Exhibit SAD1-22

Memorandum

To: Salisbury AD 1 File
Date: December 12, 2018
Project #: 58073.00
From: Lydia G. Lee, PG
Re: Digestate Management Plan

Introduction

VHB has prepared this Digestate Management Plan on behalf of Salisbury AD 1, LLC ("Salisbury AD 1") to provide supplemental material in response to comments provided by the Agency of Natural Resources ("ANR") in its *Comments of the Agency of Natural Resources on Salisbury AD 1, LLC Motion to Transfer and Amend CPG*, Docket No. 18-3449-PET, dated October 31, 2018 ("ANR's comments"). ANR's comments were filed in response to Salisbury AD 1's Motion to Amend the CPG. Specifically, this Digestate Management Plan demonstrates how the Project will help to manage and monitor levels of phosphorus ("P") at the Goodrich Farm ("Goodrich Farm"), how it will successfully extract excess P from the digestate, and identifies an outlet for managing and exporting the excess P in the form of a nutrient cake. In addition, this plan includes information related to the management of the solid and liquid nutrient produced as part of the Project and the amendment of the Goodrich Farm's Large Farm Operating ("LFO") permit in response to comments discussed during a Project meeting with ANR and the Agency of Agriculture, Food, and Markets ("AAFM") held on November 28, 2018.

This Digestate Management Plan includes information on the following major elements:

- Nutrient Recovery Technology
- Retention of a registered Technical Services Provider ("TSP");
- Development of an annual nutrient management plan ("NMP") in accordance with the Farm's LFO Permit and nutrient characteristics of the digestate;
- Liquid Nutrient Management;
- Nutrient Cake Management Plan;
- Expanded annual soil testing of all Goodrich Farm fields in the Otter Creek watershed with high or excessive soil phosphorus test levels; and
- Amendment to the Host Farm's LFO Permit.

Nutrient Recovery Technology

As described in Exhibit SAD1-7 of the Motion to Amend the CPG filing, Salisbury AD 1 proposes to use a nutrient recovery system that separates solids from the liquid portion, such as dissolved air flotation ("DAF") and polymer separation. A portion of the total P will be extracted in the solid portion, thereby removing it from the liquid portion that would be applied to the fields, as further described herein. Salisbury AD 1 is currently working with DVO, Inc. to specify a DAF System[1] for the Project, and will continue to work with DVO experts throughout operations to optimize nutrient recovery and polymer additions. Information on DVO DAF technology, including a case study, is attached.

---

[1] DVO refers to its system as a "Phosphorus Recovery System". "DAF" is used herein for consistency with prior documents related to this Project.

40 IDX Drive, Building 100
Suite 200
South Burlington, Vermont 05403

DVO's system can remove between 75% and 95% of P depending on the circumstances. The lower limit can be adjusted by reducing the running hours of the system. In general, the solids removal will be optimized to meet the nutrient needs of the farm. The P concentration in the liquid in the nutrient storage tanks will be adjusted seasonally or annually to comply with the NMP.

Consulting Agronomist

Salisbury AD 1 and the Goodrich Farm will retain a consulting agronomist (who is also a registered TSP) for the duration of the Project's operation. Salisbury AD 1's TSP will oversee all soil sampling described in this Digestate Management Plan and incorporate the results into the farm's NMP and annual phosphorus mass balance reports. The TSP will also: produce the reports identified in this document; coordinate communications between the Goodrich Farm, Salisbury AD 1, ANR, and AAFM; and recommend additional voluntary practices to enhance P reductions, as applicable.

Nutrient Management Plan

Salisbury AD 1's TSP will collaborate with the Goodrich Farm and its TSP to evaluate how much P should be extracted from the digestate, and which fields may need digestate application to meet nutrient needs of the crops. Using the prior year's LFO Permit and NMP for the upcoming year, the amount of P that needs to be extracted from the digestate will be determined based on the nutrient needs of the Farm. The amount of nutrient cake application, if used, will also be determined on a field by field basis based on soil test P levels, and P levels of the digestate cake. The TSP will provide recommendations for field application of the liquid digestate and nutrient cake so as to not increase Soil Test P levels above the optimum range. Excess cake that cannot be used in accordance with the NMP or as advised by the TSPs will be exported from the farm, as discussed in the Nutrient Cake Management and Export section of this Digestate Management Plan. A certain amount of nutrient cake export is anticipated each year.

