Feasibility Study of Biomass-Powered Renewable Energy Generation on Tribal Lands in Snohomish County, Washington

DOE Grant Number: DE-FG36-03GO13017

Final Technical Report

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The Tulalip Tribes of Washington State

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Executive Summary

In April of 2003, the U.S. Department of Energy awarded a $256,476 grant to the Tulalip Tribes of Washington State to "assess the feasibility of developing biogas generation facilities to convert manure and other biomass resources into electricity to help meet the Tribe's energy needs from a renewable energy source."

During the past year and a half, the TulalipTribes, working cooperatively with area dairy producers, have completed a comprehensive assessment of the feasibility of developing a biogas generation facility in Snohomish County. This work included an assessment of significant dairy and non-dairy biomass resources in Snohomish County, an analysis of preliminary design elements for a biogas facility, and a baseline analysis of engineering and cost values of constructing one such facility at the Monroe Honor Farm, a dairy farm formerly operated by the Washington State Department of Corrections.

This comprehensive feasibility study, including work by some of the world's foremost experts in the fields of biomass production, has concluded that development of a biogas facility in Snohomish County is both technologically and economically feasible. The final report outlined here summarizes the work performed under the DOE grant, and provides full documentation of the study results.

The final report consists of two parts:

Part I: Project Summary, is a full color 12-page booklet entitled: *The Snohomish Basin Biogas Project Feasibility Study Executive Summary* (December 1, 2004). This booklet is provided herein as Attachments 1 – 6. Each attachment is in Adobe Acrobat (.pdf) file format. The files range from 18.2 MB to 34.8 MB each. The cumulative file size is 137.6 MB.

Table 1: List of Attachments That Constitute Part I, Project Summary

Attachment 1	Front Cover & Back Cover (SB-FC-BCC) Adobe .pdf 34.8 MB
Attachment 2	Interior Front Cover & I. Back Cover (SB-IFC-IBC) Adobe .pdf 32.6 MB
Attachment 3	Page 1 & Page 8 (SB-P1-8) Adobe .pdf 13.9 MB
Attachment 4	Page 2 & Page 7 (SB-P2-7) Adobe .pdf 18.2 MB
Attachment 5	Page 2 & Page 6 (SB-P3-6) Adobe .pdf 24.1 MB
Attachment 6	Page 4 & Page 5 (SB-P4-5)

	Adobe .pdf 14.0 MB

The Project Summary booklet contains the following required elements of the DOE final report:

- Project Overview
- Objectives
- Description of Activities Performed
- Conclusions and Recommendations
- Lessons Learned

Part II: Comprehensive Business Plan, is a compilation of task deliverables (provided as attachments) that comprise the work supported by DOE during the course of this study. The cooperative agreement between the Tulalip Tribes of Washington State and the U.S. Department of Energy stipulated that the biogas feasibility study should include the following tasks:

- Site-specific renewable resource assessment;
- Review of tribal load assessment and export markets;
- Consideration of transmission and interconnection needs;
- Technology analysis;
- Economic analysis;
- Consideration of environmental benefits and impacts;
- Consideration of cultural, social, and community benefits and impacts;
- Preliminary system design;
- Consideration of training and other professional development needs;
- Consideration of long-term operation and maintenance needs; and
- Business planning needed to move from feasibility into project implementation.

A full report of each task activity and its results can be found in the following:

Table 2: List of Attachments That Constitute Part II, Comprehensive Business Plan

Attachment 7	Tulalip Tribes-Snohomish County Organic Waste Assessment—Final Report. RCM Digesters, Inc. Nov. 22, 2003 (WORD doc 20.5 MB) • Site-specific renewable resource assessment; • Consideration of cultural, social, and community benefits and impacts
Attachment 8	WA Tulalip Task 2 Digester Technologies. RCM Digesters, Inc. Sept. 2, 2003 (WORD doc)

