Exhibit SAD1-7

Memorandum

To: Salisbury AD 1 Project File

From: Lydia Lee, PG

Date: September 28, 2018

Project #: 58073.00

Re: Section 248 Water Pollution Criteria Assessment

INTRODUCTION

Salisbury AD 1, LLC ("Salisbury AD 1") proposes to construct and operate an anaerobic digester ("AD") project at the Goodrich Farm in Salisbury, VT. The project received a Section 248 Certificate of Public Good ("CPG") from the Vermont Public Utility Commission ("PUC" or "Commission") on April 8, 2016 ("the As-Approved Project").[1] Lincoln RNG is no longer pursuing development of the project, and will transfer the CPG to Salisbury AD 1, subject to the Commission's prior approval. Salisbury AD 1 has revised the As-Approved Project's design in various respects ("the Proposed Modifications"). VHB has been retained to review the environmental impact of the Proposed Modifications, and, more generally, of the final project design ("the Final Project"). The purpose of this memorandum is to assess whether the Proposed Modifications conform with the As-Approved Project's CPG with regard to Act 250 Criterion 1: Water Pollution (10 V.S.A. (§ 6086(a)(1)). Criterion 1 requires that a project will not result in undue water or air pollution. Subcriteria, such as 1(A)(Headwaters) and 1(G)(Wetlands)), identify specific aspects of water pollution for which Act 250 requires compliance, and these subcriteria are evaluated for the Final Project elsewhere (refer to the Natural Resources Memorandum, Exh. SAD1-6 to this Motion to Amend CPG). Criterion 1 also serves as a "catch all" for any other water pollution concerns.

While the Final Project design will incorporate a larger volume of food waste, both the As-Approved Project and Final Project operations comply with Criterion 1 through the appropriate management of nutrients in accordance with a Nutrient Management Plan ("NMP") and Large Farm Operating ("LFO") permit, so as to prevent undue water pollution from excess nutrient loading. This memorandum provides an evaluation of the proposed operations of the final design, with respect to nutrient management of the digestate (i.e. the output of the AD) and the mechanisms in place to ensure the Final Project's conformance with this Criterion, and to demonstrate that the design of the Final Project is not materially different than the As-Approved Project.

PROJECT DESCRIPTION AND PROCESS

The As-Approved Project planned to use manure from the Goodrich Farm, corn silage, and some food waste as raw material ("feedstock") for an AD that would generate methane gas ("green gas"). The Final Project will now use approximately the same volume of manure, in addition to a larger volume of pre-processed food waste, as feedstock to increase and optimize the green gas output of the digester. Salisbury AD 1 estimates that approximately 30,000 tons per year of manure[2] and approximately 65,000 tons per year of pre-processed food waste (including high strength wastes) would be utilized as feedstock by the proposed Project. Gas generated with this feedstock recipe will produce approximately 172,100 MCF/yr[3] of green gas at full capacity. As the Commission already approved, the green gas will

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[1] *See* Docket #8596.

[2] Separated manure. The farm currently generates approximately 36,100 tons of raw manure per year.

[3] Production could be higher or lower depending on feedstock. Compared to an approximate gross production of 130,000 MCF/yr proposed by the As-Approved Project.

40 IDX Drive, Building 100

Suite 200

South Burlington, Vermont 05403

be supplied to the existing Vermont Gas Systems ("VGS") Middlebury Distribution network. The anaerobic digestion process, along with the integration of advanced nutrient recovery technology, produces solid and liquid digestate with nutrient concentrations that can be optimized to meet the needs of the Goodrich farm's cropland. The solid products will allow new approaches to nutrient management by capturing nutrients from the digestate in solid form, while producing a liquid fertilizer with a reduced concentration (compared to untreated manure) of the nutrients that could contribute to water pollution.

For the Final Project, manure going into the digester will originate from dairy cows, and the general process will be similar to the As-Approved Project, although the Final Project design is further along in planning, allowing for the provision of more details. The Final Project design is based on the current herd size of the Goodrich Farm, which consists of 900 mature milking cows and their replacement herd (approximately 600 youngstock or heifers[4]) (per Chase Goodrich, host farmer). Currently, the farm separates raw manure into a liquid and solid phase with a screw press. The solids are, and will continue to be, used as green bedding in the barns. The bedding will be continually recycled through the screw press process, and therefore it is assumed that all the nutrients from the raw manure will eventually end up in the liquids and go through the digester.[5] The liquid will be collected in a 26,500-gallon covered manure storage tank,[6] which will be piped directly to the digester. Therefore, no precipitation or stormwater will be processed in the digester. In contrast, the As-Approved Project would have piped the separated liquid from the existing lagoons to the digester, and therefore would have included some precipitation and stormwater in the AD feedstock.

