

Protocol for Third Party Evaluation of Agricultural Nutrient Management Technologies

Version and Authorship

Version 1.0

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Authors:

Embrey Bronstad

Biological Systems Engineering, Washington State University

Georgine Yorgey

Associate Director, Center for Sustaining Agriculture and Natural Resources, Washington State University

Mark Stoermann

Chief Operating Officer, Newtrient

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Purpose

As various environmental, regulatory, and legal pressures mount with respect to nutrient management on dairies, the number of new technologies being advertised as solutions to this issue have proliferated. Dairies are now presented with a portfolio of options – and information about these options is often available solely from the technology providers themselves. This protocol was therefore developed by Washington State University in conjunction with Newtrient in response to the professed need of both the USDA’s Natural Resources Conservation Service (NRCS) and dairy farmers with whom Washington State University works: a standardized evaluation method to independently validate various treatment technologies. The protocol both adapts criteria found in Appendix A of the NRCS’s Conservation Practice Standard (CPS) Waste Treatment (629), which were designed to enable installation and cost sharing of new agricultural waste treatment technologies, and is supplemented with the collective research and field experience garnered by the authors through similar evaluations/studies.

This protocol is intended to be used to support reliable, unbiased assessments of nutrient removal technologies, generating information that supports decision-making by farmers considering implementation of these technologies at their dairies. Incorporation of the NRCS requirements enables the results of any technology evaluation to be used in developing cost-sharing opportunities with NRCS. This document therefore provides a standard that not only facilitates project assessment but also financing, which is often the limiting factor.

Third Party Evaluation of Agricultural Nutrient Management Technologies

PROTOCOL AND DOCUMENTATION PACKAGE FOR:

TECHNOLOGY:	
THIRD-PARTY EVALUATOR:	
DATES OF EVALUATION:	
PROJECT ID*:	

*DATE (DDMMYY), UNIVERSITY, TECHNOLOGY, DAIRY

EX: 032320_WSU_HUBER_GARDENDAIRY_WA

Table of Contents

Version and Authorship	i
Purpose.....	ii
Project Overview	1
Contact Information for Project Participants.....	2
Project Scope and Schedule	3
Dairy Information	4
Technology Information	5
General	5
Performance and Capital Cost.....	6
Operations & Maintenance and Warranty Information	6
Sampling and Monitoring	7
Pre-Sampling Meeting	7
General Sampling Guidelines	8
Liquid Sampling Protocols	9
Solids Sampling Protocols	9
Operations and Maintenance Monitoring During the Evaluation Period	10
Manhours	10
Utilities and Consumables Monitoring.....	10
Deliverables	11
Worksheets and Checklists.....	12
Background Data Worksheet BD-1.....	13
Operations and Maintenance Worksheet OM-1	14
Operations and Maintenance Worksheet OM-2.....	15
Pre-Sampling Checklist PS-1	16
Sampling Worksheet S-1	17
Sampling Worksheet S-2	18
Daily Log Template	19
Actual Operations and Maintenance Worksheet AOM-1	20
Post-Sampling Meeting Checklist.....	21

Project Overview

Project Participants and Scope of Work

Prior to initiating any project that would utilize this protocol, the basic team and scope of work must be laid out and agreed to. It is expected that third-party technology reviews will be requested by a technology provider in collaboration with an interested dairy. The purpose of the third-party review would be to document performance for this technology in a standard way comparable across states. The data would also be able to be used in soliciting funding as part of the NRCS EQIP program in states where both funding matches are not available and there is insufficient data related to the technology to make a funding inclusion request. The initial project summary form will be used to document these stakeholders and the basic timing of the review project (see following pages).

Dairy and Technology Questionnaires

After the project participants are identified and the scope of work is agreed upon, the documentation of the testing location and the technology is initiated. This process includes the completion of the forms for both the dairy testing location and detailed information about the technology (see pages 4-8).

Pre-Testing Meeting

After the documentation is completed the stakeholders will meet for a pre-testing meeting to discuss and finalize the details and schedule of the sampling plan.