The Goodrich Farm's TSP will continue to develop an annual NMP, in order to provide ANR and AAFM (the "Agencies") with the necessary information to understand and assess nutrient management at the Goodrich farm. The annual NMP shall be based on the following records which are required to be maintained in the project farm's NRCS590 standard NMPs: soil and manure tests; dates and methods of nutrient applications; rates of applications; source of nutrients; crops planted; crop yields; and all fertilizer products utilized. These records will be presented in a manner that is field specific. The NMP will be provided to the Agencies on the same schedule as currently required by the farm's LFO Permit.

In addition to the NMP, an annual P mass balance for the farm will be developed and used to track the quantity and characteristics of the manure and feedstock provided to the Project, as well as the digester effluent returned to the Project farm's long-term manure storage, and digestate cake exported from the farm. In addition, the mass balance will track and tabulate the total amount of P the Goodrich Farm imports in fertilizer, as well as the estimated amount of P exported in products such as milk and meat. The mass balance will be provided to ANR and AAFM as part of an annual report that includes the prior calendar year's annual operating report and NMP. The annual mass balance report will be provided to ANR and AAFM within three months following each anniversary of commercial operation, in each year the Project is operational.

Memorandum

The nutrient content of the solid and liquid digestate will vary depending on the incoming feedstock, polymer used, and needs of the farm. For use in initial estimates and planning, Table 1 below (which was included in Exhibit SAD1-7), provides a summary of Nutrient Mass Balance through the Digestion Process, and the total estimated nutrient content of the digestate prior to the DAF.

Table 1: Summary of Nutrient Mass Balance through Digestion Process (All values in Tons/yr)

	Into Digester			Out of Digester	Crop Uptake	Nutrient Balance
	Manure	**SSO**	**Total**	**Digestate [1]**		
Volume	30,000	65,000	95,000	83,000	--	--
P	40	50	90	90	60	30
K	100	40	140	140	150 [2]	-10
N	130	170	300	270 (Total N) (160 Available N)	200 [3]	-40 [3]

Notes: P = phosphorus as P_2O_5, K = potassium as K_2O, N = total nitrogen
[1] Refer to Exhibit SAD1-7 for sources and additional assumptions regarding the digestion process. "Available" N represents the amount of N that the crop is able to uptake and is estimated to be approximately 60% of the total N in the digestate.
[2] Total Crop K Recommendation in LFO Permit
[3] Available N, refer to CH Four Report for calculations based on estimated crop type and yield (per the Goodrich Farm's TSP). The nutrient balance represents the balance of Available N.

DVO provided a case study for a farm in Washington state that uses a similar nutrient extraction technology to what is proposed for this Project. The case study (attached) indicates the P, K, and N contents in the Fine Solids Soil ("FSS") amendment (nutrient cake) are as follows:

- P: 3.8 +/- 0.8% Dry Weight ("DW")
- N: 4.5 +/- 1.1% DW
- K: 0.9 +/- 0.2% DW

These values are based on a 62% reduction of total solids and an 88% reduction of P by mass. Although for the Salisbury AD 1 Project the estimated removal is 32% of the P by mass, the nutrient cake will likely have a similar nutrient content, but the DAF usage rate would be adjusted to accommodate the nutrient needs of the fields, i.e. less solid would be extracted.

Memorandum

Liquid Nutrient Management

Liquid nutrient will be trucked from the liquid nutrient storage tank(s) to other farm lagoons located closer to the fields where the liquid will be applied. Transfer of the nutrients via tanker trucks from the on-site storage locations to other locations on the farm is consistent with current farming practices. Trucking will occur year-round as storage capacity is available in the farm's lagoons.

The Goodrich Farm currently uses two lagoons located at the Project area and three lagoons located on other farm-owned land. The Farm is also considering, apart from the Project, constructing two additional lagoons in order to store liquid nutrient (or currently manure) closer to the fields prior to spreading. The Farm's five separate lagoons (plus the two potential new ones) allow for liquid nutrient "recipes" to be tailored to the needs of the fields. This process will be tested and optimized through coordination with the Farm and its TSP.

Preliminary planning indicates the annual volume of liquid will be approximately 17.9 Mgals (after DAF processing; 19.9 prior to DAF processing) compared to the approximate 15.1 Mgal of liquid the Farm currently produces (of all liquid per the LFO permit).

