198 samples were collected over 41 sampling days, providing a comprehensive dataset to evaluate the SWECO Vibratory Separator's performance in separating solids and liquids from manure.

## DISCUSSION OF RESULTS

### KEY BENEFITS OF THE SWECO VIBRATORY SEPARATION SYSTEM

The evaluation of the SWECO vibratory screens and associated manure management system at Kilby Dairy reveals several key benefits, both operational and environmental, that significantly enhance the farm's manure handling efficiencies. The primary advantages include:

**Enhanced Nutrient Separation and Recovery for Targeted Nutrient Management:** The integration of the SWECO vibratory screen and Nutrient Control Systems (NCS) tapered screw press at Kilby Dairy has demonstrated significant benefits in nutrient separation, improving both nutrient recovery and environmental management. Analysis of nutrient distribution across the system reveals efficient partitioning of key nutrients into solid and liquid fractions from manure, optimizing their potential use in agricultural applications while reducing environmental risks (Table 1). Total Kjeldahl nitrogen (TKN) concentrations remain stable in liquid fractions (average 0.31% in inflow and SWECO liquids and 0.30% in screw press liquids) but increase in solids (0.33% in SWECO solids and 0.39% in screw press solids). This indicates effective separation and concentration of nitrogen in solids, enhancing their value as slow-release fertilizers. Similarly, organic nitrogen shows greater concentrations in the solid fractions, with the screw press solids containing the highest levels (0.23%), adding further agronomic value to the recovered solids.

Phosphorus and potassium are also efficiently partitioned into the solids, with screw press solids containing slightly elevated levels of total phosphorus (0.05%) and potassium (0.18%) compared to the inflow and liquid fractions. This allows for targeted application of these nutrients in nutrient-deficient soils. Ammonium nitrogen concentrations, meanwhile, remain consistent across liquid phases (0.20%), ensuring its availability in effluent while limiting ammonia volatilization. The system's ability to concentrate critical nutrients in solids and diminish nutrient content in liquid fractions supports precision nutrient management while reducing the potential for nutrient runoff and leaching into sensitive watersheds such as the Chesapeake Bay during storage, handling, and application.

The SWECO vibratory screen serves as the primary separator, establishing distinct liquid and solid streams, while the screw press amplifies nutrient partitioning by concentrating nutrients more effectively in the solid fraction.

Together, the systems work synergistically, with the screw press playing the leading role in the nutrient partitioning observed in the study.

Table 1. Mean concentration and standard deviations of total Kjeldahl N, ammonium N, organic N, total P, total K in 41 samples collected from various points along the SWECO solid-liquid separator at Kilby Dairy in Rising Sun, MD in 2023.

| | Inflow | SWECO Liquids | Screw Press Liquids | SWECO Solids | Screw Press Solids |
|---|---|---|---|---|---|
| Total Kjeldahl N (%) | | | | | |
| Ave | 0.31 | 0.31 | 0.30 | 0.33 | 0.39 |
| Std Dev | 0.04 | 0.04 | 0.04 | 0.04 | 0.07 |
| Ammonium N (%) | | | | | |
| Ave | 0.20 | 0.20 | 0.20 | 0.19 | 0.16 |
| Std Dev | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 |
| Organic N (%) | | | | | |
| Ave | 0.12 | 0.12 | 0.11 | 0.15 | 0.23 |
| Std Dev | 0.02 | 0.02 | 0.02 | 0.04 | 0.06 |
| Total P (%) | | | | | |
| Ave | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 |
| Std Dev | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Total K (%) | | | | | |
| Ave | 0.15 | 0.16 | 0.16 | 0.16 | 0.18 |
| Std Dev | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 |

**Improved Anaerobic Digester Integration and Effluent Reuse:** The SWECO vibratory screens play a pivotal role in optimizing the manure management system at Kilby Dairy by ensuring efficient separation of solids and liquids. This separation directly enhances the performance of the farm's anaerobic digester. Over the 16-week sampling period, the SWECO system processed liquid manure at an average inflow rate of 2.41 ± 0.52 liters per second (L/s), producing a liquid outflow of 2.27 ± 0.51 L/s and diverting solids at an average rate of 0.17 ± 0.08 L/s. On average, 7.1 ± 3.1% of the inflow was captured as solids, ensuring a steady and consistent effluent flow into the anaerobic digester.

This precision in solid-liquid separation minimizes blockages and operational issues within the digester as well as a reduction of costly solid removals, allowing it to operate more efficiently and with fewer interruptions. As a result, biogas production is enhanced, maximizing renewable energy generation and reducing greenhouse gas emissions while minimizing labor costs.

Additionally, the liquid outflow from the SWECO screens is well-suited for reuse as flush water in cow barns, further closing the loop in sustainable farm operations. The system’s consistent performance, even with variable manure inflow rates, underscores its reliability and critical role in improving overall farm efficiency and sustainability.

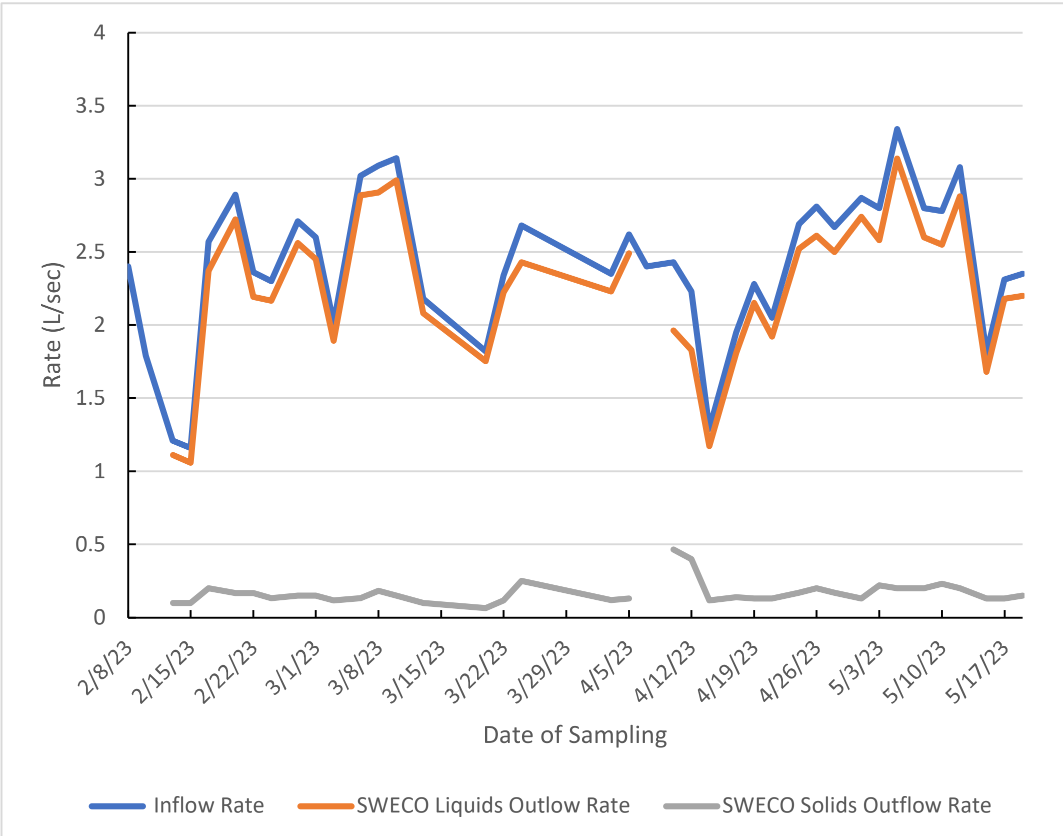



Figure 2. Flow rate throughout the manure system during the sampling period. SWECO solids outflow rate was not measured on April 7, 2023.

**Increased Operational Efficiency and Resource Utilization:** SWECO vibratory screens significantly enhance operational efficiency and cost-effectiveness on the farm by improving manure handling, reducing maintenance and cleanouts, and increasing resource utilization. By efficiently separating solids from liquids, the system minimizes the volume of manure that needs to be stored, making manure management easier and more efficient. This reduction in storage requirements decreases the risk of overflow during heavy rainfall and minimizes transportation costs. Additionally, the system's low-maintenance design reduces downtime and operational disruptions, saving both labor and resources. During the study at Kilby Dairy, the system ran continuously and did not require any downtime or shutdowns. The nutrient-rich solids recovered through the process can be repurposed as slow-release fertilizers, reducing the need for synthetic inputs and creating potential new revenue streams. Moreover, the SWECO system's scalability and adaptability make it suitable for farms of all sizes, offering flexibility in its application and integration with other technologies to further optimize farm operations.

## EVALUATION KEY ISSUES AND CHALLENGES

**Operational Challenges and System Maintenance:** The SWECO system and screw press, while effective at nutrient separation and enhancing manure management, present certain operational challenges. Routine maintenance and cleaning are necessary to ensure optimal performance, particularly with regard to the wear and tear on the vibratory screens and screw press. Periodic inspections and potential adjustments are required to keep the system running efficiently, especially when dealing with the physical characteristics of the manure and potential abrasive bedding material like sand. Managing these operational tasks is vital to maintaining long-term performance, particularly in a large-scale farm operation.

**Variability in Manure Inflow and System Adaptability**: While the SWECO system demonstrated efficient performance in handling manure inflow at an average rate of 2.41 ± 0.52 L/s, the study noted variability in manure inflow rates over the sampling period. This variability did not disrupt system function but required the system to adapt to different manure volumes. While the SWECO screens and screw press effectively handled the fluctuations, continuous monitoring is necessary to ensure optimal nutrient separation and avoid potential inconsistencies that could arise during extreme variations in manure inflow.