Sampling Gear Procurement

Following the Pre-Testing meeting, the appropriate parties will procure sampling gear, consumables, and instrumentation.

Laboratory Contracting

The laboratory identified as participating in the study will be contracted and arrangements will be made for the testing protocol to begin and a chain of custody will be established.

Pre-Testing Site Visit

A final pre-testing site visit will be made to insure the proper placement of instrumentation, its correct operation, and the proper training of those responsible for sampling.

Sampling and Testing

All sampling and testing with supporting documentation will performed on-site and at the laboratory identified (see pages 10-13).

Post-Sampling Wrap Up Meeting

After the project is completed and the laboratory results are received the participants will have a final meeting to review the results and discuss the findings of the study.

Project ID: _____

Contact Information for Project Participants

Technology Provider:		
	Lead Contact	Local Contact
Name:		
Address:		
City, State, Zip:		
Phone:		
Mobile:		
Email:		

University:		
	Lead Contact	Local Contact
Name:		
Address:		
City, State, Zip:		
Phone:		
Mobile:		
Email:		

Test Site:		
	Lead Contact	Local Contact
Name:		
Address:		
City, State, Zip:		
Phone:		
Mobile:		
Email:		

Laboratory:		
	Lead Contact	Local Contact
Name:		
Address:		
City, State, Zip:		
Phone:		
Mobile:		
Email:		

Project ID: _____

Dairy Information

Dairy Name: _____

Location: _____

Wet Cow Equivalents: _____

Dry Cows: _____

Heifers: _____

Method(s) of manure collection (e.g., scrape) _____

Average tons manure/day: _____

Minimum amount of wastewater generated/day (gallons): _____

Maximum amount of wastewater generated/day (gallons): _____

Is there any existing mechanical, chemical, or biological treatment (screening, polymer addition, thickening, digestion, etc.) prior to the technology?

Are there any seasonal, weather, or operational conditions that affect the manure quality/quantity?
Please describe.

Results from any previous testing of manure/wastewater

	Average Results	Units
Total solids (TS)		
Volatile solids (VS)		
Chemical oxygen demand		
Total volatile acids (TVA)		
Total nitrogen (TN)		
Ammonia nitrogen (NH ₄ -N)		
Total phosphorus (TP)		
Other Constituents?		

Project ID: _____

Technology Information

General

Manufacturer and Technology to be evaluated: _____

Provide a full description of your technology. (**Attach a PFD and P&ID**)

Describe any SCADA programming, process monitoring, instrumentation, and/or controls required.

Provide a footprint (ft²) for the installation being tested.

Explain how the technology will:

- Reduce nutrient content, organic strength, and/or pathogen levels of manure

- Facilitate waste handling and storage

- Produce value-added byproducts that enhance profitability of the farm

Project ID: _____

Performance and Capital Cost

Attach a detailed mass balance describing influent, effluent, and recycle flows and constituent loads for each of the targeted constituents.

Using the included worksheet BD-1, list the constituents and their concentrations that the technology targets (i.e. TN of 1000 mg/L) and the anticipated percent removal.

Provide information garnered from existing installations on how varying upstream conditions might impact the technology performance and costs, i.e. flush manure collection vs scrape results in lower removal rates due to higher hydraulic load.

Note: For the following questions installation includes, but is not limited to: interface with the dairy's waste streams, feed wells, feed pumps, piping and appurtenances, processors, electrical and I&C, structural/building components, hoisting, any site/civil grading, trenching, etc., or other systems required to make the technology fully functional.

Provide estimated installation costs for the unit being tested.

Provide an estimated installed cost scaled to dollars per ton of manure treated.

Operations & Maintenance and Warranty Information

Attach an O&M manual including monitoring requirements and use the worksheet OM-1 to provide a replacement schedule for components with a lifespan of one, five, and ten years.

Use the worksheet OM-2 to provide an estimated operational cost and estimated number of man hours per week of labor required to maintain the system.

Attach standard warranty information on all construction/equipment included with the technology and on the process, if a process guarantee is provided.