The liquid will be applied in accordance with the Farm's NMP and in a manner so as to comply with Required Agricultural Practices ("RAPs"). The new storage tanks and existing storage lagoons have the capacity to store half of the annual volume of liquid generated, or 180 days of digestate production. The Farm has 2,357 acres of cropland on which to apply this liquid. The liquid would be spread on the fields approximately twice per year. Assuming, conservatively, that no liquid is spread on the approximately 550 acres with high or excessive Soil Test P values[2], the depth of the liquid spread over the cropland would be approximately 0.18 inches, per application period (assuming the total volume of liquid would be spread over two application periods per year), which represents a minor difference compared to the depth of liquid for existing conditions over two application periods (0.15 inches, based on the existing volume of manure, stormwater, and wastewater currently generated at the farm). These calculations are provided to conceptualize the difference in depth of liquid caused by the Project compared to existing conditions, and are conservative as they assume all the liquid would be spread instantaneously across all of the fields, which would not be the case. Liquid would be applied or injected on fields at rates prescribed by the NMP, and in a manner consistent with the RAPs. Table 2 below presents the estimate for the depth of liquid resulting from the Project in comparison to existing conditions.

[2] Liquid nutrient will be applied in accordance with the Farm's NMP and RAPs.

Memorandum

Table 2: Estimate of Inches of Manure versus Digestate Liquid				
Scenario	**Annual Volume**		**Acres of Cropland**	**Depth of Liquid (in)***
	Gallons	**Cubic Feet**		
Existing Conditions				
(Manure + Stormwater/ Wash water)	15,067,569	2,014,381	1,807	0.30
Proposed Conditions				
Manure + Food Waste	19,844,685	2,653,033	1,807	0.40
Manure + Food Waste - DAF Solids	17,860,910	2,387,822	1,807	0.36
*Annual, with two application events.				

The permeability for soil types listed for the farm's fields (2017 NMP) range widely from 0 (the lowest range for Covington soil) to 20 (the highest range for Elmwood soil) inches per hour in their natural, undisturbed state. Permeability rates for Covington soil, which is listed to have the lowest permeability range of the soil types within the farm's fields, range between 0 to 0.2 inches per hour, but given that these soils are disturbed from tilling, amendments, and prior crops, the permeability rate would likely be closer to the higher end of its range. Using permeability and an assumed vertical gradient of 100 percent in accordance with Darcy's Law, at its higher range of permeability the soil is able to infiltrate the entire depth of liquid (0.36 inches per year) within approximately two hours. Accordingly, a single application event could be infiltrated within one hour, which would likely be the case because the farm spreads the total annual volume of liquid twice per year. Liquid will be applied in accordance with the farm's NMP and RAPs, so as to not cause liquid to pond on the ground surface and pose a significant potential of runoff to waters of the State. Further, separated liquid digestate provided by the Project serves as a more suitable liquid for drag line injection, which can improve the incorporation of the liquid into soil.

Should it become apparent that the additional volume of liquid from the Project cannot be land-applied or stored in accordance with RAPs, and there are no other alternatives such as exporting the liquid, the Project will slow down or stop digestate production until an outlet for the volume of water is identified.

Nutrient Cake Management Plan

Salisbury AD 1 recognizes the importance of developing and implementing a plan for the on-going management and use of the nutrient cake produced by the Project's nutrient recovery system (DAF). The production of a solid nutrient cake provides the Project and the Host Farm with the opportunity to amend only fields that need P while exporting excess P off of the farm, and potentially out of the Otter Creek watershed.

Memorandum

The Project intends to truck excess nutrient cake off-site daily. Approximately two to three days' worth of storage is provided in the nutrient management building where the DAF system will be located[3]. The Project will also provide approximately three days of additional covered storage through the use of on-site covered dumpsters (roll offs or bins) should additional storage be needed. As presented in Exh. SAD1-7 of the October 4, 2018 filing, approximately 32% (28.2 tons) of the P from the digestate will need to be exported from the farm. A 32% P reduction could be achieved with the DAF, resulting in the production of approximately 8,395 tons/yr of nutrient cake that would be exported from the farm (refer to the Mass Flow Diagram, provided as an attachment to Exh. SAD1-7). The annual crop requirement of the farm is 59.7 tons of P/yr (based on the farm's 2018 LFO permit), which would be supplied back to the farm in the form of digestate. The farm and its TSP will work with Salisbury AD 1 to determine if further separation of this remaining digestate into liquid and solid fractions would assist in optimizing the nutrient application. Solids would be provided to the farm if requested, and the farm would use it in a manner consistent with its LFO permit.

It is the Project's intention to find a suitable, sustainable market for the excess nutrient cake that the Goodrich Farm cannot use, such as a local composting facility. However, because the products captured from digester effluent by the facility are relatively new and markets are difficult to identify for a product that will not be available until 2020, firm contracts for selling excess nutrient cake cannot be finalized at this juncture. Therefore, as a contingency, Salisbury AD 1 will commit to disposing excess cake at a landfill or waste management facility certified to accept such material, if needed, to provide assurances that these materials will be appropriately managed.