An increased amount of regionally sourced food waste will be incorporated into the Final Project's digestion process to optimize methane output and the health of the digester. Typical food residuals ("Source Separated Organics") could include organic waste from commercial/restaurant kitchens, grocery stores, food shops, supermarkets, schools, hospitals and other institutions as well as dairy processing waste, brewery waste and fats, oils and grease ("FOG"), and solid residuals from food processing facilities. The food waste will be processed at a facility not owned by Salisbury AD1 LLC and located off-site. SSO, FOG, and solid residuals will be accepted into a hydrolyzer for hydrolysis and homogenization. The As-Approved Project conceptualized that up to two-percent of the feedstock would be SSO.

Salisbury AD1 retained CH Four Biogas, LLC ("CH Four"), who is the technology provider/designer of the AD for the final design, to estimate the mass flow of feedstock coming into the digester, energy production, and digestate coming out of the digester. A mass flow diagram, provided as Attachment 1 to this memorandum, represents the digestion process, which is similar in nature to most AD projects, including the As-Approved Project. In summary, liquid manure and hydrolyzed feedstock will be homogenized in the digestion tank, where microbes will break down the mixture in an anaerobic environment, resulting in the production of biogas (methane, carbon dioxide, hydrogen gas, and water vapor) that will be upgraded to pipeline quality natural gas on site. The effluent from the digestion tank ("digestate") will be pumped to a nutrient recovery system which consists of a dissolved air flotation ("DAF") tank where the digestate is treated with a polymer, or similar system that will remove suspended matter[7], so that smaller solids float to the surface

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[4] Calves are housed in a separate barn, and the associated manure may be excluded from the digester. We have included nutrients from the replacement herd in the mass balance as they would need to be factored into the NMP.
[5] The volume of the liquid entering the digester assumes removal of the bedding volume, but the nutrient content is assumed to be processed through the digester.
[6] Separated manure tank volume can hold approximately 1.5 days' worth of separated manure.
[7] Not all vendors use DAF to remove of suspended matter. Salisbury AD1 may consider other systems that separate materials to achieve P extraction to meet the P needs of the crops in accordance with the farm's NMP.

and are skimmed from the tank. As discussed further in the next section, treatment of the feedstock with DAF technology (or similar system) is proposed so that nutrients in excess of what is needed by the Goodrich Farm's crops can be extracted from the liquid into a solid form. Excess solids, or "nutrient cake" would be used on fields with higher nutrient needs than what is in the liquid fertilizer, based on the most recent Goodrich Farm NMP, or exported off-site for use of fertilizer elsewhere.

NUTRIENT MASS BALANCE THROUGH THE DIGESTION PROCESS

This section summarizes the nutrient mass balance that CH Four completed for the Final Project design based on the proposed feedstock mixture, digestion process, energy production, nutrient recovery technology, and current needs of the crops, as detailed in the *Nutrient Loading and Distribution Anaerobic Digester System Report* (Attachment 2). Table 1 below summarizes the estimated mass balance of feedstock volume and nutrients through the digestion process, which as described in CH Four's report, is based on approximate industry typical values and values provided in the Goodrich Farm's NMP (2017) and LFO Permit. As pointed out in Section 3.0 of CH Four's Report and as proposed in the original As-Approved Project filing, project-specific testing of feedstock materials and digestate will need to be incorporated into nutrient management planning, and the annual mass balance refined based on the inputs and outputs of the digester, soil testing results, and crop needs. A general testing schedule is described in the following section of this memorandum as requested during a meeting with the Agency of Natural Resources ("ANR") and Agency of Agriculture, Food and Markets ("AAFM") held on August 28, 2018.

According to the Goodrich Farm's NMP and LFO Permit, the importation of mineral fertilizer is currently required to meet the recommended nitrogen, phosphorus, and potassium applications based on the nutrient content in the manure, soil nutrient content, and crop acreage, vegetative uptakes, and yield (see the Manure nutrient value versus the crop needs value in Table 1 below). Also, as presented in Table 1, the incorporation of off-site feedstock into the digester will result in a nutrient change in the digestate that will allow the farm to meet the phosphorus and potassium requirements of the crops; however, based on CH Four's analysis, the importation of chemical nitrogen may be required if the digestate is applied based on phosphorus requirements (an approximate deficit of 60 tons/year for Nitrogen).

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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 = nitrogen
[1] Refer to the attached CH Four Report 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 agronomist). The Nutrient balance represents the balance of Available N.

As presented in Table 1 above, the estimated mass balance suggests that there will be an excess of approximately 30 tons of phosphorus in the digestate. The Final Project will therefore incorporate the use of a DAF and polymer (or similar system), where smaller solids float to the surface and are skimmed from the tank. This process provides the ability to sequester a range of P from the liquid that will be supplied to the farmer. Nutrient recovery though the DAF (or similar system) will be optimized so that the liquid digestate will meet crop requirements and applied in accordance with the NMP. In general, nutrient extraction with the DAF (or similar system) would be completed based on the nutrient needs of fields with lower P requirements (i.e. medium or high P index). The sequestered nutrients will be in a dry, solid form that can be used in areas that have a higher P need, or will be exported from the farm. Alternatively, as CH Four's report suggests, approximately 6 million gallons of liquid digestate could be exported from the farm, but the Final Project's design is intended to optimize the use of the DAF (or similar) system rather than export liquid digestate.