**Economic Feasibility and Return on Investment**: While the SWECO system provides substantial environmental and operational benefits, the financial feasibility of implementing and maintaining such systems remains a critical consideration. The initial investment and ongoing operational costs for the SWECO system and screw press require careful financial planning, especially for smaller or resource-limited operations. Understanding the long-term economic benefits, such as enhanced biogas production, reduced nutrient runoff, and improved nutrient recovery, is essential to justifying the upfront costs and ensuring a positive return on investment. These economic factors must be weighed against the system's operational challenges to determine its overall viability for broader adoption in dairy operations.

## IMPLICATIONS

Key findings from the Kilby Dairy study indicate that the SWECO vibratory screens effectively reduce solids accumulation in the digester, improving its operational efficiency and increasing biogas production. By preventing solids from forming a crust in the digester, the system maximizes methane production and helps maintain consistent digester function. Additionally, the separated solids are higher in nutrient concentrations, which reduces environmental impact and provides value as a slow-release fertilizer for agricultural applications. The system also enables efficient liquid effluent reuse for irrigation, reducing water and energy costs for the farm. Overall, the SWECO system presents significant potential for cost savings, environmental benefits, and improved farm sustainability for both solid and liquid fractions. Further evaluation is needed to fully assess the long-term economic viability of the system and its broader impact on farm operations.

For additional information on the vendor, environmental impacts, financial implications, and SWECO vibratory screen technology, visit the SWECO Vendor Snapshot on the Newtrient website.

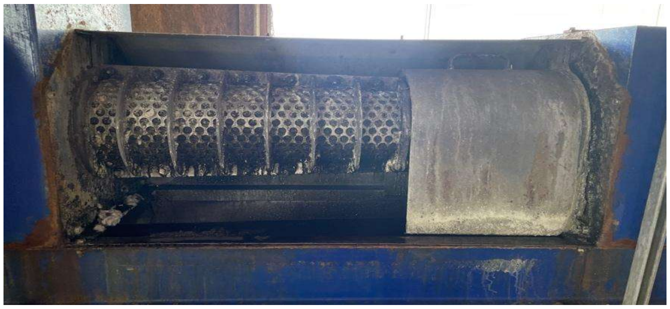
### REFERENCES

SWECO (2024). https://sweco.com/addinfo/Round-Separator.pdf

This study was funded by the Natural Resources Conservation Service (NRCS) through a Conservation Innovation Grant (CIG). The views and findings presented in this publication are those of the author(s) and do not necessarily reflect the official views or policies of NRCS or the U.S. Department of Agriculture.

**Appendix C**

***Third-Party Review of SWECO Vibratory Screens at Kilby Dairy Farm in Rising Sun, MD. (Full Report)***



# Analysis of SWECO Vibratory Screens at Kilby Dairy Farm, Rising Sun, MD

# February – May 2023


**INTRODUCTION**

Kilby Dairy, located in Rising Sun MD, has been operating since the 1920s. Some of the characteristics of the dairy and manure management system are listed below. At the time of this study, there were 870 cows and 750 heifers on site housed on sand and sawdust bedding, respectively. The dairy has integrated the use of SWECO vibratory separation screens in order to increase the efficiency of the methane digester. Solids exiting the SWECO are further dried with the use of a screw press and composted. Sixty percent of the manure compost is sold off site as fertilizer. Kilby dairy reduces cost inputs of operation by reusing the effluent water from manure processing as flush water in the cow barns and as irrigation for the fields. They utilize outsourced saw dust for bedding of heifers and are able to get some of that money back by using the bedding as a carbon source for the solid compost. By sending the nutrient dense compost to farms on the Eastern Shore of Maryland, Kilby helps to retain the water quality of the Chesapeake Bay watershed.

Characteristics of Kilby Dairy Farm and manure management system.

- Number of cows
  - 870 cows
  - 750 heifers
- Stall Bedding Material
  - Milk cows: deep sand bed
  - Dry cows and heifers: sawdust
- Covered Separating Building Dimensions
  - 80’ x 250’
- Separator Vibrator (2)
  - SWECO/NCS Nutrient Solution

- Screw press
- Biogas Utilization
    - Used to solely power a generator system powering the entire farm and 20 surrounding residential houses
- Year Installed
    - Methane digestor and Sweco built in 2019

*--Kyle Sensenig, farm manager at Kilby*

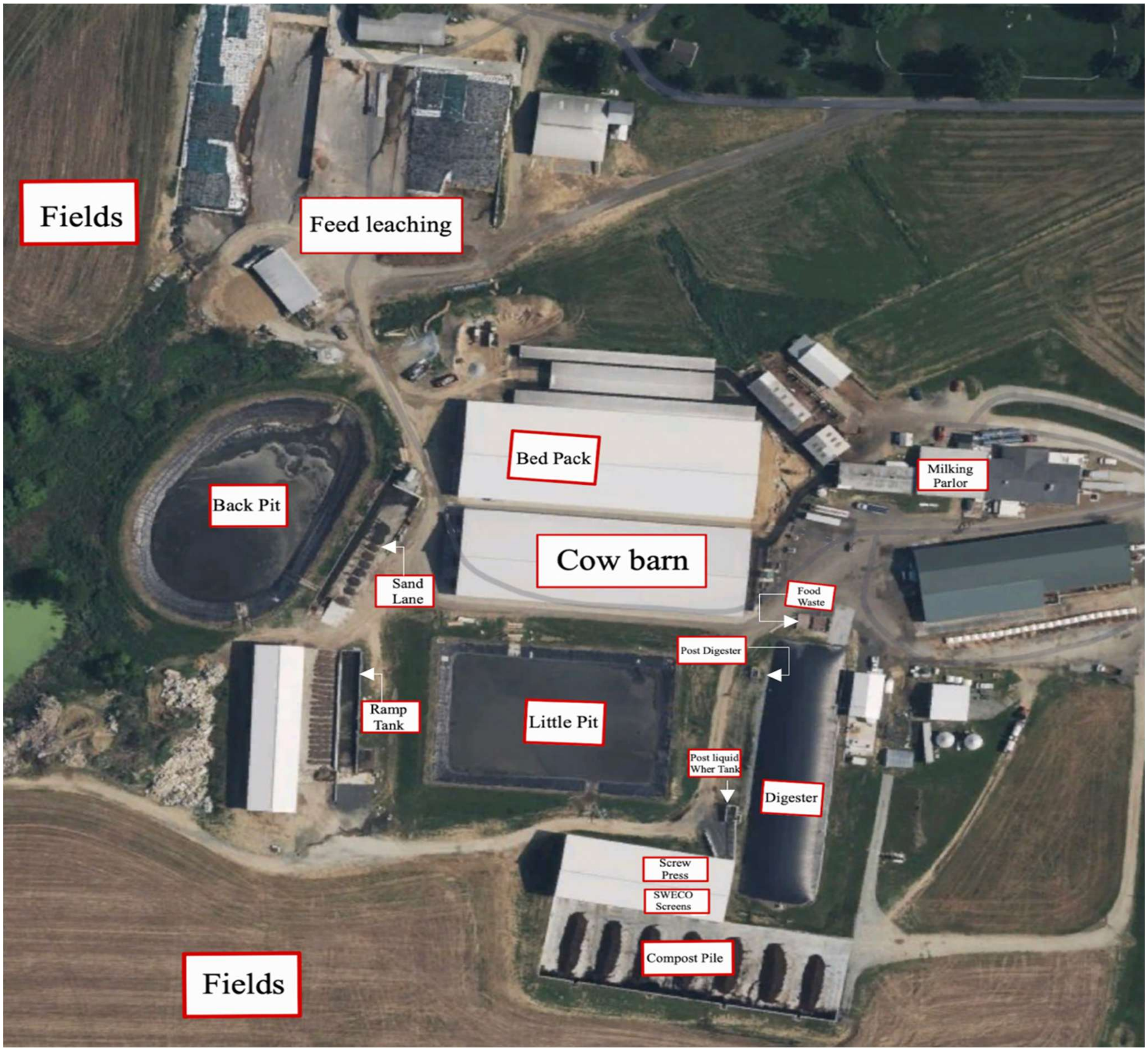



**Figure 1.** Overhead ariel photo of Kilby Dairy Farm, labeled with parts of the dairy and manure system. Photo from Apple iPhone map application.

The SWECO machines operate from 05:00 until 18:00 seven days a week. Figure 1 provides an ariel view of the farm, while the flows of manure are outlined in Figure 2. Manure from various locations (e.g., milking parlor, cow barn, sand lane, and ramp tank) on the dairy flows up through piping within the separating barn (inflow) and onto the SWECO separating screens. Large pieces of manure are separated from the liquid by the SWECO screen and fall through a chute that feeds into the screw press. The liquid effluent that flows through the SWECO screens is pumped to the post liquid weir tank before being fed into the methane digester. Removal of the larger particles prior to methane digestion increases the efficiency of digestion. The solids from the screw press are transferred to the compost pile, while liquids from the screw press are pumped into the "little pit" and then onto the field or into the back pit.