	• Technology analysis;
Attachment 9	Preliminary Design Elements. RCM Digesters, Inc. Jan. 2004 (WORD doc 394 KB) • Consideration of transmission and interconnection needs; • Consideration of training and other professional development needs; • Consideration of long-term operation and maintenance needs
Attachment 10	Baseline Analysis of Engineering and Cost Values. RCM Digesters, Inc. March 2004 (WORD doc 862 KB) • Economic analysis; • Consideration of environmental benefits and impacts; • Preliminary system design;
Attachment 11	Working Copy Business Structures Memo. Dairy Strategies LLC March 3, 2004 (WORD doc) • Business planning needed to move from feasibility into project implementation.
Attachment 12	Business Structures and State Tax Issues Memo. Tribal Strategies Inc. April 28, 2004 (WORD doc) • Business planning needed to move from feasibility into project implementation.

In addition to the required task activities, outlined above, the feasibility study effort included the following:

- A RFQ/Expression-of-Interest request effort to identify and rank anaerobic digestion system technology providers; and
- An early NEPA scoping effort to identify outstanding issues related to future development of a regional digester at the Monroe Honor Farm.

These activities complemented the DOE-required tasks, and allowed the team a more realistic assessment of feasibility and of the long-term sustainability of the project. The results of these two additional task elements are found in the following:

Table 3: List of Additional Attachments in Part II, Comprehensive Business Plan

Attachment 13	Expression-of-Interest Review Memo. The Stella Group. Jan. 21, 2004 (WORD doc) • Technology analysis; • Consideration of training and other professional development needs
Attachment 14	Finding of No Significant Impact (FONSI). USDA Rural

	Development. Jan. 28, 2004 (WORD doc) • Consideration of cultural, social, and community benefits and impacts; • Consideration of environmental benefits and impacts

These 14 attachments constitute The Tulalip Tribes formal submittal to the Department of Energy of a Final Technical Report for work completed under DOE Grant **DE-FG36-03GO13017.**

All of these reports, as well as all of the power point presentations made during the course of the study to the Tribal Council, DOE and other federal agencies, and the public can also be found at the following: http://www.quilcedapower.com/Document.htm

The Tribes is pleased to report that the project is moving forward, and that expectations are that construction will begin on the first Tribal-private regional anaerobic digester in the country in summer 2005.

We thank the Department of Energy, Office of Tribal Programs, for their encouragement, support, and commitment.

This project managed by
The Clark Group, LLC on behalf of
the Tulalip Tribes.

THE CLARK GROUP, LLC

Not only are business and environmental protection compatible, when they are integrated they provide a strategic competitive advantage.