With the intent to find a more sustainable solution once the Project is constructed and markets are more easily secured, Salisbury AD 1 proposes the following timeline for preparing and informing the Agencies of the Nutrient Cake Management Plan ("NCMP") as it evolves:

- Prior to filling the digesters with manure, Salisbury AD 1 will provide an update on the NCMP and the identification of potential markets or agreements, if established by this time. It is estimated that Salisbury AD 1 will commence filling up the digester in fall 2019.
- At least 30 days prior to the Project's first acceptance of food waste, Salisbury AD 1 will provide information on the selected facility or facilities who will accept the waste for ANR and AAFM review and approval.
- The approved NCMP will be implemented upon acceptance of food waste and as nutrient cake is produced.

The following NCMP will be implemented during Project Operations:

1. Nutrient cake may be provided to the Goodrich Farm for application to fields they own or rent provided it shall only be applied to fields that do not have high or excessive phosphorus levels as determined by a current (within three years) soil test. Such use shall be documented in the NMP for all application fields.

2. All nutrient cake not used by the Goodrich farm on fields they own or rent shall be exported from the farm. Exceptions to this requirement will only be allowed on a case by case basis, and only after pre-approval by AAFM and ANR. Requests for exceptions must be submitted in writing at least four weeks prior to the proposed activity.

[3] Existing building; Building 9 on Exh. SAD1-3(Rev.) to the PUC.

Memorandum

3. Salisbury AD 1 shall comply with the following conditions for all nutrient cake that is provided to non-Host farms for application to fields which are located in Vermont and within the Lake Champlain Basin, including any within the Otter Creek watershed after the required pre-approval by AAFM and ANR.

    a. Each recipient farm shall acknowledge in writing that the nutrient cake is being provided to the farm on the condition that it shall only be applied to fields that do not have high or excessive phosphorus levels as determined by a current (within three years) soil test. Salisbury AD 1 shall provide AAFM and ANR notice of the addition of each new recipient within 30 days of receiving the written acknowledgement from each participant.

    b. Salisbury AD 1 shall provide AAFM and ANR with an annual report that contains the following information:

        i. The identity and location of each farm that nutrient cake was provided to;
        ii. The quantity of nutrient cake that was provided to each farm; and
        iii. A copy of the written acknowledgement signed by each farm, if available.

4. Salisbury AD 1 shall comply with the following conditions for all nutrient cake that is provided to an entity for the purpose of incorporation as an ingredient in any product produced by that entity for wholesale or retail sale to a third party for eventual use or resale by the third party.

    a. Each recipient entity shall acknowledge in writing that the nutrient cake is being provided to that entity on the condition that it is to be incorporated as an ingredient in a product produced by that entity for wholesale or retail sale to a third party, and not for any other use by that entity.

    b. Salisbury AD 1 shall provide AAFM and ANR with an annual report that contains the following information:

        i. The identity and location of each entity that nutrient cake was provided to;
        ii. The identity of the product into which the nutrient cake was incorporated;
        iii. The quantity of nutrient cake that was provided to each entity; and
        iv. A copy of the written acknowledgement signed by each entity.

Contingency Plan

In the unlikely event that the markets identified in the NMCP are unable to accept the nutrient cake and no other markets are immediately available, Salisbury AD 1 will dispose of the excess nutrient cake at a landfill or waste management facility certified to accept such material. As previously stated, should it become apparent that the additional volume of liquid from the Project cannot be land applied or stored in accordance with RAPs and there are no other alternatives, such as exporting the liquid, the Project will slow down or stop digestate production until an outlet for the volume of water is identified.

Memorandum

Expanded Field Soil Testing

Currently, a soil test from each field at the Goodrich Farm is taken at least once every three years to identify the level of nutrients contained in the soil. As part of this Digestate Management Plan, Salisbury AD 1 agrees to conduct additional, annual soil sampling on select fields at the Goodrich Farm as described in this section. Specifically, Salisbury AD 1 will collect annual soil samples from all fields where the Project digester effluent is applied and which have been identified by previous soil tests as having high or excessive soil P levels. At a minimum, the expanded soil testing shall include P and organic matter content, and will be conducted by qualified personnel. Because it may take several years for a measurable and statistically significant drawdown of soil test P on the appropriate fields to occur, the expanded soil testing shall continue for a minimum period of ten years, unless otherwise agreed upon by Salisbury AD 1, ANR, and AAFM.