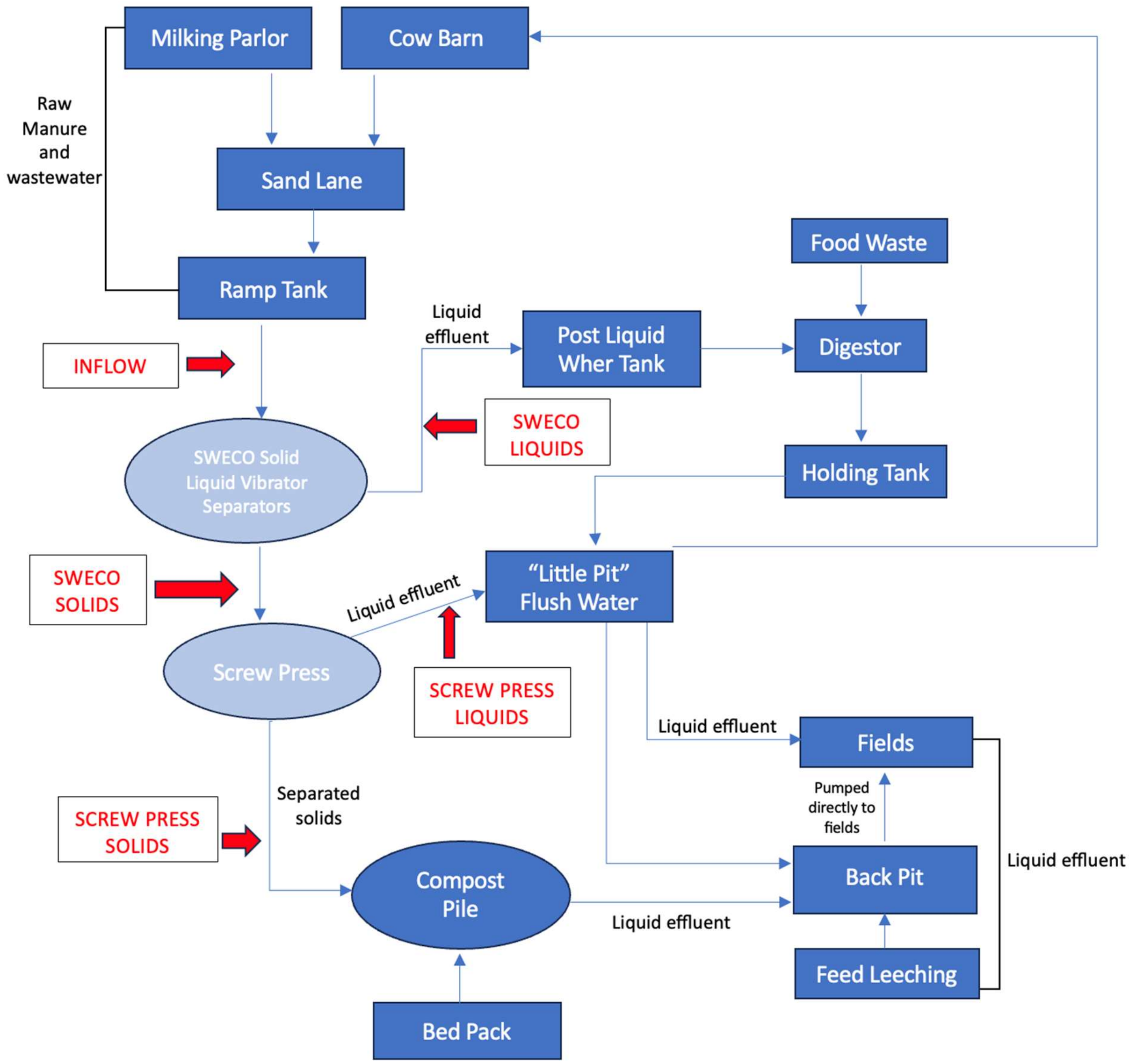



**Figure 2.** Kilby Dairy Manure Management System Process Flow Diagram**.**

## Purpose of the Study

Numerous waste separation options are available for dairy operations. The intent was to evaluate the performance and water quality advantages of utilizing a SWECO vibratory screen placed in-line with a NCS tapered screw press in separating solids and nutrients from the dairy waste stream at the Kilby Dairy in Colora, MD. High nutrient removal rates can improve flush water performance and reduce land application costs of liquid effluent. Separated solids can be composted and used for multiple purposes. For land application, composted manures can be hauled longer distances more economically.

## METHODS

The study was commissioned by Newtrient, Inc. to evaluate liquid and dry matter nutrient fluxes as processed by SWECO vibratory screens. University of Delaware College of Agriculture and Natural Resources was contracted to measure manure flow rates, as well as collect solid and liquid samples from various points along the process flow (red arrows in Figure 2). Students obtained flow rates and samples three times a week for 16 weeks starting 6 February 2023 and ending on 24 May 2023.

Throughout the duration of the sampling period weather data was recorded at each sampling time. Temperature and relative humidity at the time of sampling was collected from the weather application installed on Apple iPhone. Students also noted whether there was precipitation at the time of sampling. A web-based spreadsheet application was kept documenting this information as well as the operation status of the manure system, and feed pump speed on monitor screen for each sample day (Figure 3).

### Sample Collection and Measurement of Flow Rates

On each sampling date, students collected the following samples (see Figure 2): one sample from the initial raw manure (INFLOW), one liquid sample that passed through the Sweco screens (SWECO LIQUIDS), one solid sample that was retained by the Sweco screens (SWECO SOLIDS), one liquid sample off of the screw press (SCREW PRESS LIQUIDS), and one solid sample from the screw press (SCREW PRESS SOLIDS).

Students obtained the manure inflow rate by first shutting off the inflow from the screens by manually sealing off the pipe with an exterior lever, then removing the bottom of the feeder cone. The students then unsealed the pipe and one student held a 13 L bucket under the inflow pipe, while another student timed how long it took the bucket to nearly fill. The volume of manure collected in the bucket was recorded to the nearest 1 liter. This flow rate measuring process was repeated a total of three times per visit and averaged to estimate inflow rate. A ladle was used to obtain a subsample from each of the filled buckets and those were composited into a single sample for analysis (“inflow”). Although there were two SWECO units, flow rates were only measured from the one unit equipped with the shut off valve and removable feeder cone.

The sample of “Sweco Liquids” was collected from the SWECO liquid effluent using a 32-ounce flat bottomed ladle.

Students obtained the flow rate of SWECO solids into the screw press hopper by first turning off the screw press mechanism using the system electronic control panel. After that was completed, one student held a trash bag underneath the chute transporting the SWECO solids to the screw press, while another student timed for 30 seconds. At the end of the 30 second collection period, students removed the bag from the system and transferred the solids from the bag into a graduated bucket. The volume of solids was recorded to the nearest liter and a subsample was collected into the sampling bottle labeled “Sweco Solids”. This flow rate of SWECO solids was measured only once per visit to prevent the buildup of solids in the hopper. There were two solid chutes flowing into the screw press, with the two chutes being fed by each of the two SWECO units. Students alternated which chute was used for solid flow rate measurement and sample collection each visit.

The outflow rate of Sweco liquids was then calculated by subtracting the Sweco solids flow rate from the inflow rate.

Students removed the screw press side panel to obtain a sample of “Screw Press Liquid”. They held the 32-ounce ladle beneath the screw press to collect the liquid being pressed out of the solids. A sample of “Screw Press Solids” was obtained by from the conveyor belt exiting the screw press.

Between each sampling process, the equipment used was rinsed with tap water from a connected hose in the manure barn.

Throughout the 16-week sampling period, the functionality of the SWECO vibratory screens was recorded (Figure 3). There were twelve sampling dates where the manure management system was not fully operational at the time of sampling. Five instances (20 Feb, 8 Mar, 20 Mar, 24 Mar, and 3 May) were a result of the sampling team stopping the screw press for too long while obtaining the flow rate of solids into the collection hopper. This extended stoppage caused the solids to build up to the automatic emergency stop sensor inside of the hopper. Other instances of incomplete operation were the result of repairs and shutdowns initiated by the Kilby Dairy management. On 15 Mar and 17 Mar, the system was shut down due to routine cleaning of the sand lane and ramp pit. The ramp pit is thoroughly cleaned out semiannually to remove the excess sand and solids not pulled up to the manure barn. On 22 May and 24 May, the SWECO system was shut down for the replacement of the current screens, as well as the addition of a third SWECO vibratory screen. The management at Kilby decided to add a third screen to keep up with the production of manure from the growing number of lactating cows. Although the students were able to collect all samples on 24 May when the new system was operational, manure inflow rates could not be measured because the removeable feeder cone was not reinstalled. Sampling ended after 24 May due to the end of the semester. A total of 198 samples were taken over a course of 41 sampling dates.

**Sample Analysis**

All liquid and solid samples were sent to A&L Great Lakes Laboratory for compost and manure analysis. Samples were analyzed for the following physical and chemical characteristics: percent of moisture, solids, ash, organic matter, organic carbon, nitrogen (i.e., total Kjeldahl, ammonium, organic), and select minerals (i.e., P, K, S, Mg, Ca, Na, Al, Cu, Fe, Mn, Zn).

Within manure type, data were evaluated for outliers identified as greater than or less than 3 standard deviations from the mean, and outliers were removed prior to summary.

## UD - Newtrient Project Data Recording Sheet

Last Updated By - Olivia Frego (UD College of Agriculture and Natural Resources Undergraduate)

Samples taken from Kilby Dairy - 795 Firetowe
Colora, MD 21917

Check after sampling (each should be a composite of several independent samples). Alternate sampling from left and right.