TESTING REGIME

Salisbury AD1, CH Four, and the Goodrich family and their agronomist will work collaboratively to optimize energy production and nutrient management so that no undue water pollution will result from excess nutrients associated with the Final Project. To do so, a nutrient testing regime will be in place that will consist of periodic testing of the digester inputs and outputs, as well as continued testing of fields in accordance with the NMP and Required Agricultural Practices ("RAPs").

As requested by ANR in discussions regarding the Final Project design, Table 2 below presents a conceptual nutrient testing regime for the initial operation of the AD, which may need to be adjusted based on feedstock sources and the performance of the digestion process. It must be understood that there will be a period of optimization until the system is fully functional and feedstock sources are secured. During this optimization period, more testing may be completed than would be for the duration of the Final Project.

Table 2: Initial Nutrient Testing Regime

	Sample Location	**Parameters to be sampled**	**Estimated Sampling Frequency**
Inputs			
Separated Manure	From Manure Storage tank (after screw press, prior to digester)	N, P, K	Up to once monthly for the first six months of operation, annually thereafter in accordance with the NMP
Feedstock	By each provider prior to acceptance	N, P, K	Annually
Outputs			
Liquid Digestate	Prior to DAF or similar system	N, P, K	Weekly, or per Vendor recommended schedule
Liquid Digestate (from DAF/similar system)	Storage tank/lagoons	N, P, K	Weekly initially or when polymer is adjusted to confirm nutrient extraction After mixing, prior to each land application period
Solid Digestate (from DAF/similar system)	Dry storage	N, P, K	Volume/tonnage based, as recommended by vendor

STORAGE

According to CH Four's Report, approximately 19.7 Mgal of liquid digestate will be produced on annual basis. This volume does not account for the solid removal from the DAF or similar nutrient removal technology. With the assumption that an approximate 32% P sequestration will be needed, the total annual liquid digestate volume would be approximately 17.9 Mgal, which represents the upper end of expected digestate volume. This equates to the need for approximately 8.8 Mgal of storage for a 180-day period when the farm cannot spread manure. The Final Project design includes the construction of a 5.3 Mgal storage tank (with a nominal volume of 5.5 Mgal). Existing on-farm storage includes approximately 3.2 Mgal in the North Lagoon and the South Lagoons, and approximately 3.9 Mgal of storage in off-site lagoons located elsewhere on the farm. The existing lagoons and proposed new slurry tank therefore provide sufficient storage volume for 180 days of liquid digestate storage, based on the highest estimated flows through the system (refer to Attachment 3, Lagoon Storage Schematic). The farmer will likely transfer (by truck) digestate from the on-site storage areas to off-site lagoons for spreading on fields in closer proximity to those lagoons.

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The existing lagoons are permitted in the Goodrich Farm LFO Permit. The new slurry tank will be constructed in accordance with engineering practices in an upland location as shown on the Site Plan (Exh. SAD1-3 to this Motion to Amend CPG), so as not to result in undue water pollution.