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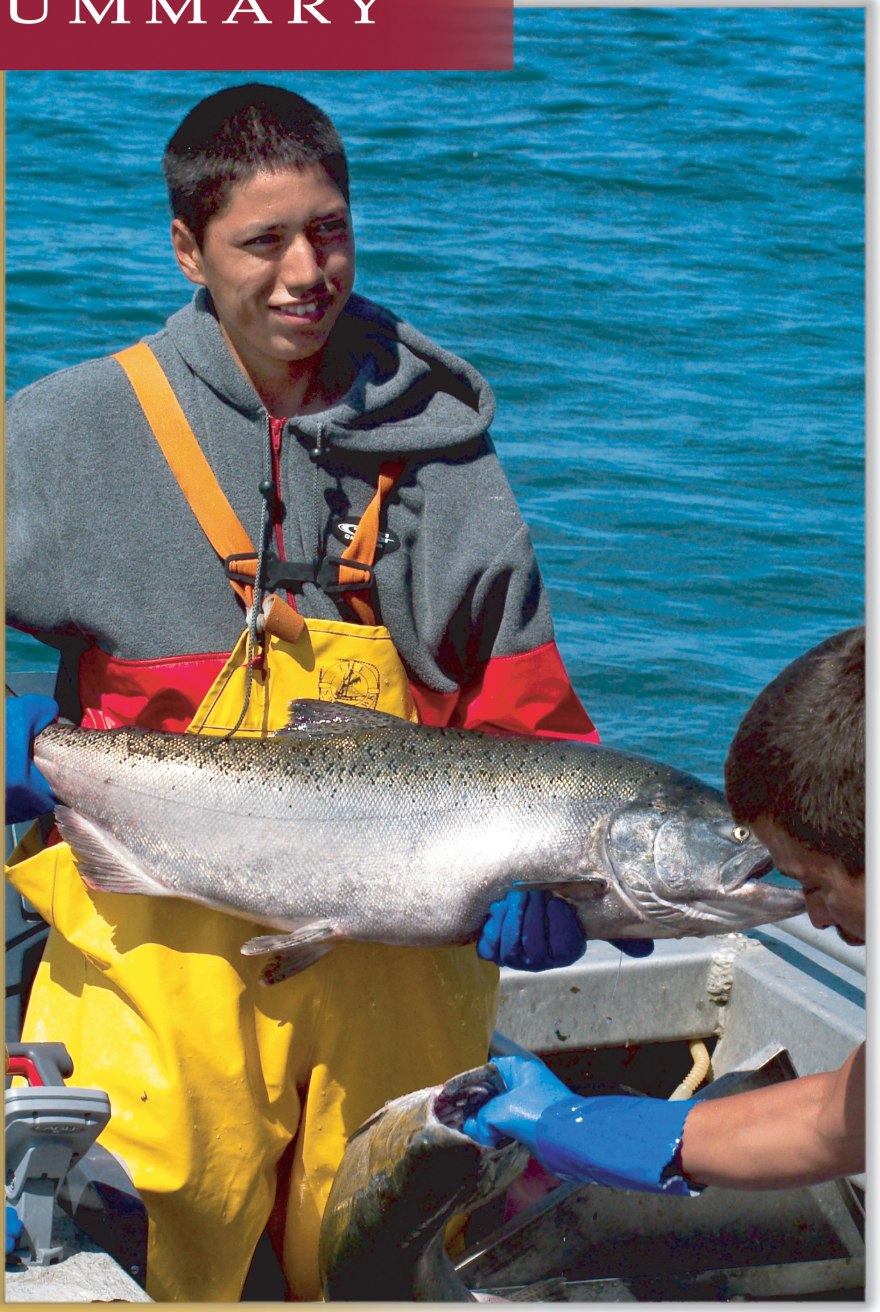
PROJECT SUMMARY



PARTNERS

NORTHWEST CHINOOK RECOVERY

SNO/SKY AGRICULTURAL ALLIANCE

WASHINGTON STATE DAIRY FEDERATION

SNOHOMISH BASIN BIOGAS PROJECT

Feasibility Study Executive Summary

TULALIP TRIBES

Tulalip Tribes of Washington State

December 1, 2004

For too long, farmers and tribes have been at loggerheads.

We are opening a new chapter in our relationships.

Fishermen and farmers both make their living from the land.

Working together, we can ensure that our children can continue

the heritage passed on to us by our fathers.

– Herman Williams, Jr.
Tulalip Tribes Board of Directors

Special Thanks to the U.S. Department of Energy, the U.S. Department of Agriculture, the State of Washington, and Snohomish County for support of this project.

Front Cover/Inside Back Photos by Beth Maynor Young

VI. CONCLUSION

Development of a biogas facility in Snohomish County is both technologically and economically feasible. The comprehensive feasibility study commissioned by the Tulalip Tribes has identified a high-priority site for construction of such a facility and has produced an estimate of the costs, revenues and environmental and economic benefits of such a facility.

With this comprehensive assessment in hand, the Tulalip Tribes and their partners in the Snohomish Basin Biogas Partnership are now moving forward with plans to design and construct a regional biogas facility.

The Snohomish Basin Biogas Partnership is working to secure all necessary permits for a facility at the Monroe Honor Farm, and is in the process of selecting a developer and arranging financing for construction of the facility.