Flow Rate: Measure this every sampling date.

| Date | Time | Temperature (F) | Weather Conditions + Humidity | Is The Entire System Operational? | Inflow (Right) | Sweco Liquids (Left) | Sweco Liquids (Right) | Sweco Solids (Left) | Sweco Solids (Right) | Screw Press Liquids | Screw Press Solids | Manure Into Sweco Screens Liters | Manure Into Sweco Screens Seconds | Flow Rate Into Sweco (L/sec) | Avg flow rate (L/sec) | Screened Liquids Through Sweco (potentiall y subtract the solids | Screened Material Into Screw Press Liters | Screened Material Into Screw Press Seconds | Flow Rate into Screw Press (L/sec) | Feed Pump Speed (on Monitor) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02-06-23 | 16:45 | 36 | overcast | No... | X | | X | X | | X | X | | | | | | | | | | Minor clog between Sweco and Screw Press |
| | | | 67% | See Notes | | | | | | | | | | | | | | | | | -Duke |
| | | | | | | | | | | | | | | | | | | | | | |
| 02-08-23 | 16:49 | 53 | sunny, calm | Yes | X | X | | | X | X | X | 11 | 5.00 | 2.20 | | | | | | | |
| | | | 64% | | | | | | | | | 12 | 5.00 | 2.40 | | | | | | | |
| | | | | | | | | | | | | 13 | 5.00 | 2.60 | 2.40 | | | | | | |
| 02-10-23 | 16:40 | 45 | clear | Yes | X | | X | X | | X | X | 11.5 | 6.04 | 1.90 | | | | | | | |
| | | | 59% | | | | | | | | | 11.5 | 6.10 | 1.89 | | | | | | | |
| | | | | | | | | | | | | 10 | 6.30 | 1.59 | 1.79 | | | | | | |
| 02-13-23 | 16:35 | 57 | mostly sunny | Yes | X | X | | | X | X | X | 10.5 | 8.30 | 1.27 | | | 3 | 30 | 0.1 | | |
| | | | 30% | | | | | | | | | 11 | 9.51 | 1.16 | | | | | | | |
| | | | | | | | | | | | | 10 | 8.26 | 1.21 | 1.21 | 1.11 | | | | | |
| 02-15-23 | 16:43 | 60 | partly cloudy | Yes | X | | X | X | | X | X | 10 | 8.55 | 1.17 | | | 3 | 30 | 0.1 | | First sampling date without Dr Gressley and Dr Shober. Students and Duke Williams only |
| | | | 60% | | | | | | | | | 10.5 | 8.87 | 1.18 | | | | | | | -Duke |
| | | | | | | | | | | | | 10 | 8.80 | 1.14 | 1.16 | 1.06 | | | | | |
| 02-17-23 | 15:53 | 46 | overcast, rain | Yes | X | X | | | X | X | X | 11 | 4.46 | 2.47 | | | 6 | 30 | 0.2 | 45 | |
| | | | 60% | | | | | | | | | 11.5 | 4.58 | 2.51 | | | | | | | |
| | | | | | | | | | | | | 10.5 | 3.86 | 2.72 | 2.57 | 2.37 | | | | | |

**Figure 3.** Web-based spreadsheet used to record data on each sampling date.

**Table 2.** SWECO sampling dates for Kilby dairy including an explanation for incomplete data collection.

| Sampling Dates | Complete Data Recorded | Reason for incomplete sampling data |
|---|---|---|
| 2/6/23 | | No flow rates obtained: Students determined best process to use in the future |
| 2/8/23 | | No "Sweco Solids" flow rate obtained: Lack of equipment, original plan did not work with physical constraints |
| 2/10/23 | | No "Sweco Solids" flow rate obtained: Lack of equipment, original plan did not work with physical constraints |
| 2/13/23 - 3/13/23 | X | |
| 3/15/23 | | No sampling conducted: Manure system shut down manually by Kilby staff in order to conduct biannual cleaning of ramp pit and sand lane |
| 3/17/23 | | No sampling conducted: Manure system shut down manually by Kilby staff in order to conduct biannual cleaning of ramp pit and sand lane |
| 3/20/23 | X | |
| 3/22/23 | X | |
| 3/24/23 | X | |
| 3/27/23 | | No sampling conducted: Students spring break |
| 3/29/23 | | No sampling conducted: Students spring break |
| 3/31/23 | | No sampling conducted: Students spring break |
| 4/3/23 | X | |
| 4/5/23 | X | |
| 4/7/23 | | No "Sweco Solids" flow rate obtained: Collection bin was almost overflowing. Was entirely liquid upon visual analysis.<br><br>Note: Highest recorded percentage of moisture in Sweco solids recorded. Previous night there was a thunderstorm. |
| 4/10/23 - 5/19/23 | X | |
| 5/22/23 | | No sampling conducted: System was shut down due to new SWECO vibratory screens being installed. |

|  |  |  |
|---|---|---|
| 5/24/23 |  | No flow rates obtained: New vibratory screens that were installed prevented students access to obtain flow rates |

## RESULTS

### Weather Conditions during Sampling

As expected, ambient temperatures increased during the study, reflecting the seasonal changes from February to May 2023 at Rising Sun, Maryland (Figure 4). The average air temperature over the course of the study was 58 ± 12°F (mean + standard deviation). Relative humidity varied each day and did not follow a seasonal pattern (Figure 5). The average relative humidity was 53.6 ± 16.3% (mean + standard deviation).

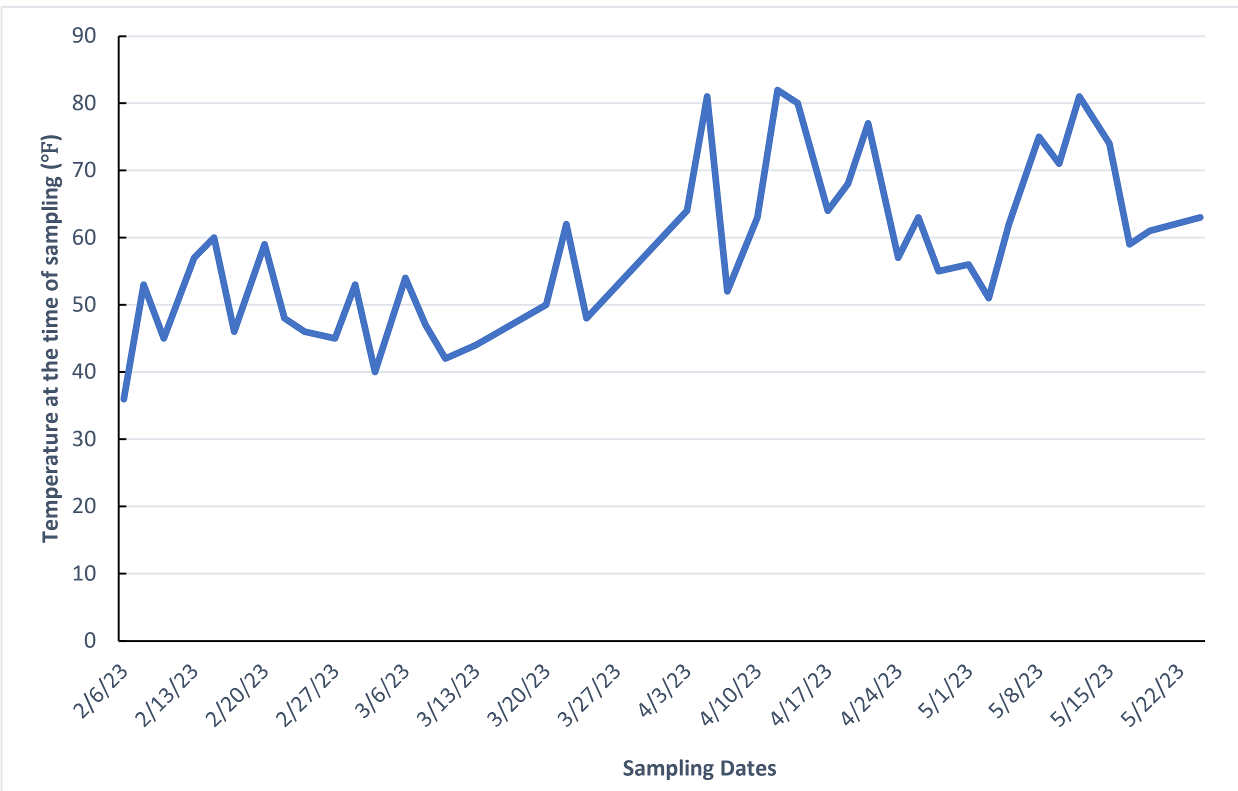



**Figure 4.** Air temperatures at the time of sampling (°F) throughout the duration of the sampling period as provided by the weather application installed on Apple iPhone.