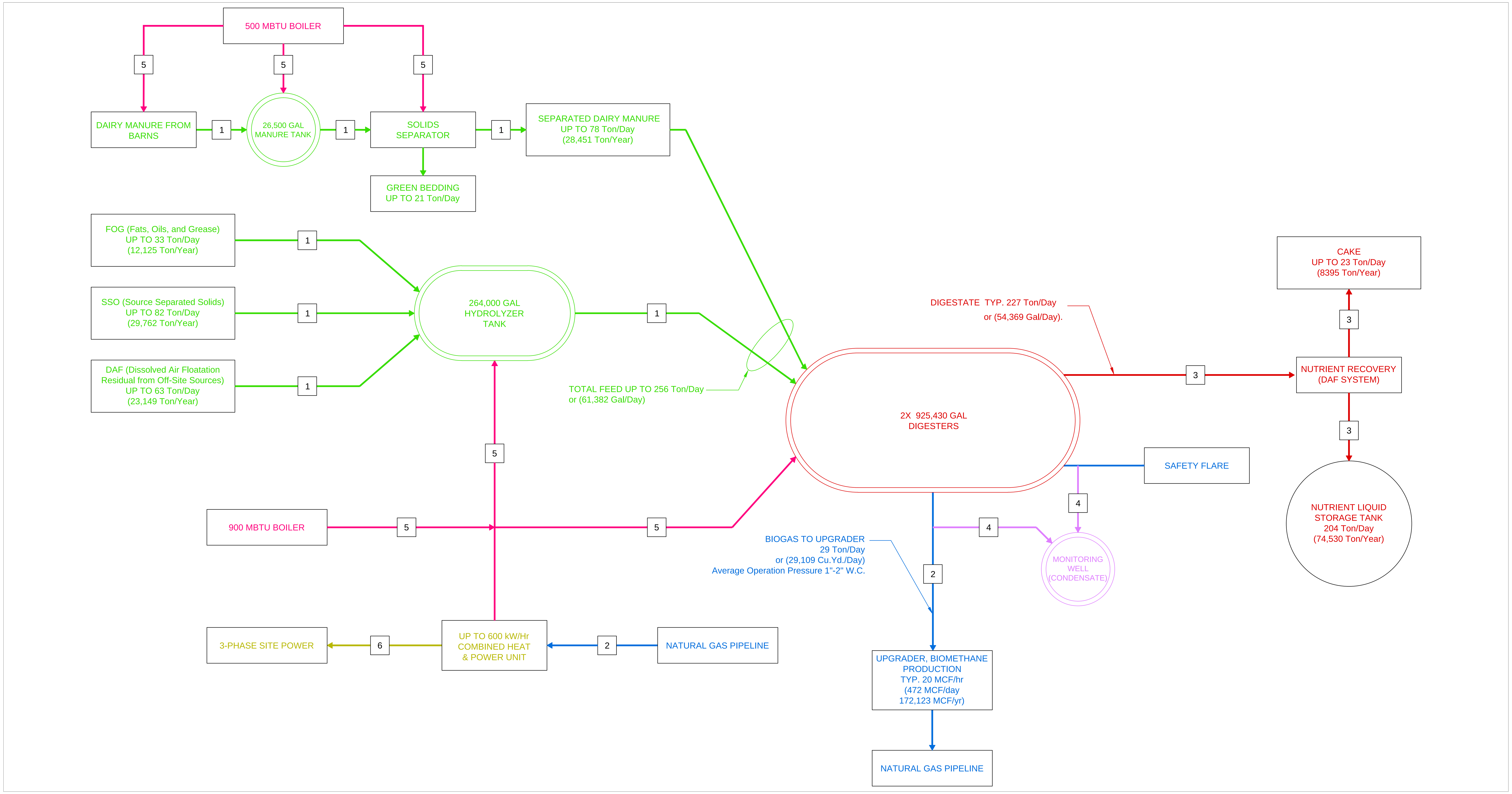
CONCLUSIONS

As presented herein, the Final Project design will not result in undue water pollution due to runoff of excess nutrients from the cropland since nutrients will be managed in accordance with the Goodrich Farm NMP, which will be prepared by a certified agronomist and in accordance with the farm's Large Farm Operating Permit. Salisbury AD1 is proposing the use of a DAF or (similar system) to sequester phosphorus from the liquid manure for spreading on the fields, while the solid "cake" can be used to amend fields that require more nutrients per the NMP, or exported off-site. Additional liquid digestate storage in the form of a 5.3 Mgal tank will be provided by the Final Project to meet the nutrient storage requirements of the NMP. Available storage capacity will also include the use of existing on-farm lagoons. Use of the existing lagoons and potential additional storage is consistent with the As-Approved Project, with the amount of additional storage to be determined based on the resulting digestate production.

We also conclude that the Final Project is not materially different than As-Approved Project. The As-Approved Project intended to use mostly manure and corn silage, although it also planned to incorporate SSO over time. Digestate from the As-Approved Project would have also needed to be tested and managed in accordance with a NMP. The addition of nutrient extraction (such as DAF) technology to the Final Project will provide greater flexibility with the final nutrient content of the digestate. This provides value to the farmer, who currently imports mineral/chemical fertilizer to meet the nutrient needs of the crops. The Final Project design allows for the conversion of organic waste (SSO) to a liquid fertilizer that can be used to supplement the farm's nutrient needs. With the use of a DAF (or similar system) technology and collaboration between the project owner, farmers, and the farmers' agronomist, nutrients will be land applied as necessary in accordance with an NMP, as is currently done, and as was part of the approved As-Approved Project.

ATTACHMENTS:

1. Mass Flow Diagram, CH Four, September 27, 2018
2. Nutrient Loading and Distribution Anaerobic Digester System, Salisbury VT. Report by CH Four, October 2018.
3. Lagoon Storage Schematic, VHB September 2018



SALISBURY AD - 900 Dairy					
180,000 MCF Biomethane Summary (mid solids)					
Inputs					
	solids %	tpy	tpd	gpd	cu.yd/d
Separated Manure	2.5	28,451	78	18,681	
FOG	6	12,125	33	7,961	
SSO	16	29,762	82	19,541	
DAF	6	23,149	63	15,199	
Total		**93,488**	**256**	**61,382**	
Co-Products					
	solids %	tpy	tpd	gpd	cu.yd/d
Green Bedding	35	7,759	21		
Biogas		10,681	29		29,109
Liquid Digestate		82,807	227	54,369	
Cake		8,395	23		
Nutrient Liquid Effluent		74,530	204	48,934	

Biomethane production					
	MCF/yr	MCF/d	MCF/hr		
	172,123	472	20		
Reject to Atmosphere					
	MCF/yr	MCF/d	MCF/hr		
	114,749	314	13		

LEGEND

1. FEEDSTOCK
2. BIOGAS
3. DIGESTATE
4. CONDENSATE
5. HEAT
6. POWER

NO.	DATE (DD/MM/YYYY)	REVISION	DRAWN
01	27-09-2018	DESIGN REVISION	D.L.