Sampling and Monitoring

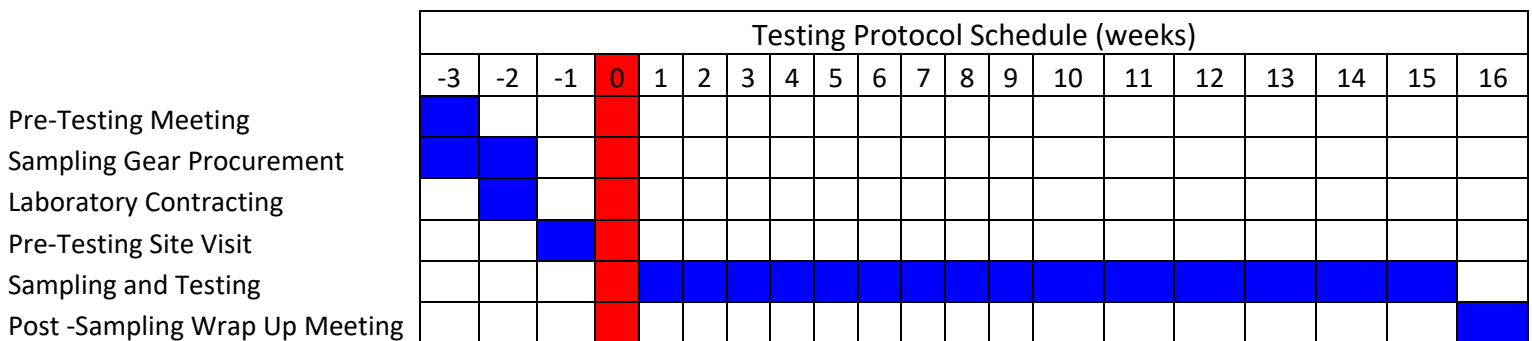
Pre-Sampling Meeting

A meeting will be held among all stakeholders to discuss and finalize the details of the sampling plan. A checklist is included in this protocol to facilitate the meeting with regard to sample timing, duration, type, and other critical components of the sampling plan (“Pre-Sampling Checklist”). A pre-sampling site visit will be conducted by the appropriate parties no later than one week prior to the beginning of the evaluation to ensure that the facility and technology installation is ready for sampling as agreed to in the Pre-Sampling Meeting.

After the conclusion of the sampling evaluation, a Post-Sampling Meeting should be held to discuss the results of the testing, including inconsistencies or anomalous data, and evaluate the study with respect to actual man-hours required, utilities consumed, etc. This affords the team an opportunity to provide any additional information for the evaluation that has not already been documented in the Daily Logs or other worksheets. A Post-Sampling Checklist PTS-1 is provided to help facilitate this meeting.

The Gantt chart below provides a general schedule for pre- and post-project activities; depending on the complexity of the installation and the necessary modifications to meet the General Sampling Guidelines, however, the schedule may be modified. A schedule should be agreed to as part of the Pre-Sampling Meeting once all stakeholders and those familiar with the site have an opportunity to discuss the specific characteristics of the project.

Sample Gantt Scheduling Tool



General Sampling Guidelines

In addition to the site-specific details of the particular technology assessment, the following baseline guidelines apply to all evaluations:

- Prior to installation, a survey of the electrical capacity available will be conducted by the technology representatives to ensure that sufficient power is available for simultaneous support of both peak dairy operations and the technological system.
- Flow meters should be installed on relevant waste streams and tested prior to the beginning of sampling.
- Isolated, separate meters for monitoring electricity, water, and consumption of other utilities specific to the technology should be installed and tested prior to the beginning of sampling.
- Isolated, separate meters for recording chemical use, polymer use, and use of other consumables should be installed and tested prior to the beginning of sampling.
- No sampling point will require confined space entry or otherwise endanger the person taking samples.
- Provision of appropriate sampling equipment (Sludge Judges, coolers, sampling bottles, gloves, etc.) will be agreed to prior to sampling.
- A laboratory accredited by the governing environmental regulatory agency to test for the targeted constituents will be identified, approved for use by all parties, and contracted with no later than two weeks prior to the beginning of sampling.
- Testing methods in Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020 (U.S. EPA, 1983), Standard Methods for the Examination of Water and Wastewater, 21st edition (American Public Health Association, 2005), or equivalent methods agreed upon by all parties prior to the beginning of sampling should be used.
- Specific methods from the aforementioned references for evaluating target constituents should be identified and agreed upon by all parties and documented in the sample worksheet prior to the beginning of sampling.
- Use of laboratories identified by the Minnesota Department of Agriculture as Certified Manure Testing Laboratories is encouraged.
- Sampling will be conducted for a minimum of three (3) days a week for a minimum of fifteen (15) weeks, resulting in a minimum of 45 data points. Additional sampling can be arranged provided that sample holding times are not jeopardized.
- Sampling should ideally be conducted at the same time each day assuming the equipment is operating normally. Normal operation is defined as operation of the system with interference or adjustments by staff as per the technology provider's expectations.
- A daily log should be kept by a testing representative to document changes in weather, operations, influent conditions, upsets, etc. that might impact the performance of the technology. A Daily Log template is included in this protocol.

Note on Seasonality

It is expected that during the course of the sampling period, fluctuations in dairy operations will afford the technology some variation in influent conditions. Depending on the location of the dairy, however, there may be dramatic differences in operations because of seasonal variability. To the extent possible, therefore, the sampling protocol will be conducted during the most extreme conditions faced by the dairy in order to test the technology under stressed conditions. This may include but not be limited to scheduling around or during rainy seasons, extreme temperatures, etc.

Liquid Sampling Protocols

- Three (3) grab samples of a minimum 1L quantity from a continuously flowing stream will be taken over the course of one hour and composited for a single sample.
- If the liquid medium to be sampled is contained in a wet well, lagoon, or EQ basin, samples should be taken at different elevations in the basin unless the basin is equipped with a mixer or pump that maintains a relatively homogenous mixture.
- Influent and effluent samples should be taken with the hydraulic residence time of the technology in mind.
- Flow rates of the sampled stream will be documented no fewer than three (3) times over the course of the sampling hour and averaged to provide a basis for load calculations and mass balance development.
- Flow measurements will only be considered valid if they are determined by an appropriate in-line flow measurement device (mag meter, e.g.). Timed "bucket" tests will have to be evaluated on site specific basis to determine their feasibility for precise measurement.

Solids Sampling Protocols

- If the technology permits sampling from a stream of product (screw press discharge, e.g.), a minimum of six (6) grab samples of a minimum 500 mL quantity should be collected over the course of one hour and composited.
- Estimate solids production rates by documenting weight captured over a specific time and using the results of the total solids (%) to back calculate solids generation for mass balance purposes
- If the technology results in a batched solids discharge, then a minimum of eight (8) representative samples of at least 500 mL from various depths should be sampled and composited as close to the time the batch was produced as possible.
- Do not sample a batch more than four (4) hours after production, as conditions in the batch may contribute to alterations of constituent states and affect test results.
- Estimate solids production rates by documenting weight captured over a specific time and using the results of the total solids (%) to back calculate solids generation for mass balance purposes.

Document liquid and solids sampling conditions and results using the attached worksheets (S-1 and S-2).

Project ID: _____

Operations and Maintenance Monitoring During the Evaluation Period

Manhours

- Manhours for maintaining the system once it reaches normal operation should be documented, including but not limited to:
 - Time spent shutting down/starting up the system if the system is not designed to operate 24/7
 - Time spent monitoring the equipment for proper operation
 - Time spent optimizing performance even after normal operation is achieved
 - Any other conditions that would impact a farm's standard work schedule
- Manhours for addressing abnormal or emergency conditions should be documented, including but not limited to:
 - Time spent responding to alarms and corrective actions taken
 - Time spent shutting down and bringing back up any portion of the technology/system NOT associated with normal operations
- Document man-hours for all above conditions on the Daily Log worksheet.