Goodrich Farm LFO Amendment

The Goodrich Farm will apply for a minor amendment to the LFO permit to indicate the use of liquid and solid nutrient from the Project. It is anticipated that liquid nutrient will be applied on all fields able to accept application, per the NMP. Nutrient cake will be used secondarily to meet P needs of crops on fields with Soil Test P levels below the "high" range. Chemical fertilizer would be imported as a last resort, as needed, to meet K and N needs. It is anticipated that the LFO amendment application would be prepared and submitted a year prior to the farm using either the liquid nutrient or nutrient cake from the Project, or at a timeline agreed upon between the farm and AAFM, and that this material would not be used prior to issuance of the amended permit.

The Goodrich Farm and its TSP will continue to work with AAFM on this application and its requirements. Preparation of a draft NMP for 2020 operations to incorporate the products from the Project is underway, which will assist in this process.

Conclusions

In addition to the Project's primary intended purpose as a renewable natural gas generation facility, Salisbury AD 1 believes that this Digestate Management Program will enable it to demonstrate that the importation of additional feedstock to the Goodrich Farm will not result in undue water pollution from excessive soil nutrient enrichment and erosion, and therefore would not contribute to the existing Phosphorus impairment of Lake Champlain or nutrient impairment of the lower Otter Creek.

Attachments

DVO Information Sheet and Case Study

NEWTRIENT™
INNOVATIVE SOLUTIONS IN RESOURCE RECOVERY

CASE STUDY

DVO Phosphorus Recovery System

Edaleen Dairy, Lynden, WA

Vendor:
DVO Incorporated
820 W. Main St.
Chilton, WI 53014 USA
1-920-849-9797
info@dvoinc.com
www.dvoinc.com/phosphorus-recovery.php

Industry:
Fine Solids and Phosphorus Separation

Project type:
Post Anaerobic Digestion Fine Solids and Phosphorous Separation

Project goal:
Partition remaining suspended solids and associated phosphorus and nitrogen into stackable solid

Study Prepared by:
Craig Frear

Date of Case Study:
September 27, 2017

OVERVIEW

Edaleen dairy is a 1,800 wet-cow dairy in Northwest Washington State producing an approximate 7% total solids manure wastewater from a combination of alley-scrapers, maternity barn flush and parlour/wash water. This manure wastewater is then pumped to a DVO mesophilic mixed plug-flow anaerobic digester that practices limited co-digestion with off-farm organics (<5% volume). Effluent from the digester is then sent to a GEA/Houle two-stage, slope-screen solids separator for separation of fibrous, coarse solids. The resulting liquid, still containing large amounts of suspended solids and associated nutrients, is sent through a DVO Phosphorus Recovery System, which is a modified dissolved air flotation (DAF) system. Separated solids are a wet but stackable product rich in nutrients, particularly phosphorus. Final liquid wastewater is then sent to lagoon for storage and subsequent land application.

BACKGROUND

The DVO Phosphorus Recovery System adds important nutrient partitioning capabilities to the Edaleen dairy manure management system.

Edaleen dairy is a family-owned producer/processor located in Lynden Washington, presently milking approximately 1,800 Holstein wet cow equivalents. Edaleen dairy has one of the more complete, modern manure management systems in the US, which they have phased into place since 2012. The system starts with alley cable-scrapers as well as a flush system within their maternity barn. The combined scrape and flush manure are mixed with farm wash water to manure pits. The manure wastewater from these pits is sent to a DVO mesophilic mixed plug-flow anaerobic digester for treatment and production of renewable electricity and carbon credits in a Dresser-Rand Guascor SFGLD 560 engine/generator combined heat and power system packaged by Martin Energy Group. Effluent from the digester is passed across a GEA/Houle two-stage, slope-screen separator, producing a high-quality fibrous solid used as both an internal animal bedding and sold off-farm as a soil amendment ingredient to a commercial retail product. Liquid effluent from the screen is sent to an equalization pit for control of flows and timing,

FIGURE 1. MANURE MANAGEMENT SYSTEM FLOWCHART — DVO PHOSPHORUS RECOVERY SYSTEM (SOLID PRODUCT CIRCLED).

"We invested in the advanced solids/nutrient system because the future of the dairy industry is evolving, and the needle is moving towards nutrient management systems as a key element in creating a closed loop, sustainable farm where nothing goes to waste, and we steward the land with utmost care so it can feed future generations."