PROJECT:
SALISBURY AD 1
Goodrich Farm
655 Shard Villa Rd.
SALISBURY, VT 05769

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DRAWING TITLE: MASS FLOW PRELIMINARY DESIGN

DESIGNED BY: D.L. | CHECKED BY: J.K.B. | DRAWN BY: D.L.
JOB NUMBER: 17C08 | SCALE: AS SHOWN | DATE: 27-Sep-2018

DRAWING NUMBER: G2

Nutrient Loading and Distribution
Anaerobic Digester System

Salisbury, Vermont

WESTERN OFFICE
1685 H Street, #25590
Blaine, WA 98230
T: 800-823-6844

CH Four Biogas, Inc.
info@chfourbiogas.com
www.chfourbiogas.com

EASTERN OFFICE
37 Walnut Street, Suite 300
Wellesley, MA 02481
T: 800-823-6844

EXECUTIVE SUMMARY

This study presents a possible feedstock scenario and accompanying nutrient loading for an anaerobic digester facility at Goodrich Farm in Salisbury, Vermont. The scenario detailed in this study uses a combination of literature, farm and laboratory data for similar feedstocks to determine an expected nutrient loading at the facility.

A total of approximately 93,500 tons (approximately 22.4 million gallons) of material is fed to the digester to produce biogas and digestate. The feedstocks that are considered are the liquid fraction of separated dairy manure and off-farm feedstocks such as fats, oils and grease (FOG), source separated organics (SSO), and dissolved air flotation (DAF) material. The farm currently generates green bedding from the manure and wishes to continue this practice, as such only separated liquid manure is fed to the anaerobic digester (assuming 2.5% total solids content).

Biogas is used to generate renewable natural gas (RNG) and digestate is used as organic fertilizer either on the 2,358 acres (leased and owned) of land available to the Goodrich Farm.

The nutrient loading information in this document provides a guideline for an Agronomist to use in developing a Nutrient Management Plan with Goodrich Farm for the anaerobic digester system. This report assumes the composition and nutrient content of both the manure and off-farm feedstocks; these assumptions must be checked with site-specific data.

Approximately 83,000 tons (19.7 million gallons) of liquid digestate are produced on an annual basis at the digester facility prior to any nutrient extraction. The processes of anaerobic digestion will alter the major nutrients, nitrogen-phosphorous-potassium (NPK), in the liquid digestate as compared to raw manure; the unique characteristics of liquid digestate for crop uptake are compared to those of raw manure in this report.

The table below provides the estimated current manure nutrients in the separated liquid manure (after green bedding generation) to those in the digestate produced in the anaerobic digester.

	Volume	N		P_2O_5		K_2O	
	tons/yr [million gal/yr]	ton/yr	conc (%)	ton/yr	conc (%)	ton/yr	conc (%)
Separated Liquid Manure (2.5% TS)	28,451 [6.8]	130.1	0.46	37.7	0.13	97.8	0.34
Digestate (3.6% TS)	82,807 [19.7]	272.3	0.33	88.0	0.11	139.8	0.17

A preliminary nitrogen balance indicates that all of the liquid digestate could be suitable for land application at the farm but the Farm's *2018 Large Farm Operation Permit Amendment* indicates that to meet the crop's phosphorus requirements, approximately 28 tons P_2O_5 should be removed from the digestate prior to land application; this could be accomplished by removing approximately 6.3 million gallons of digestate from the farm or recovering approximately 32% of the P_2O_5 through a nutrient recovery technique.

Table of Contents

1.0 Introduction

This document details the nutrients produced from the anaerobic digestion process proposed at Goodrich Farm in Salisbury, Vermont. The proposed project includes the generation of renewable natural gas, bedding for the farm ("green" bedding from raw manure prior to anaerobic digestion) and digestate for land application. Details are provided as to the distribution of these nutrients throughout the process.

Information is provided regarding the impact of the digestion process on the nutrients in terms of their availability for crop uptake. The characteristics of digested manure are different from those of raw manure, particularly with regard to nitrogen. These characteristics need to be considered by the Agrologist when preparing the nutrient management plan for the Farm with the anaerobic digester.

2.0 Nutrients from Anaerobic Digester

The anaerobic digester in Salisbury, Vermont, will process dairy manure and off-farm organics. The feedstock scenario used in this report is described in Table 1 below. This feedstock recipe will produce approximately 172,100 MCF /year renewable natural gas.

Substrate	**Solids %**	**TPY**
Separated Manure	2.5	28,451
FOG	6	12,125
SSO	16	29,762
DAF	6	23,149
Total		**93,488**

Table 1: Feedstock Recipe (based on solids content)

.2.1 Dairy Manure

The Salisbury anaerobic digester will process manure from approximately 900 dairy cows (and replacement herd) which generate a total of approximately 36,135 tons (approximately 8.6 million gallons) of manure per year. Prior to processing within the anaerobic digester, the raw manure will be separated into a liquid and solid phase using the farm's existing screw press. The solid fraction will be used as green bedding in the barns and the liquid fraction will be processed in the anaerobic digester. It is anticipated that approximately 28,451 tons per year of separated manure (2.5% total solids) will be processed through the anaerobic digester.