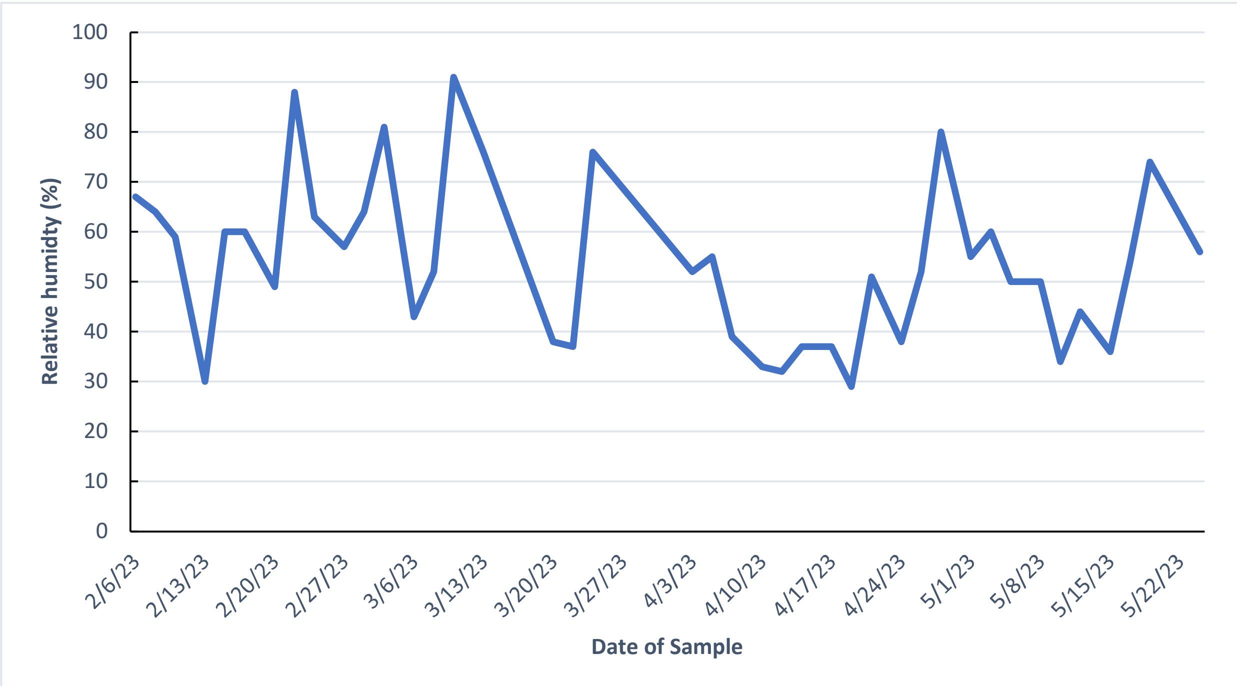



**Figure 5.** Relative humidity at the time of sampling throughout the duration of the sampling period as provided by the weather application installed on Apple iPhone.

### Flow Rates of Manure into and through the SWECO System

Manure inflow rates, SWECO liquids outflow rates, and SWECO solids outflow rates are presented in Figure 6. The inflow rate and SWECO liquids outflow rate followed similar patterns. This is expected, as the SWECO liquids outflow rate was calculated as the difference between the inflow rate and the SWECO solids outflow rate. The manure inflow rates, and consequently SWECO liquids outflow rates, were variable throughout the sixteen-week sampling period.

Liquid manure from the ramp tank was pumped into the manure barn and SWECO vibratory screens at an average rate of 2.41± 0.52 L/s (mean ± standard deviation). Liquid outflow from the SWECO screens were returned to the digester at an average rate of 2.27± 0.51 L/s (mean ± standard deviation). Solid outflow from the SWECO screens into the screw press averaged at 0.17± 0.08 liters/second (mean ± standard deviation). On average, the SWECO solids outflow accounted for 7.1 ± 3.1% of the manure inflow.


**Figure 6.** Flow rate throughout the manure system during the sampling period. SWECO solids outflow rate was not measured on 7 April 2023.

**Physical and Chemical Characteristics of Liquid and Solid Manure Samples**

The mean concentration (and standard deviation) of total Kjeldahl N, ammonium N, organic N, total P, total K for each sample type is presented in Table 3.

**Table 3.** Mean concentration and standard deviations of total Kjeldahl N, ammonium N, organic N, total P, total K in 41 samples collected from various points along the SWECO solid-liquid separator at Kilby Dairy in Colora, MD in 2023.

| | Inflow | SWECO Liquids | Screw Press Liquids | SWECO Solids | Screw Press Solids |
|---|---|---|---|---|---|
| Total Kjeldahl N (%) | | | | | |
| Ave | 0.31 | 0.31 | 0.30 | 0.33 | 0.39 |
| Std Dev | 0.04 | 0.04 | 0.04 | 0.04 | 0.07 |
| Ammonium N (%) | | | | | |
| Ave | 0.20 | 0.20 | 0.20 | 0.19 | 0.16 |
| Std Dev | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 |
| Organic N (%) | | | | | |
| Ave | 0.12 | 0.12 | 0.11 | 0.15 | 0.23 |
| Std Dev | 0.02 | 0.02 | 0.02 | 0.04 | 0.06 |
| Total P (%) | | | | | |
| Ave | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 |
| Std Dev | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Total K (%) | | | | | |
| Ave | 0.15 | 0.16 | 0.16 | 0.16 | 0.18 |
| Std Dev | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 |

*Total Kjeldahl N*

Figure 7 shows that total Kjeldahl N concentrations were typically highest in the screw press solids when compared with other samples. In general, trends in total Kjeldahl N concentrations were relatively stable through March but then became a bit more variable thereafter, particularly for the screw press solids.

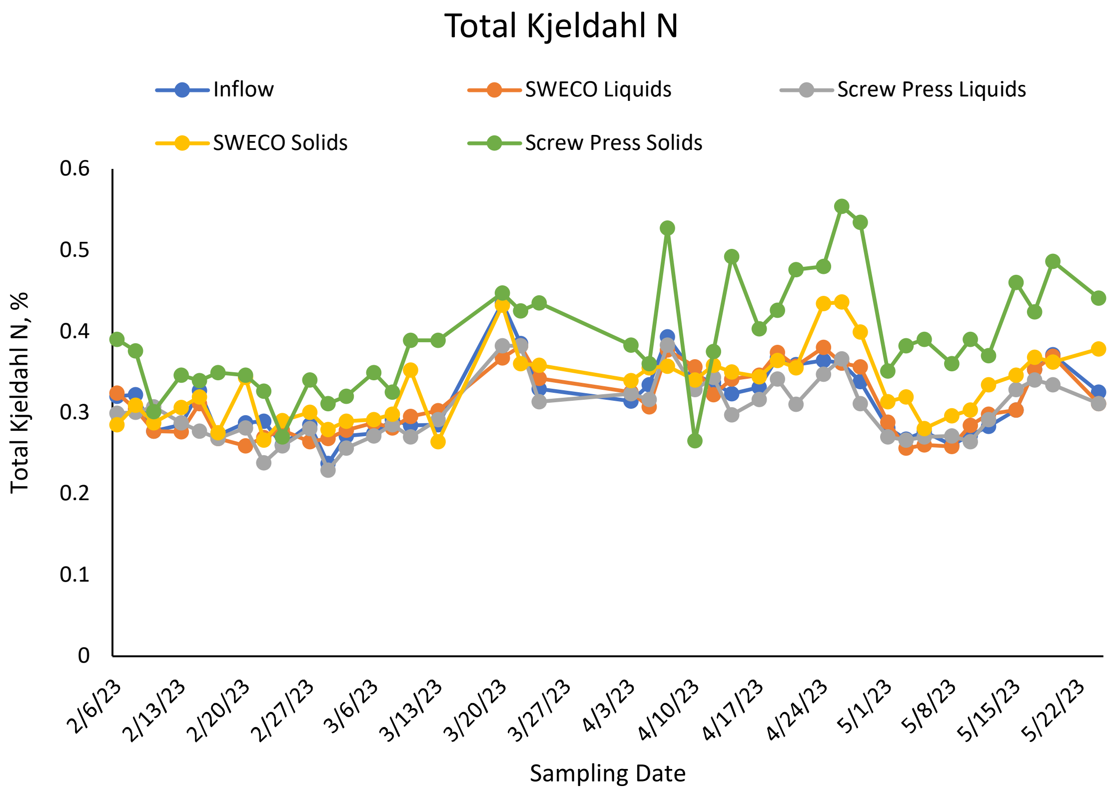



**Figure 7.** Total Kjeldahl nitrogen (N) concentrations in liquid and solid manure samples collected from various points along the SWECO separator system at Kilby dairy from February to May 2023, as reported by A&L Great Lakes Labs.

*Ammonium N*

Figure 8 shows that all manure forms had similar concentrations of ammonium N except for screw press solids that tended to be lower than the other manures. Ammonium N concentrations increased in all sample types in mid March and then stayed greater and more variable for the duration of the sampling period. Ammonium N is immediately plant available, and when land applied, ammonium N is easily converted to nitrate N, which is subject to leaching if it is moved below the root zone.

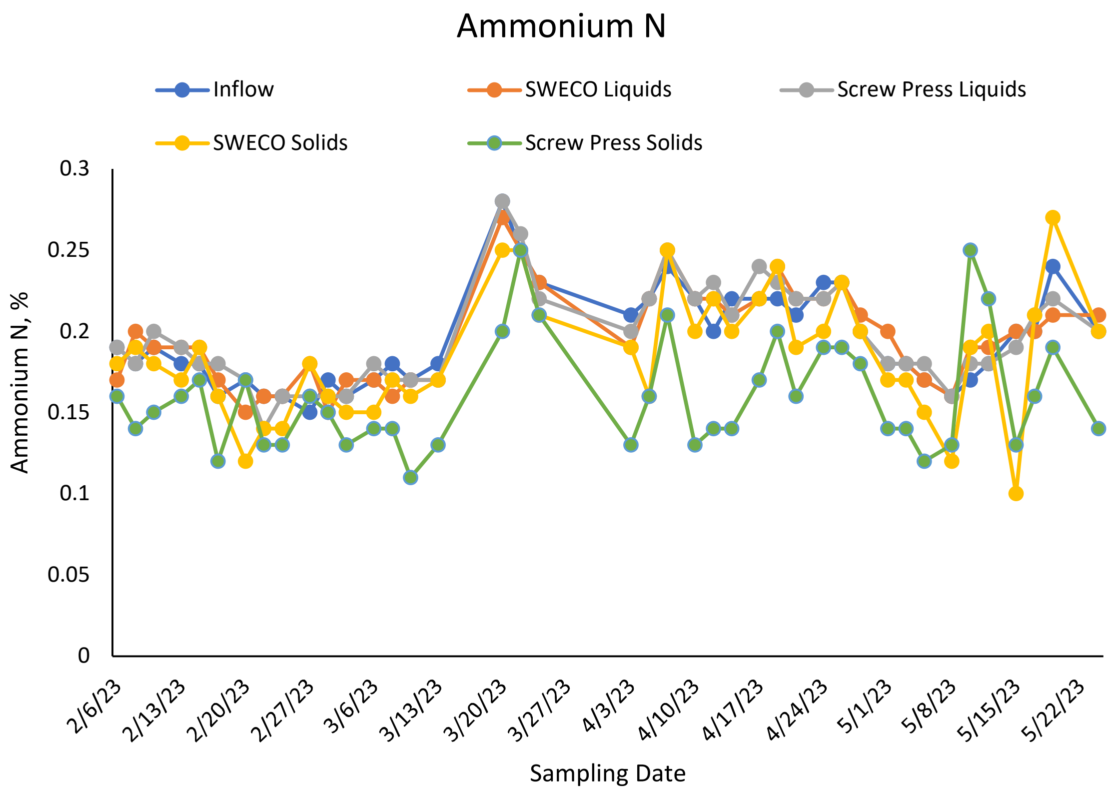



**Figure 8.** Ammonium nitrogen (N) concentrations in liquid and solid manure samples collected from various points along the SWECO separator system at Kilby dairy from February to May 2023, as reported by A&L Great Lakes Labs.