***Mitch Moorlag,** General Manager Edaleen Dairy*

with dispersal to a DVO Phosphorus Recovery, modified dissolved air flotation (DAF) system for recovery of fine solids and associated nutrients. Collected solids are hauled and stored to an off-site location, with local agricultural producers with fields in transition using the solids as carbon/nutrient soil amendment. Final liquid effluent is stored in lagoons until ultimate use as fertilizer for nearby fields/forage crops.

KEY LEARNINGS

The DVO Phosphorus Recovery system provides a unique ability to produce both low solids/nutrient irrigation water and a stackable nutrient-rich solid.

The DVO Phosphorus Recovery System is a modified DAF system comprising several key components: a polymer mixing and dosing system, a micro-air compression and injection system, a proprietary manure/polymer/air mixing tube for optimal treatment, the DAF vessel itself for separation, rise and skimming of solids, and lastly dewatering moving disc presses for production of a stackable solid under continuous flow conditions. The system is placed at an elevation that allows for gravity feed of manure to an equalization pit, mixing/pumping from the pit to the system, and gravity feed of both produced solids to a concrete pad and treated tea-water liquid to a storage lagoon. The system is placed within a dedicated processing building. Solids are presently trucked daily to a long-term storage building with sales to nearby crop producers with transition fields in need of carbon and nutrient supplementation.

The entire system is automated for continuous operation, only turning off when float valves on the equalization pit determines low flow and temporary stop/restart of operations. Regular operations/maintenance is a daily 20-minute walk-through and completion of monitoring checklist with a morning filling of solid polymer to a feed hopper.

KEY BENEFITS

Production of a low-solids, low nutrient irrigation tea water — The system is effective in removing nearly all suspended solids and a large fraction of total solids, producing an irrigation water more suitable for use in a variety of irrigation systems. Importantly, during lagoon storage, prior to irrigation of fields, there exists reduced need for costly agitation and/or dredging due to the removal of these solids. Removal of solids from the anaerobic lagoon to a more primarily aerobic storage and processing also reduces the greenhouse gas footprint of the dairy, beyond what is already accomplished.

Production of a nice, stackable pile of nutrient-rich solids — The system partitions these solids and associated nutrients to a dewatered, stackable pile. With approximately 90% of phosphorus and 35% of nitrogen and appreciable amounts of secondary and micro-nutrients from the influent within the solids, the solids can be either sold off-farm or more optimally applied to dairy fields as an organic-matter fertilizer.

Savings in both energy and manure management costs — While hard to quantify from a true accounting of farm manure management and application costs, the partitioning as noted above can clearly lead to important savings in both energy and manure management costs. Specifically, reduced energy to mix, dredge, pump and haul liquid manure; greater flexibility in targeting specific fractions and types of nutrients to individual fields/crops; and with potential export off the farm, reduced acreage, haul and/or application costs to meet dairy nutrient management plans.

Potential sales/export of solids and nutrients off-farm — Presently, the dairy has negotiated contracts for the solids whereby neighboring crop producers with transition fields in need of organic matter and nutrients will pick up the solids. This is in-part due to the new product, lack of mature markets and the raw, wet nature of the product. There is potential with either time or down-stream drying/processing to achieve higher sales and revenues. Even without, significant benefit exists for the dairy to remove this nutrient load from their nutrient management plan accounting.

RESULTS

Washington State University (WSU) recently monitored the Edaleen DVO Phosphorus Recovery system for a combination of solids/nutrient partitioning performance, solids product characteristics and project techno-economics (2-week period, morning and afternoon duplicate grab samples mixed into single sample for approximately n =12 samples with replicates for reporting of mean and standard deviations). While the study report is not complete and is finalizing additional data and flow refinements, the following is a summary of the early results.

Key Benefits & Results Summary:

- Production of nearly 6 wet tons of solids per cow per year at 25% total solids
- 62% and 92% reduction of total solids and total suspended solids in liquid wastewater
- 40%, 88%, and 15% N, P, K reduction in liquid wastewater
- Third party purchase/installation capital costs of $219 and $339 per cow, respectively for equipment and total installed system
- Third party O/M costs average of $50-68 per cow per year

NEWTRIENT
INNOVATIVE SOLUTIONS IN RESOURCE RECOVERY

NEWTRIENT
10255 W. Higgins Road
Suite 900
Rosemont, IL 60018
1.866.123.4567
info@newtrientllc.com

www.newtrient.com

Highlights of the following tables are:

- Strong partitioning of key nutrients out of the liquid fraction and into the solids product, notably approximately 62%, 92%, 40%, 88%, and 15% total solids, total suspended solids, total nitrogen, total phosphorus, and potassium. Total liquid fraction reduced in volumetric flow rate by approximately 10%.
- Solids were produced as a relatively dry stackable pile, with a yield of 5.68 tons per cow per year (1.14 dry tons per cow per year), having a density of 1,149 lbs. per cubic yard. Fertilizer value as reported in typical dry units are 4.5%, 3.8%, 0.9% NPK with significant amounts of carbon (39%), calcium (4.1%), and magnesium (1.2%), with no concerns regarding heavy metals. Salts as a measurement of electro-conductivity (EC) were on the moderate end while pathogen as measured by faecal coliform indicators were well below Class A bio-solids standards at a mean of 145 MPN/g DW.
- Economics highlight equipment and total installed costs of $219 and $339, respectively with installed including design, permitting, engineering, groundwork, pads, pumps/mixers, equalization tank, and building. The data collected was performed while dosing polymer at 136.5 parts per million, although the dairy has subsequently lowered the dosing significantly and is seeing no negative effects on performance (WSU data still to be completed). At both the lower and higher ranges of polymer dosing, the estimated operating costs including electrical, chemical, labour and maintenance are $50-68 per cow per year.

TABLE 1. SOLIDS AND NUTRIENT PORTIONING PERFORMANCE

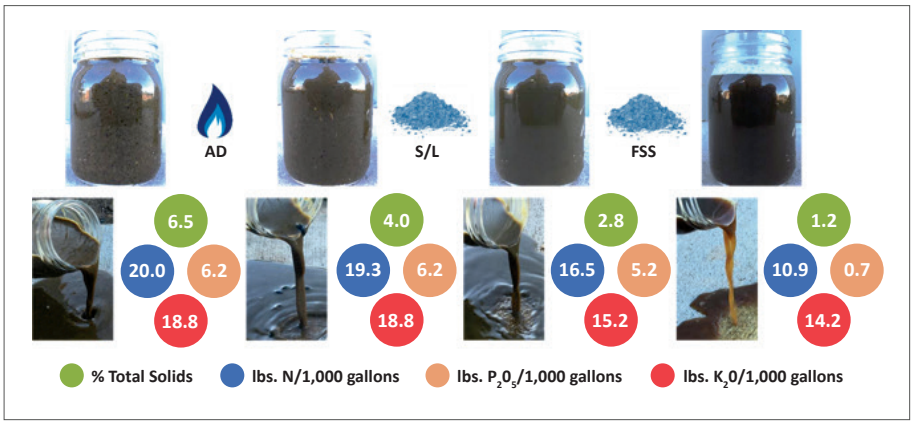
	TS (%)	CA (% of TS)	TSS (g/L)	N (g/L)	P (mg/L)	K (g/L)	Flow Rate (GPM)
Post AD/Sep Liquid	2.82 ± 0.29	71.3 ± 2.7	20.98 ± 3.4	1.98 ± 0.21	270 ± 19	1.51 ± 0.12	46.13
DVO FSS Effluent	1.17 ± 0.26	59.5 ± 8.8	1.85 ± 0.32	1.30 ± 0.25	36 ± 6	1.41 ± 0.09	41.75
Reduction by Conc. (%)	58.5	16.6	91.2	34.3	86.7	6.6	9.5
Reduction by Mass (%)	62.5	16.6	92.0	40.6	87.96	15.5	

TABLE 2. DAF SOLIDS CHARACTERISTICS AND PARAMETERS

	TS (%)	CA (% of TS)	EC (mmhos/cm)	N (% DW)	P (% DW)	K (% DW)	Flow Rate (yd³/day)
DVO FSS Solids	24.4 ± 4.1	79.9 ± 2.9	2.31 ± 0.48	4.5 ± 1.1	3.8 ± 0.8	0.9 ± 0.2	40 ± 7
	C: 39.3 ± 5.1	Ca: 4.1 ± 0.6	Mg: 1.2 ± 0.1	Fe: 0.2 ± 0.04	S: 0.7 ± 0.1	% DW	
	Mo: 0.95	Ni: 0.77	Se: 0.30	As: 0.09	Cd: 0.04	Cr: 0.76	Co: 0.62	Cu: 25.6	Pb: 0.12	Hg: 0.01	Zn: 83.7	ppm

TABLE 3. ECONOMIC SUMMARY

DVO FSS Capital Installed	$607,465	$21.20 per 1,000 gallons throughput	$339 per cow	
DVO FSS O&M	80-140 ppm polymer dosing	40 kWh/h electrical	40 minutes/day labor	3% capital parts
	$89,866-122,189 per year	$3.10-4.30 per 1,000 gallons throughput	$50-68 per cow per year	
DVO FSS Solids	103 lbs. N per cow per year	87 lbs. P_2O_5 per cow per year	21 lbs. K_2O per cow per year	



Pictogram of full-Edaleen system including DVO Phosphorus Recovery System **(a)** liquid samples at various stages of process; **(b)** liquid-poured samples at various stages of process; **(c)** NPK fertilizer values along various stages of process.