Utilities and Consumables Monitoring

- Consumption of utilities should be monitored throughout the duration of the sampling period. Total kWh's, BTUs, and/or gallons of water used for the system will be recorded.
- Consumption of chemicals, polymer, and other incidentals necessary to the performance of the system should be monitored throughout the sampling period. Total gallons for each used will be recorded.
- Both the actual utilities and consumables used during the sampling study should be recorded using attached worksheet AOM-1.

If during the sampling protocol the system has to be shut down due to process or mechanical failure, the duration of shutdown and cause will be documented, and the appropriate parties will have to determine if the shutdown represents a failure significant enough to invalidate the test.

Project ID: _____

Deliverables

The project results should be organized, packaged, and shared with all stakeholders and team members. At a minimum, the package should include:

- Information documented in this protocol as part of the dairy and technology information background, including the BD-1 worksheet.
- The completed Pre-Sampling Meeting Checklist and schedule developed for the evaluation.
- All S1 and S2 worksheets documenting times and conditions of sample collection
- All sampling results certified by the accredited laboratory
- The AOM-1 worksheet documenting total electricity, gas, water and/or other utilities used during the course of the study and total consumables used during the course of the study
- An estimate of the total tons of manure treated during the evaluation
- All Daily Logs kept by the testing representative
- The Post-Sampling meeting checklist

Project ID: _____

Worksheets and Checklists

BD-1: Influent Limitations and Maximum Expected Removal Rates of Targeted Constituents

Project ID: _____

Technology: _____

Manufacturer: _____

Tons of manure/day _____

Estimated installed cost _____

Constituent	Limits of Technology			
	Min Influent (gpm, mg/L, lbs/day)	Max Influent (gpm, mg/L, lbs/day)	Max % Reduction at Min Influent Conditions and Value	Max % Reduction at Max Influent Conditions and Value
Flow (gpm)				
Total solids (TS)				
Volatile solids (VS)				
Chemical oxygen demand (COD)				
Total volatile acids (TVA)				
Total nitrogen (TN)				
Ammonia nitrogen (NH4-N)				
Total phosphorus (TP)				
Other Constituents Targeted by the Technology				
Salinity/EC				
Total sulfur (S)				
Fecal Coliforms (FC)				

OM-1: Replacement Parts Schedule and Cost

Project ID: _____

Technology: _____

Manufacturer: _____

Tons of manure/day _____

Estimated installed cost _____

Part	Replacement Schedule (yrs)			Commercially available (CA) or tech. manufacturer (TM)?	Estimated Cost
	1	5	10		
Example: Drive Belt		X		CA	\$100

Estimated one year costs:	
Estimated five year costs:	
Estimated ten year costs:	

OM-2: Consumables and Utilities

Project ID: _____

Technology: _____

Manufacturer: _____

Tons of manure/day _____

Estimated installed cost: _____

Utilities	Quantity	Cost per Unit	Unit	Estimated Yearly Cost
EXAMPLE @ 10 tons manure: Electricity (kwh/ton manure treated)	50	\$0.10	kwh	\$18,250
Electricity (kwh/ton manure treated)				
Gas (BTUs/ton manure treated)				
Water (gallons/ton manure treated)				
Consumables	Quantity	Cost per Unit	Unit	Estimated Yearly Cost
Polymer (gal/ton manure treated)				
Labor	Quantity	Cost per Unit	Unit	Estimated Yearly Cost
Estimated labor cost (hours per week)				
Estimated yearly consumable/labor costs:				

PS-1: Pre-sampling Checklist

To be filled out at the Pre-sampling Meeting

Date of Pre-sampling Meeting: _____
 Project ID: _____
 Technology: _____

Attendees:

Name	Company/Representation

Have the following been discussed and agreed to by all parties?	Y/N	Date Determined	Notes/Comments
Duration of sampling			
Sampling days (MTW, e.g.)			
Number of samples (duplicate, triplicate) and sample type (solid, liquid)			
Lab identified and contracted with			
Testing methods agreed to by lab and team			
Sample transport determined (overnight ship, drive and drop, e.g.)			
Responsible party for sampling equipment (coolers, bottles, etc.)			
Any specialized sampling equipment needed (sludge judge, e.g.)			
Technology installed			
Sampling points identified			
Sampling methods determined (grab, composite, etc.)			
Flow measurements determined (inline meter, bucket, etc.)			
Person/team sampling determined (tech provider, dairy operations, etc.)			
Access to site and sampling points coordinated			
Any other modifications to the site that have to be done prior to sampling			
Other:			
Other:			