The project timeline currently calls for the regional biogas facility to be constructed and fully operational by the close of 2005.

The Tulalips came to us with a pretty simple philosophy:

'We believe cows would be better in these valleys than condos.'

We, as farmers, couldn't agree more.

– Andy Werkhoven
Fourth-generation Skykomish Valley Dairy Farmer

Assumptions were that the plant would be designed to accept the manure waste from about 2000 cows, along with about 30,000 pounds per day of high grade food waste. That represents approximately 20% of the substrate going into the digester on a daily basis. With such as assumed input, the biogas output is expected to be about 165.000 cubic feet per day. This would generate about 300 kWhr of power. Such a power output would provide for the electric needs of about 200 homes.

COST AND REVENUE

Estimated Costs

Costs were developed for a digester with electricity production and excess hot water available for on-site facility use. Costs of construction were assumed using typical private contractor cost estimates for construction of on farm projects in the area. The heated, complete mix digester system sized for a hydraulic retention time of 24 days for 2,005 mature Holstein equivalents (MHE) and the identified food waste should cost about $2,066,284.

Estimated Potential Revenue

The annual sale of excess electrical energy in the amount of $81,493 is assumed in this analysis. Additionally, the marketable value of fiber was assumed to be approximately $36,884 per year. An annual greenhouse tax credit was calculated at $24,672.

ECONOMIC BENEFITS

Direct economic benefits from the project would be production of renewable energy in the form of electricity and hot water. After meeting the site electrical needs, excess biogas could also be used for drying manure solids to enhance the production of marketable fiber. Accepting food wastes into the digester may also generate tipping fees in addition to enhancing the biogas production. Secondary economic benefits from completion of the project stem from waste utilization, pathogen and weed seed reduction, and a more readily usable liquid nutrient for crop fertilization.

ENVIRONMENTAL BENEFITS

Anaerobic digestion significantly reduces odor problems associated with manure handling and land application at farms. It is very effective in denaturing weed seeds and reducing pathogens. Weed seed destruction is virtually 100%, whereas, pathogen reduction is greater than 99%. What this means is that both the liquid effluent returned to farm fields for fertilizer and compost produced for the retail or wholesale trade are exceptionally clean.

The energy produced from anaerobic digestion systems is both renewable and displaces fossil fuel use elsewhere. In addition, the system prevents uncontrolled methane emissions from on-farm lagoon systems and untreated effluent that is land-spread. Both the displaced fossil fuel and the control on methane emissions help mitigate global warming.

On the water side, anaerobic digestion helps control ammonia and biological oxygen demand (BOD) stresses on receiving waters, which in the Honor Farm area are salmon-bearing streams. Also, the development of a renewable energy project at the Honor Farm site will proceed alongside compatible and environmentally-beneficial projects such as salmon habitat restoration and conservation easements either at the Honor Farm or at participating dairies, providing additional environmental benefit to salmon.

I. INTRODUCTION

Across Washington State and indeed, across the West, Native American tribes and agricultural producers often turn their sights on each other when faced with economic and cultural pressures. Lawsuits, animosity, and inaction tend to be the hallmark of such conflicts.

In Snohomish County, the Tulalip Tribes and local dairy producers concluded that there had to be a better way. Over the past three years, the Tulalip Tribes and a number of Snohomish County agricultural producers, represented by the Lower Skykomish River Habitat Conservation Group known as Sno/Sky Agricultural Alliance, began quietly meeting to find common ground on issues relating to restoration of area salmon runs and sustainability of the local agricultural industry.

On April 11, 2003, the Tulalip Tribes, Northwest Chinook Recovery, Sno/Sky Agricultural Alliance, and the Washington State Dairy Federation entered into an historic cooperative agreement creating the Snohomish Basin Biogas Partnership and pledging to work together to protect water quality, restore salmon habitat, and support agriculture in Snohomish County.