*Organic N*

Figure 9 shows that organic N was more concentrated in the screw press solids than the other sample types, which was likely related to the greater solids content of the material. The average moisture content of the screw press solids was 75.2 ± 5.6%, compared to 96.2 ± 0.3,90.8 ± 0.6, 96.6 ± 0.3, and 97.0 ± 0.2% for the inflow, SWECO solids, SWECO liquids, and screw press liquids, respectively. The SWECO screens efficiently separated inflow manure into solid and liquid outflow for the 16-week study. The liquid outflow from the SWECO screens is used for the digester, as well as fertilizer on the fields and flush water in the cow barns. Organic N must be mineralized before the N becomes plant available.

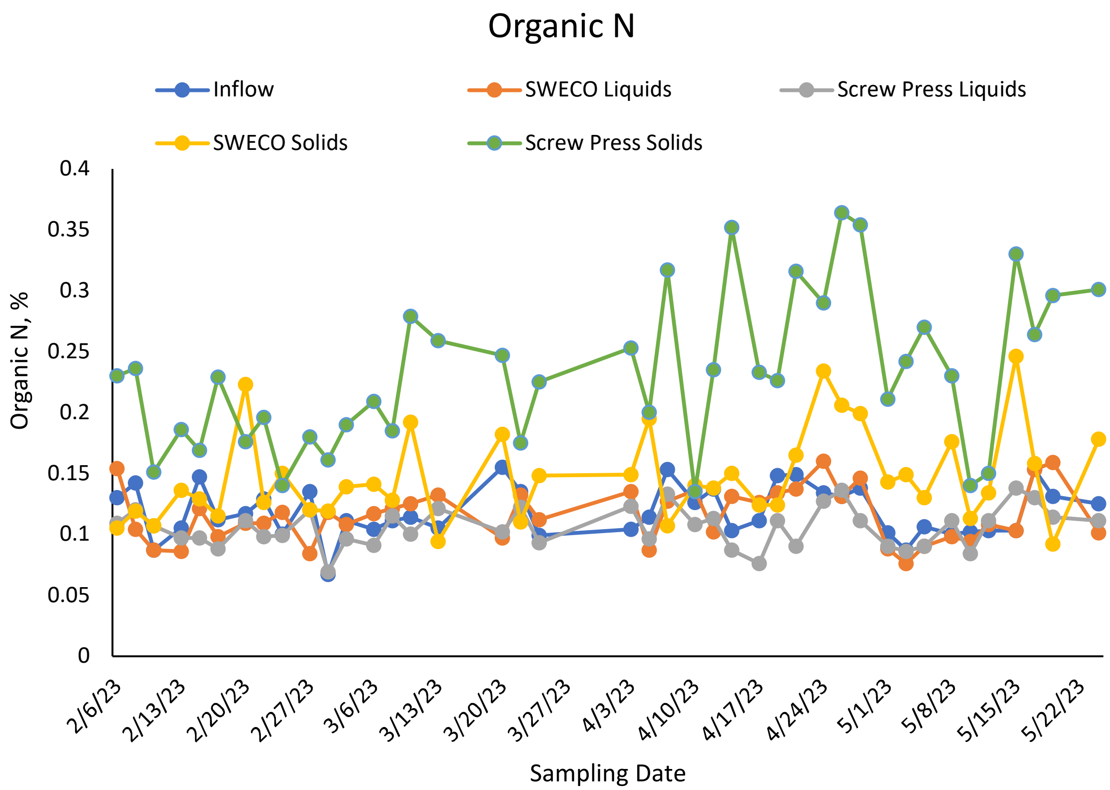



**Figure 9.** Organic nitrogen (N) concentrations in liquid and solid manure samples collected from various points along the SWECO separator system at Kilby dairy from February to May 2023, as reported by A&L Great Lakes Labs.

Nitrogen concentrations tended to remain relatively consistent among manure types, however, the system does allow for the diversion of some N from land application streams, which can ultimately reduce the potential for N leaching (Aguirre-Villegas, Larson, & Ruark, 2017). Rising Sun, Maryland is a part of the Chesapeake Bay watershed; thus reduction in land application of N at Kilby Dairy can have a positive impact on water quality (Forest and Rangeland Ecosystem Science Center, 2021).

*Total Phosphorus (P)*

As shown in Figure 10, phosphorus (P) concentrations tended to be greater in the inflow, SWECO liquids, and screw press solids than in the SWECO solids and screw press liquid, with this separation being most pronounced beginning in April..

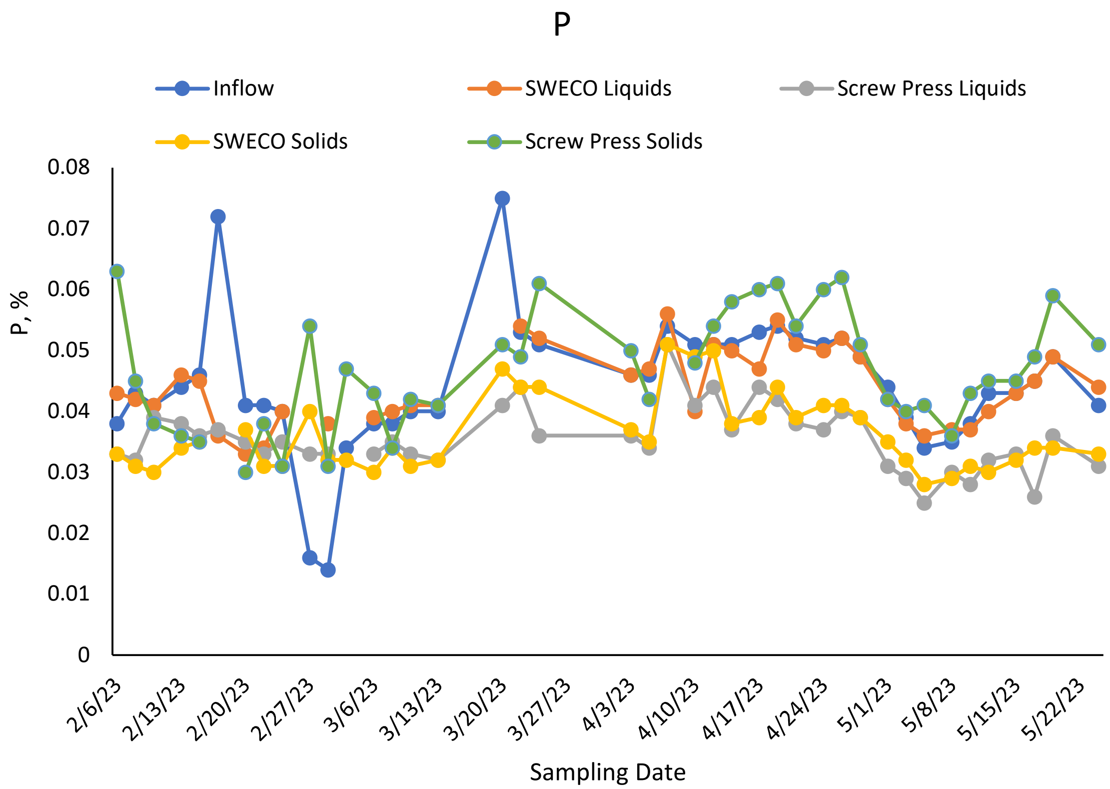



**Figure 10.** Total phosphorus (P) levels in liquid and solid manure samples collected from various points along the SWECO separator system at Kilby dairy from February to May 2023, as reported by A&L Great Lakes Labs.

Removal of P using the SWECO system reduces P that is land applied, which is a desirable outcome for dairies in general. Dairies often have a hard time managing manure without P accumulation in soils. As such, nutrient partitioning can help to improve land application of nutrients and reduce the need to apply on soils already high in P. This results in an environmental benefit for the watershed.

*Total Potassium (K)*

Potassium was relatively stable across manure streams and time. Potassium is required plant nutrient and fertilizer K sources are typically mined from finite sources. Any K that is removed from land application through the SWECO system may result in the need for the dairy to apply K fertilizers in the future.