To determine the nutrients (Total Nitrogen-Phosphorous as P_2O_5-Potasium as K_2O or NPK) contribution from manure, the following data was used:

- Nitrogen data from the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) "Soil Fertility and Nutrient Use: Manure Management" for dairy manure was used for dairy manure in the range of 6-8% total solids manure, 0.36% total nitrogen (0.36% total nitrogen equates to 0.0036 tons N/ton manure) (Available online September 5, 2018: http://www.omafra.gov.on.ca/english/crops/facts/13-043.htm)

  The calculation for nitrogen is as follows:
  N [tons N/yr] = 36,135 tons manure/year x 0.0036 tons N/ton manure
  = 130.1 tons N/yr

- The phosphorous (as P_2O_5) and potassium (as K_2O) data is taken from Goodrich Farm's 2018 *Large Farm Operation (LFO) Permit Amendment, Table "Land Base Nutrient Balance Overview*".
  - Note that nitrogen is not used from this table as the value in the table does not include all available nitrogen and the availability of nitrogen for crop uptake is different in raw manure than digestate.
  - Note that the P_2O_5 and K_2O values in this table are for a herd size of 1025 cows but it is expected that manure from 900 cows will be used in the anaerobic digester, so these values are corrected to reflected the reduced number of cows.
- As all of the green bedding is recycled to the barn, we assume that all of the nutrients from the raw manure will eventually end up in the anaerobic digester.
- It should be noted that liquid manure that will be used in this project should be tested for NPK as it is unclear that these results are the most accurate given that the data in the LFO document includes other wash water from the farm and the nitrogen value was taken from literature.

Substrate	Volume ton/yr	N %	P %	K %	N ton/yr	P_2O_5 ton/yr	K_2O ton/yr
Raw Manure	36,135	0.36	0.10 (Calculated)	0.27 (Calculated)	130.1	37.7	97.8
Separated Liquid Manure (2.5% TS)	28,451	0.46 (Calculated)	0.13 (Calculated)	0.34 (Calculated)	130.1	37.7	97.8

Table 2: Manure NPK (ton/yr)

Note: For comparison purposes, the *Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) "Soil Fertility and Nutrient Use: Manure Management" table* that was used to estimate the nitrogen content of the raw manure was used to calculate phosphorous and potassium content, this table estimates 58 tons P_2O_5 and 104.5 tons K_2O. The estimates from OMAFRA are higher than the estimates in the LFO. It is assumed that the LFO estimates are more accurate as they are site-specific/Vermont estimates.

.2.2 Off-Farm Organics

The anaerobic digester uses off-farm organic feedstocks to augment biogas production; which introduces additional nutrients to the digester.

Table 3 below provides the typical compositions of FOG, DAF and SSO from an operation in Ontario and the NPK contribution at the Salisbury AD. During the planning stage for an AD project it is important to have an estimate of the nutrient contribution from the various feedstocks but it must be considered that these are subject to change based on actual feedstocks used. A laboratory analysis of typical material is attached; it provides an example of typical NPK imports (percentage N, P, K are a percent of the total solids). This analysis is a starting point for Salisbury; feedstocks will change over the life of the project and site specific testing must be done.

An example calculation is as follows:
N [tons N/yr] = (35,274 tons FOG-DAF/yr) x (0.06) x (0.0185) = 39.2 tons N/yr
Note: The nutrients are reported as a percentage of the total solids.

Substrate	Volume ton/yr	Total Solids %	N %	P %	K %	N ton/yr	P_2O_5 ton/yr	K_2O ton/yr
FOG/DAF	35,274	6	1.85	0.35	0.3	39.2	7.4	6.3
SSO	29,762	16	2.8	0.9	0.75	133.3	42.9	35.7
Total	**65,036**					**172.5**	**50.3**	**42.1**

Table 3: FOG/DAF and SSO N-P-K Contribution

.2.3 Total Nutrients Entering Anaerobic Digester

Table 4 below summarizes the annual tonnage and NPK entering the digester. It also indicates the contribution of these nutrients that come from the use of manure. This demonstrates the increase in nutrients brought onto the farm from off-farm feedstocks. The nutrients available for land application are discussed later in this report.

Nutrient	Entering Digester	Contribution from Manure	
	ton/yr	ton/yr	%
Volume	93,488	28,451	30%
N	302.6	130.1	43%
P_2O_5	88.0	37.7	43%
K_2O	139.8	97.8	70%

Table 4: Total Nutrients Entering Anaerobic Digester

Note: In the Farms LFO Permit Amendment, it is indicated that only 28.7 tons of Nitrogen from manure is available for crop use. A total nitrogen value is not provided so a literature value is used in place of the Farm specific data. This is done to provide the Agronomist with a full picture of the existing nitrogen.

.2.4 Nutrient and Volume Distribution from AD Process

The anaerobic digester system at Salisbury will impact both the quantity and distribution of nutrients for land application compared to raw manure.