S-1: Sampling Worksheet: Times and Conditions

Fill out one for EACH sampling point

Project ID: _____

For the week of (date): _____

Indicate which week this is in the sampling period:

- | | | | | | |
|------|------|------|------|------|------|
| 1st | 2nd | 3rd | 4th | 5th | |
| 6th | 7th | 8th | 9th | 10th | |
| 10th | 11th | 12th | 13th | 14th | 15th |

Sketch the PFD in the space provided and indicate where samples were taken:

		Composite Sample Times			Flow/Production Rates at Sample Times		
	Date	1st	2nd	3rd	1st	2nd	3rd
Day 1							
Notes: Indicate any abnormal conditions or operations. Indicate any upstream conditions in the dairy that would impact the technology							
Day 2							
Notes: Indicate any abnormal conditions or operations. Indicate any upstream conditions in the dairy that would impact the technology							
Day 3							
Notes: Indicate any abnormal conditions or operations. Indicate any upstream conditions in the dairy that would impact the technology							

S-2: Sampling Worksheet: Testing Results

Fill out one for EACH sampling date

Project ID: _____

For the week of (date): _____

Indicate which week this is in the sampling period:

- | | | | | | |
|------|------|------|------|------|------|
| 1st | 2nd | 3rd | 4th | 5th | |
| 6th | 7th | 8th | 9th | 10th | |
| 10th | 11th | 12th | 13th | 14th | 15th |

Sketch the PFD in the space provided and indicate where samples were taken (Sample Points A,B,C etc):

Sampling Date:	Sample Point and Results					Analytical Method Used
	A	B	C	D	E	
Constituent						
Total solids (TS)						
Volatile solids (VS)						
Chemical oxygen demand (COD)						
Total volatile acids (TVA)						
Total nitrogen (TN)						
Ammonia nitrogen (NH4-N)						
Total phosphorus (TP)						
Other Targeted Constituents						

Daily Log

Project ID: _____ Date: _____

Weather: _____ Temperature: _____

Daily Log Notes: Document any conditions or operational issues that might impact performance.

Manhours Spent on Normal Maintenance: _____

Manhours Spent on Emergency/Abnormal Conditions: _____

Abnormal or Unplanned Shutdown? (Y/N) _____

If Y, please explain: _____

Documented By: _____

Title: _____

Company: _____

Signature: _____ Date: _____

AOM-1: Actual Consumables and Utilities for the Evaluation Duration

Project ID: _____

Technology: _____

Manufacturer: _____

Tons of manure treated during the evaluation _____

Duration of evaluation (weeks) _____

Utilities Used During the Evaluation	Quantity	Cost	Unit	Total Cost
Electricity				
Gas				
Water				
Consumables Used During the Evaluation	Quantity	Cost	Unit	Total Cost
Polymer				
Labor Employed During the Evaluation	Quantity	Cost	Unit	Total Cost
Manhours				
Total consumable/labor costs for the evaluation:				
Consumable/labor costs normalized by weeks:				
Estimated annual costs based on weekly costs				

PTS-1: Post-sampling

To be filled out at the Post-sampling Meeting

Date of Post-sampling Meeting:

Project ID:

Technology:

Attendees:

Name	Company/Representation

Issues, Questions, Challenges	Notes/Comments
Were any sampling days skipped? If so why?	
Was treatment performance more or less than expected?	
Are there any anomalies in the performance?	
Can the anomalies be explained?	
Was maintenance more or less than expected?	
Was utility consumption more or less than expected?	
Did any concerns about the equipment arise during the evaluation?	
Did any unexpected benefits of the equipment arise during the evaluation?	
Were any field modifications made during the evaluation to address performance issues?	
Were any field modifications made during the evaluation to address maintenance issues?	
Other:	