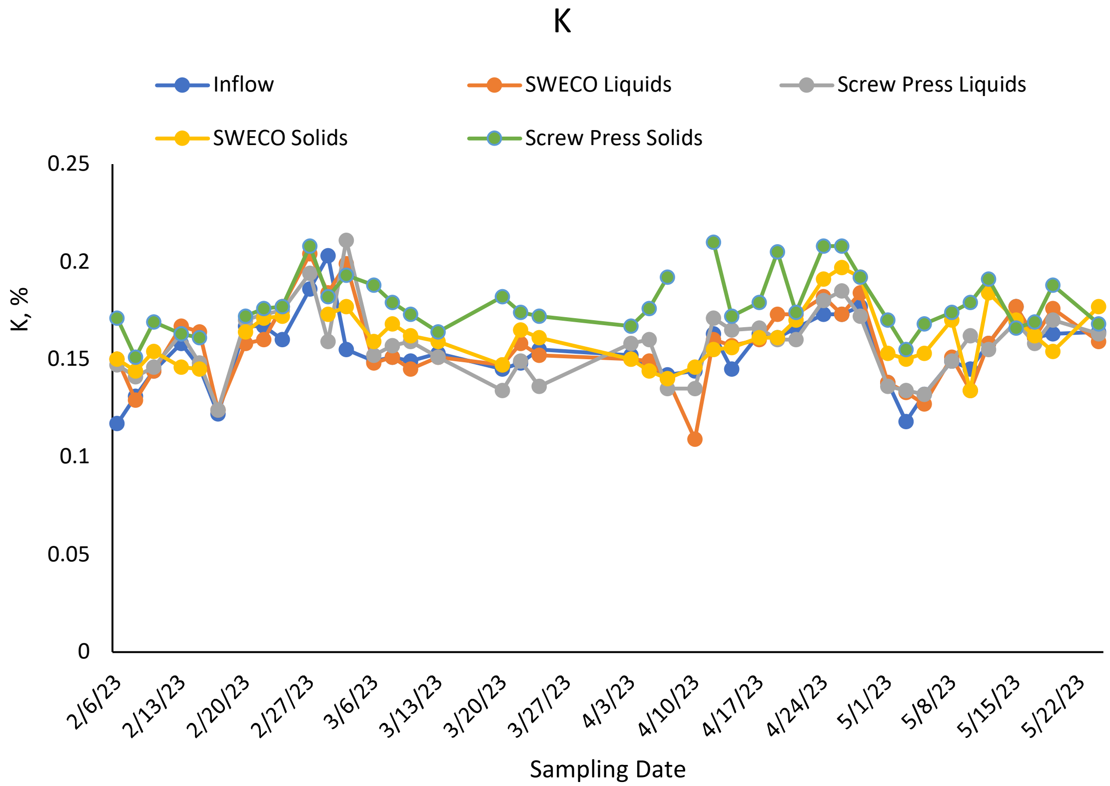



**Figure 10.** Total potassium (K) concentrations in liquid and solid manure samples collected from various points along the SWECO separator system at Kilby dairy from February to May 2023, as reported by A&L Great Lakes Labs.

## CONCLUSION

In the analysis of the data, the SWECO vibratory screens on Kilby Dairy Farm performed as expected. Per Kyle Sensenig the farm manager, the SWECO screens reduced the frequency of the digester needing to be cleaned out by reducing the amount of solids accumulating in the bottom of the digester. By separating the large solids out, it prevents a crust from forming on top of the manure within the digester maximizing the amount of gas produced allowing for a fully functioning digester. The solids created at the end of the process were also higher in concentration in the chemical elements, reducing the environmental impact Kilby Dairy has.

Recycling manure onsite at the dairy farm enables Kilby to be able to reduce cost outputs of irrigating their fields by utilizing effluent water that was separated from the raw manure. Not only does Kilby utilize wastewater, but also food waste. Off site on the Eastern Shore of Maryland is a poultry processing facility, the digester utilizes a byproduct from this facility called DAF-sludge. DAF-sludge contains high oil and fats concentration adding to biogas potential of the digester. As shown in Figure 2, the digestor takes advantage of this as an additional source for methane production. At Kilby Dairy Farm, the screw press solids are composted and sold to Scotts on the Eastern Shore of Maryland. Scotts incorporates the compost into fertilizer that is sold to homeowners. They may utilize it for personal use to grow crops or other miscellaneous personal uses. The entirety of Kilby Dairy Farm and several nearby residential homes, source their electricity off of the dairy's digester (Figure 2). Onsite biogas production reduces cost of electricity for the farm since it is self-produced, as well as utilizing the methane that otherwise would be excess expelled to the environment.

In conclusion, the SWECO vibratory screens on Kilby Dairy Farm aided in reducing the concentration of chemical components within the effluent water and separating out the solids prior to entry of the manure into the digester. Separated solids also allow for nutrients to be land applied on fields further away from the dairy more economically. Water quality was improved as well as reducing costs for the dairy farm.

# Appendix

Report Number
F23053-6502
Account Number
63570

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Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: KILBY DAIRY
COLORA, MD 21917

Attn: MARK STOERMAN

Purchase Order: UNIV OF DELAWARE

Lab Number: 52716
Sample ID: INFLOW
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 2/17/2023
Date Received: 2/22/2023
Date Reported: 2/24/2023 Page: 1 of 10

## MANURE ANALYSIS

| Analysis | Unit | Analysis Result (As Received) | Pounds Per 1,000 Gal** | First Year Availability @ Pounds Per 1,000 Gal |
|---|---|---|---|---|
| Moisture | % | 96.89 | 8071 | |
| Solids | % | 3.11 | 259 | |
| Ash @ 550 C | % | 0.69 | 57.7 | |
| Organic Matter (LOI @ 550 C) | % | 2.42 | 201.4 | |
| Organic Carbon (LOI @ 550 C) | % | 1.40 | 116.8 | |
| Carbon:Nitrogen Ratio (C:N) | - | | 5.2:1 | |
| Nitrogen, Total Kjeldahl (TKN) | % | 0.272 | 22.7 | 16.1 * |
| Nitrogen, Ammonium ($NH_4$-N) | % | 0.160 | 13.3 | 13.3 * |
| Nitrogen, Organic (N) | % | 0.112 | 9.3 | 2.8 * |
| Phosphorus (P) | % | 0.072 | 13.8 (as $P_2O_5$) | 13.8 * (as $P_2O_5$) |
| Potassium (K) | % | 0.122 | 12.2 (as $K_2O$) | 12.2 * (as $K_2O$) |
| Sulfur (S) | % | 0.04 | 3.6 | 1.8 # |

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Approved By: Approval Date: 2/24/2023
Don Burgess - Agronomist / Technical Services - CPAg/CPSS/CCA

Report Number
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COLORA, MD 21917

Attn: MARK STOERMAN

Purchase Order: UNIV OF DELAWARE

Lab Number: 52716
Sample ID: INFLOW
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 2/17/2023
Date Received: 2/22/2023
Date Reported: 2/24/2023 Page: 2 of 10

## MANURE ANALYSIS

| Analysis | Unit | Analysis Result (As Received) | Pounds Per 1,000 Gal** | First Year Availability @ Pounds Per 1,000 Gal |
|---|---|---|---|---|
| Magnesium (Mg) | % | 0.02 | 1.9 | 0.9 # |
| Calcium (Ca) | % | 0.14 | 11.9 | 6.4 # |
| Sodium (Na) | % | 0.03 | 2.6 | |
| Aluminum (Al) | ppm | 36 | 0.3 | |
| Copper (Cu) | ppm | 26 | 0.2 | 0.1 # |
| Iron (Fe) | ppm | 48 | 0.4 | 0.3 # |
| Manganese (Mn) | ppm | 16 | 0.1 | 0.1 # |
| Zinc (Zn) | ppm | 20 | 0.2 | 0.1 # |

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
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** Manure density assumed to be 8.33 lb/gallon

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11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: KILBY DAIRY
COLORA, MD 21917

Attn: MARK STOERMAN

Purchase Order: UNIV OF DELAWARE

Lab Number: 52717
Sample ID: SWECO SOLIDS
Manure Type: DAIRY, SOLID W/O BEDDING (6)

Date Sampled: 2/17/2023
Date Received: 2/22/2023
Date Reported: 2/24/2023

Page: 3 of 10

## MANURE ANALYSIS

| Analysis | Unit | Analysis Result (As Received) | Pounds Per Ton | First Year Availability @ Pounds Per Ton |
|---|---|---|---|---|
| Moisture | % | 90.64 | 1813 | |
| Solids | % | 9.36 | 187 | |
| Ash @ 550 C | % | 0.63 | 12.7 | |
| Organic Matter (LOI @ 550 C) | % | 8.73 | 174.5 | |
| Organic Carbon (LOI @ 550 C) | % | 5.06 | 101.2 | |
| Carbon:Nitrogen Ratio (C:N) | - | | 18.4:1 | |
| Nitrogen, Total Kjeldahl (TKN) | % | 0.275 | 5.5 | 4.0 * |
| Nitrogen, Ammonium ($NH_4$-N) | % | 0.160 | 3.2 | 3.2 * |
| Nitrogen, Organic (N) | % | 0.115 | 2.3 | 0.8 * |
| Phosphorus (P) | % | 0.223 | 10.2 (as $P_2O_5$) | 10.2 * (as $P_2O_5$) |
| Potassium (K) | % | 0.321 | 7.7 (as $K_2O$) | 7.7 * (as $K_2O$) |
| Sulfur (S) | % | 0.09 | 1.8 | 1.0 # |

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin

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For: KILBY DAIRY
COLORA, MD 21917

Attn: MARK STOERMAN

Purchase Order: UNIV OF DELAWARE

Lab Number: 52717
Sample ID: SWECO SOLIDS
Manure Type: DAIRY, SOLID W/O BEDDING (6)