Nutrients are distributed in the following ways:

- During processing and material handling, approximately 10% of the nitrogen that enters the digester will be lost to the atmosphere. Post-anaerobic digestion loss of volatile ammonia during handling, storage and transfer phases may be as much as 25% of the original ammonia content (dependent mostly on the land application technique that is used), but a conservative 10% is used here as "nitrogen lost to material handling".

- The anaerobic digestion process reduces the overall volume of material that enters the digester through the formation of biogas.

- Nutrients from manure are transferred to the bedding prior to the anaerobic digester. Since all of the bedding will be used in the barn, it is assumed that all of nutrients in the raw manure will eventually enter the anaerobic digester and therefore nutrient loss from this process is not considered.

Table 5 below shows the distribution of material and nutrients throughout the anaerobic digester process. The final column of Table 5 shows NPK that is available for land application in the digestate.

Nutrient	Entering Digester	Creation of Biogas	Material Handling	Digestate	
	ton/yr	ton/yr	ton/yr	ton/yr	**gal/yr** *lb/1000gal*
Volume	93,488	10,681		82,807	**19,708,083**
N	302.6		30.3	272.3	*27.6*
P_2O_5	88.0			88.0	*8.9*
K_2O	139.8			139.8	*14.2*

Table 5: Nutrient Distribution in Digestate

From Table 4 and 5, note that the volume of material for land application increases from approximately 28,400 tons of raw liquid manure per year (approximately 6.8 million gallons) to 82,800 tons (approximately 19.7 million gallons) of digestate per year prior to nutrient recovery.

There is a change in nutrients for land application. The change in nutrient tonnage and concentration for NPK are as follows (also summarized in the Executive Summary of this Report):

- Raw separated liquid manure contributes 130.1 tons nitrogen/year, after processing all the feedstocks through the anaerobic digester 272.3 tons of nitrogen/year will be in the liquid digestate for land application. Raw separated manure has a concentration of approximately 0.46% N and digestate has a concentration of approximately 0.33% N.

- Raw separated manure contributes 37.7 tons P_2O_5/year, after processing all the feedstocks through the anaerobic digester 88.0 tons P_2O_5/year will be in the liquid digestate for land application. Raw separated manure has a concentration of approximately 0.13% P_2O_5 whereas liquid digestate has a concentration of approximately 0.11% P_2O_5.

- Raw separated manure contributes 97.8 tons K_2O/year, after processing all the feedstocks through the anaerobic digester 139.8 tons K_2O/year will be in liquid digestate for land application. Raw separated manure has a concentration of approximately 0.34% K_2O whereas liquid digestate has a concentration of approximately 0.17% K_2O.

See Section 4 on Land Application of Digestate details the anticipated impact of these changes for the farm.

3.0 Anaerobic Digestion and Nutrient Management Planning

.3.1 Considerations for Nutrient Management Plan

The following should be considered when nutrient management planning for the anaerobic digester on the Farm.

1. Existing amount of nutrients on the farm including
    a. Nutrients (N,P,K), in separated manure (site-specific test results)
    b. Nutrients in the off-farm feedstocks (feedstock-specific test results)
    c. Nutrients from imported chemical fertilizer
    d. Release of nitrogen from the soil reserves
2. Estimate the amount of organic nitrogen immobilized in the soil and ammonia losses to the atmosphere
3. Estimates of anaerobic digestions impact on nutrients
4. Nutrients requirements of crops using liquid digestate
5. Current nutrient surplus or deficit (existing data indicates medium to high phosphorous levels on most fields)
6. Volume of digestate and or/acres required to balance nitrogen and phosphorous
7. Resulting nutrient surplus or deficit

.3.2 Nitrogen Availability

The digestion process converts organic nitrogen into a mineralized form (ammonia and nitrate nitrogen) that can be taken up more quickly by plants than organic nitrogen. Research from Denmark indicates that total nitrogen utilization by plants improves from about 40% with raw manure to about 60% with digested manure.

Nitrogen in typical dairy slurry manure is normally 50% organic nitrogen and 50% ammonium nitrogen. European research indicates that nitrogen in a typical anaerobic digestate is 1/3 organic nitrogen and 2/3 ammonium nitrogen. This relationship is influenced by the type of feedstocks entering the digester.

These factors could be determined by on-site testing once the anaerobic digester is operation at Salisbury but these guidelines should be considered when developing the Nutrient Management Plan for Goodrich Farm.

4.0 Land Application of Digestate

Nutrient application rates, type of crop and residual soil nutrients will affect the amount of land that is required to safely land apply the nutrients that are generated at Salisbury AD. Nutrient application rates will be determined with on-site testing from the digester but the following provides some guidelines.

The values used in this report are typical values, but are not guaranteed to be the nutrient values for the specific materials used at Salisbury; nutrient loading will change with time, crop, in-coming nutrients and will be field specific. The off-farm materials being accepted are waste materials from other processes and the nutrient loading may change slightly from batch to batch. Due to these uncertainties, the material should be tested prior to being accepted onto the farm and digestate must be tested prior to land application.