Organizations Involved:

Farm or facility
Edaleen Dairy

Electrical Utility
Puget Sound Energy

Engineers
DVO Inc.

Contractor
Regenis

Developers
Edaleen Dairy

NEWTRIENT
10255 W. Higgins Road
Suite 900
Rosemont, IL 60018
1.866.123.4567
info@newtrientllc.com

www.newtrient.com

CONCLUSION

The DVO Phosphorus Recovery System is an integral part of the Edaleen Dairy manure management system, positioned after anaerobic digestion and fibrous solids separation. Produced solids partition a significant fraction of phosphorus and nitrogen into stackable, solid form while producing a low-nutrient, tea-water significantly reduced in suspended solids. While a more-costly unit operation than simple fibrous solids separation, the gains in nutrient partitioning, wastewater volume reduction, and tea-water irrigation water can be of importance to some dairies. Early evaluation shows a constant and steady operation producing a dry, stackable product with quite consistent performance. Further observation will be required to better ascertain long-term maintenance costs as well as development of markets, uses and price points for the solids.

DVO AT EDALEEN DAIRY PROJECT BY THE NUMBERS

Location type	Dairy
Number of animals	Approximately 1,800 wet cow equivalents
Type of bedding	Digested, separated fibrous solids
Manure collection	Alley cable scraper with one maternity barn flush
Daily flow	85,000 gallons per day
System designed by	• DVO Two Stage Mixed Plug-Flow Anaerobic Digester • Dresser-Rand Guascor Engine with Martin Machinery Package • GEA Houle Two stage slope screen manure separator • DVO Phosphorus Recovery system
Date operational	Fall 2017
Energy produced/required	• DVO Anaerobic digester approximately 40-45 KW parasitic load • GEA/Houle Separator approximately 2 KW parasitic load • DVO Phosphorus Recovery system approximately 40 KW parasitic load
Installed energy production capacity	Averaging 544 KW of electrical generation to the grid from the anaerobic digester
Products produced	Electrical Power, Green Tags, Carbon Credits, Tipping Fees, Fibrous Solids Bedding Offset, Fibrous Solids Soil Amendment Ingredient, Fine Solids Soil Amendment
Residual materials	• Digested, separated liquid manure wastewater • Fine Solids Soil Amendment
Residual storage	• Lagoon storage for digested, separated liquid manure wastewater • On-site storage for fibrous solids prior to use/sales • On-site storage for fine solids prior to use/sales
Residual use	• Wastewater residual fate as fertilizer for local fields/forage crops • Fibrous solids recycled internally as bedding and sold as ingredient to retail soil amendment • Fine solids as fertilizer to local fields/forage crops or sold as fertilizer/soil amendment to fields undergoing crop rotation
Electrical utility	Electrical power purchase agreement with Puget Sound Electric
Ownership structure	Family owned dairy

DVO Phosphorus Recovery System Side View.

Daily volume of stackable solids produced by DVO Phosphorus Recovery System.

For more information about DVO Phosphorus Recovery System, or to join our mailing list, email info@newtrientllc.com.

Newtrient's mission is to help all dairy farmers reduce the environmental footprint of manure while enhancing their economic opportunities and their social license to operate. The information contained in this case study was developed with the cooperation of the organizations involved and Newtrient has endeavoured to make sure it is accurate and complete as possible.

Equipment and Technology:

Manure collection
GEA/Houle Alley Scrapers, GEA/Houle mixers/pumps

Primary treatment
DVO Two-Stage Mixed Plug-Flow Mesophilic Anaerobic Digester

Secondary treatment
GEA/Houle Two-Stage Slope Screen Solids Separator

Tertiary treatment
DVO Phosphorus Recovery Modified Dissolved Air Flotation (DAF) System

Energy systems
Dresser-Rand Guascor SFGLD 560 engine/generator set, heat recovery and interconnect packaged by Martin Energy Group

Other
Regenis construction, installation and operation/ maintenance

NEWTRIENT
INNOVATIVE SOLUTIONS IN RESOURCE RECOVERY

NEWTRIENT
10255 W. Higgins Road
Suite 900
Rosemont, IL 60018
1.866.123.4567
info@newtrientllc.com

www.newtrient.com