Date Sampled: 2/17/2023
Date Received: 2/22/2023
Date Reported: 2/24/2023

Page: 4 of 10

## MANURE ANALYSIS

| Analysis | Unit | Analysis Result (As Received) | Pounds Per Ton | First Year Availability @ Pounds Per Ton |
|---|---|---|---|---|
| Magnesium (Mg) | % | 0.07 | 1.4 | 0.8 # |
| Calcium (Ca) | % | 0.42 | 8.4 | 4.6 # |
| Sodium (Na) | % | 0.06 | 1.3 | |
| Aluminum (Al) | ppm | 93 | 0.2 | |
| Copper (Cu) | ppm | 36 | 0.1 | <0.1 # |
| Iron (Fe) | ppm | 122 | 0.2 | 0.2 # |
| Manganese (Mn) | ppm | 45 | 0.1 | 0.1 # |
| Zinc (Zn) | ppm | 53 | 0.1 | 0.1 # |

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin

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To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: KILBY DAIRY
COLORA, MD 21917

Attn: MARK STOERMAN

Purchase Order: UNIV OF DELAWARE

Lab Number: 52718
Sample ID: SWECO LIQUIDS
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 2/17/2023
Date Received: 2/22/2023
Date Reported: 2/24/2023 Page: 5 of 10

## MANURE ANALYSIS

| Analysis | Unit | Analysis Result (As Received) | Pounds Per 1,000 Gal ** | First Year Availability @ Pounds Per 1,000 Gal |
|---|---|---|---|---|
| Moisture | % | 97.13 | 8091 | |
| Solids | % | 2.87 | 239 | |
| Ash @ 550 C | % | 0.71 | 58.9 | |
| Organic Matter (LOI @ 550 C) | % | 2.16 | 180.2 | |
| Organic Carbon (LOI @ 550 C) | % | 1.25 | 104.5 | |
| Carbon:Nitrogen Ratio (C:N) | - | | 4.7:1 | |
| Nitrogen, Total Kjeldahl (TKN) | % | 0.268 | 22.3 | 16.7 * |
| Nitrogen, Ammonium ($NH_4$-N) | % | 0.170 | 14.2 | 14.2 * |
| Nitrogen, Organic (N) | % | 0.098 | 8.2 | 2.5 * |
| Phosphorus (P) | % | 0.036 | 6.9 (as $P_2O_5$) | 6.9 * (as $P_2O_5$) |
| Potassium (K) | % | 0.124 | 12.4 (as $K_2O$) | 12.4 * (as $K_2O$) |
| Sulfur (S) | % | 0.02 | 1.8 | 0.9 # |

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Number
F23053-6502
Account Number
63570

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algreatlakes.com

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WHEATFIELD, IN 46392-7364

For: KILBY DAIRY
COLORA, MD 21917

Attn: MARK STOERMAN

Purchase Order: UNIV OF DELAWARE

Lab Number: 52718
Sample ID: SWECO LIQUIDS
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 2/17/2023
Date Received: 2/22/2023
Date Reported: 2/24/2023 Page: 6 of 10

## MANURE ANALYSIS

| Analysis | Unit | Analysis Result (As Received) | Pounds Per 1,000 Gal ** | First Year Availability @ Pounds Per 1,000 Gal |
|---|---|---|---|---|
| Magnesium (Mg) | % | 0.04 | 3.0 | 1.8 # |
| Calcium (Ca) | % | 0.06 | 5.4 | 2.7 # |
| Sodium (Na) | % | 0.04 | 3.5 | |
| Aluminum (Al) | ppm | 116 | 1.0 | |
| Copper (Cu) | ppm | 7.6 | 0.1 | <0.1 # |
| Iron (Fe) | ppm | 76 | 0.6 | 0.4 # |
| Manganese (Mn) | ppm | 4.8 | <0.1 | <0.1 # |
| Zinc (Zn) | ppm | 7.4 | 0.1 | <0.1 # |

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

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For: KILBY DAIRY
COLORA, MD 21917

Attn: MARK STOERMAN

Purchase Order: UNIV OF DELAWARE

Lab Number: 52719
Sample ID: SCREW PRESS SOLIDS
Manure Type: DAIRY, SOLID W/O BEDDING (6)

Date Sampled: 2/17/2023
Date Received: 2/22/2023
Date Reported: 2/24/2023 Page: 7 of 10

## MANURE ANALYSIS

| Analysis | Unit | Analysis Result (As Received) | Pounds Per Ton | First Year Availability @ Pounds Per Ton |
|---|---|---|---|---|
| Moisture | % | 74.88 | 1498 | |
| Solids | % | 25.12 | 502 | |
| Ash @ 550 C | % | 0.64 | 12.9 | |
| Organic Matter (LOI @ 550 C) | % | 24.48 | 489.5 | |
| Organic Carbon (LOI @ 550 C) | % | 14.20 | 283.9 | |
| Carbon:Nitrogen Ratio (C:N) | - | | 40.7:1 | |
| Nitrogen, Total Kjeldahl (TKN) | % | 0.349 | 7.0 | 4.0 * |
| Nitrogen, Ammonium ($NH_4$-N) | % | 0.120 | 2.4 | 2.4 * |
| Nitrogen, Organic (N) | % | 0.229 | 4.6 | 1.6 * |
| Phosphorus (P) | % | 0.081 | 3.7 (as $P_2O_5$) | 3.7 * (as $P_2O_5$) |
| Potassium (K) | % | 0.361 | 8.7 (as $K_2O$) | 8.7 * (as $K_2O$) |
| Sulfur (S) | % | 0.07 | 1.5 | 0.8 # |

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin

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F23053-6502
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For: KILBY DAIRY
COLORA, MD 21917

Attn: MARK STOERMAN

Purchase Order: UNIV OF DELAWARE

Lab Number: 52719
Sample ID: SCREW PRESS SOLIDS
Manure Type: DAIRY, SOLID W/O BEDDING (6)

Date Sampled: 2/17/2023
Date Received: 2/22/2023
Date Reported: 2/24/2023 Page: 8 of 10

## MANURE ANALYSIS

| Analysis | Unit | Analysis Result (As Received) | Pounds Per Ton | First Year Availability @ Pounds Per Ton |
|---|---|---|---|---|
| Magnesium (Mg) | % | 0.09 | 1.8 | 1.0 # |
| Calcium (Ca) | % | 0.17 | 3.4 | 1.9 # |
| Sodium (Na) | % | 0.11 | 2.3 | |
| Aluminum (Al) | ppm | 239 | 0.5 | |
| Copper (Cu) | ppm | 24 | <0.1 | <0.1 # |
| Iron (Fe) | ppm | 207 | 0.4 | 0.3 # |
| Manganese (Mn) | ppm | 13 | <0.1 | <0.1 # |
| Zinc (Zn) | ppm | 20 | <0.1 | <0.1 # |

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
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WHEATFIELD, IN 46392-7364

For: KILBY DAIRY
COLORA, MD 21917

Attn: MARK STOERMAN

Purchase Order: UNIV OF DELAWARE

Lab Number: 52720
Sample ID: SCREW PRESS LIQUIDS
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 2/17/2023
Date Received: 2/22/2023
Date Reported: 2/24/2023



## MANURE ANALYSIS

| Analysis | Unit | Analysis Result (As Received) | Pounds Per 1,000 Gal ** | First Year Availability @ Pounds Per 1,000 Gal |
|---|---|---|---|---|
| Moisture | % | 97.27 | 8103 | |
| Solids | % | 2.73 | 227 | |
| Ash @ 550 C | % | 0.65 | 54.4 | |
| Organic Matter (LOI @ 550 C) | % | 2.08 | 173.0 | |
| Organic Carbon (LOI @ 550 C) | % | 1.20 | 100.3 | |
| Carbon:Nitrogen Ratio (C:N) | - | | 4.5:1 | |
| Nitrogen, Total Kjeldahl (TKN) | % | 0.268 | 22.3 | 17.2 * |
| Nitrogen, Ammonium ($NH_4$-N) | % | 0.180 | 15.0 | 15.0 * |
| Nitrogen, Organic (N) | % | 0.088 | 7.3 | 2.2 * |
| Phosphorus (P) | % | 0.037 | 7.2 (as $P_2O_5$) | 7.2 * (as $P_2O_5$) |
| Potassium (K) | % | 0.124 | 12.4 (as $K_2O$) | 12.4 * (as $K_2O$) |
| Sulfur (S) | % | 0.02 | 1.8 | 0.9 # |

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

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For: KILBY DAIRY
COLORA, MD 21917

Attn: MARK STOERMAN

Purchase Order: UNIV OF DELAWARE

Lab Number: 52720
Sample ID: SCREW PRESS LIQUIDS
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 2/17/2023
Date Received: 2/22/2023
Date Reported: 2/24/2023



## MANURE ANALYSIS

| Analysis | Unit | Analysis Result (As Received) | Pounds Per 1,000 Gal ** | First Year Availability @ Pounds Per 1,000 Gal |
|---|---|---|---|---|
| Magnesium (Mg) | % | 0.04 | 3.1 | 1.8 # |
| Calcium (Ca) | % | 0.07 | 5.5 | 3.2 # |
| Sodium (Na) | % | 0.04 | 3.4 | |
| Aluminum (Al) | ppm | 118 | 1.0 | |
| Copper (Cu) | ppm | 8.2 | 0.1 | <0.1 # |
| Iron (Fe) | ppm | 79 | 0.7 | 0.4 # |
| Manganese (Mn) | ppm | 5.1 | <0.1 | <0.1 # |
| Zinc (Zn) | ppm | 7.6 | 0.1 | <0.1 # |

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

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