The combination of the volume and concentration of nutrients in the remaining liquid digestate determine the land application rate, this is demonstrated below in Table 6.

Nutrient	Nutrient Distribution in Digestate		
	ton/yr	lb/ton	lb/1000 gal
Volume	82,807		
N	272.3	6.6	27.64
P_2O_5	88.0	2.1	8.93
K_2O	139.8	3.4	14.19

Table 6: Nutrient Application Rate from Liquid Digestate

.4.1 Digestate Application - Nitrogen Balance

Digestate application rates can be based on balancing for nitrogen or phosphorous. In the area of the farm, phosphorous overloading is a concern so ultimately a phosphorous balance will be most important (see Section 4.2). Actual material production and on-farm usage will be based on the requirements of the host-farm fields, which will dictate the level of phosphorous recovery and the quantity that needs to be exported.

Anaerobic Digester digestate research from Denmark indicates that only approximately 60% of the nitrogen content is actually available for crop production because of losses of available nitrogen through leaching, and due to mineralization and ammonia retention factors (compared to 40% for raw manure). Therefore about 3.95 lbN/ton digestate would be available for crop uptake.

NPK requirements varies between crops and is strongly influenced by several factors including crop yields, crop protein levels, the base fertility of crop land, and climatic conditions.

Goodrich Farm has 2358 acres of land available for cultivation. Information provided to us estimates 1638 acres of land currently grow grass and 720 acres of land currently grow corn. Based on this information, the table below indicates that all of the digestate produced on the farm could be land applied to balance for nitrogen.

NITROGEN BALANCE							
Crop	Yield	Protein Content	N uptake	Digestate Req	Current Land Crop	Digestate Req'd	Surplus [+/-]
	ton/acre	%	lb N/acre	tons /acre	acres	tons	tons
Grass	4	18	200	50.68	1,638	83,014	-22,101
Corn	5	9	120	30.41	720	21,894	

Table 7: Nitrogen Balance

The balance above indicates that based solely on nitrogen, there could still be a need to import chemical nitrogen onto the farm to meet the nitrogen requirements of the crops.

.4.2 Phosphorous Balance

Given the phosphorous overloading within the local watershed, a phosphorous balance is carried out to determine how the addition of an anaerobic digester at the farm will impact phosphorous loading at the Farm.

The *LFO Permit Amendment* document indicates that the phosphorous crop requirement is 119,489 pounds or 59.7 tons of P_2O_5 per year. It is estimated that the use of off-farm feedstock at the digester facility will result in a total of 88.0 tons of P_2O_5 being available for land application. As such approximately 28.2 tons of P_2O_5 per year will need to be removed from the digestate prior to land application in order to meet crop requirements and avoid overloading of P_2O_5 in the soil. This equates to a 32% phosphorous reduction requirement.

5.0 Nutrient Recovery (Phosphorous)

Based on the Farm's *2018 Large Farm Operation Permit Amendment* phosphorus crop requirements, approximately 28.2 tons of P_2O_5 should be removed from the farm; this could be accomplished by either removing approximately 6.3 million gallons of digestate from the farm or recovering approximately 32% of the P_2O_5 through a nutrient recovery technique.

A multitude of possible nutrient recovery techniques could be implemented to treat the digestate for phosphorous reduction. Based on the results of this initial analysis, the use a dissolved air flotation (DAF) system using a polymer application could achieve the required reduction in phosphorous. It should be noted that this would also result in nitrogen recovery from the liquid digestate. The resulting nutrient rich phase could be used on or off-farm where additional nutrients are required.

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EXISTING OFF-SITE LAGOONS:

BERTHIAUME PIT	*VOL. = 1.7 Mgal*
DESAUTEL PIT	*VOL. = 1.5 Mgal*
QUESNEL PIT	*VOL. = 0.7 Mgal*
TOTAL STORAGE	*VOL. = 3.9 Mgal*

Proposed Digestate Storage Volume Summary		
Storage Needed		
Estimated Digestate Production	8.8	Mgal
Parlor Wastewater	0.5	Mgal
Precipitation, Runoff, and Evaporation	2.0	Mgal
Precipitation into Digestate Tank	0.3	Mgal
Total Storage Needed:	**11.6**	**Mgal**
Storage Available		
Existing Onsite Lagoons	3.2	Mgal
Existing Offsite Lagoons	3.9	Mgal
Proposed New Storage Volume (digestate tank)	5.3	Mgal
Total Storage Volume:	**12.4**	**Mgal**
Excess Storage Capacity:	**0.8**	**Mgal**

vhb.com
vhb
40 IDX Dr
Building 100 Suite 200
South Burlington, VT 05403
802.497.6100

0 25 50 100Feet

Goodrich Farm & Salisbury AD 1

615 Shard Villa Road
Salisbury, Vermont

No. Revision Date Appvd.

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Issued for Date

Sept.20, 2018

Not Approved for Construction

Drawing Title

Lagoon Storage Summary Schematic

Drawing Number

Sheet of

Project Number

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