As the name implies, the centerpiece of this cooperative effort is a proposal to jointly develop a biogas facility to help restore salmon runs and sustain family farms by converting dairy waste into energy.

In April of 2003, the U.S. Department of Energy awarded a $256,476 grant to the Tulalip Tribes of Washington State to "assess the feasibility of developing biogas generation facilities to convert manure and other biomass resources into electricity to help meet the Tribes' energy needs from a renewable energy source."

> *"Development of a biogas facility in Snohomish County is both technologically and economically feasible."*

During the past year and a half, the Tulalip Tribes, working cooperatively with area dairy producers, have designed and completed a comprehensive assessment of the feasibility of developing a biogas generation facility in Snohomish County. This included an assessment of significant dairy and non-dairy biomass resources in Snohomish County, an analysis of preliminary design elements for a biogas facility, and a baseline analysis of engineering and cost values of constructing one such facility at the Monroe Honor Farm, a dairy farm formerly operated by the Washington State Department of Corrections.

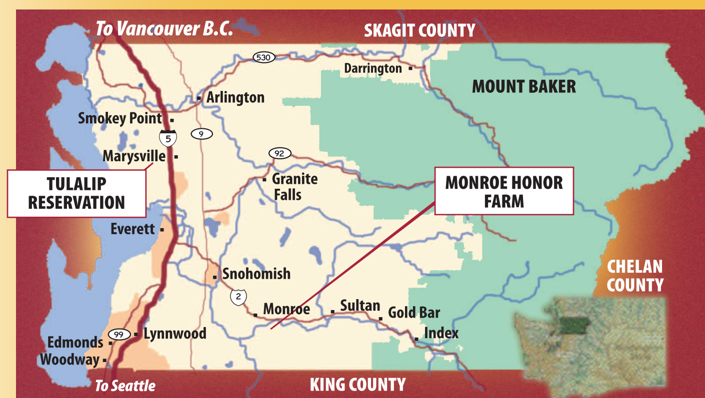
This comprehensive feasibility study, including work by some of the world's foremost experts in the fields of biogas production, has concluded that development of a biogas facility in Snohomish County is both technologically and economically feasible.

With this comprehensive assessment in hand, the Tulalip Tribes and their partners in the Snohomish Basin Biogas Partnership are now moving forward with plans to design and construct a regional biogas facility in Snohomish County. In support of this effort, the U.S. Department of Agriculture has pledged $500,000 in construction funding, while the Washington State Legislature has passed legislation providing for the transfer of the Monroe Honor Farm to the Tulalip Tribes as a site for the proposed facility. Efforts are underway to secure all necessary permits for a regional biogas facility and the Snohomish Basin Biogas Partnership is working to select a developer and arrange financing for construction of the facility.

The project timeline currently calls for the regional biogas facility to be constructed and fully operational by the close of 2005.

II. BACKGROUND OF THE TULALIP TRIBES & SNOHOMISH-AREA AGRICULTURE

The Tulalip Tribes have been fishing for salmon and shellfish in the Puget Sound area for thousands of years. The Tulalip Reservation was established by the Point Elliott Treaty of January 22, 1855 and enlarged by Executive Order of December 23, 1873. It was established to provide a permanent home for the Snohomish, Snoqualmie, Skagit, Suiattle, Samish and Stillaguamish Tribes and allied bands living in the region. The Point Elliot Treaty provided that the Tribes retained fishing and hunting rights which has been interpreted by federal courts to give the Tulalip co-management responsibility and authority with the State of Washington over fish and wildlife resources in this area.



SNOHOMISH COUNTY, WASHINGTON

Snohomish County also has a proud agricultural heritage with dairy farming playing an important part of this region's economy. Snohomish County has over 1,200 farms, and county agriculture is a $260 million dollar industry. Snohomish County ranks first in the state in annual milk production per cow, and second in boiler production. There are several large Confined Animal Feeding Operations (CAFOs) in the county. A recent study by the County's Office of Solid Waste found that, of the county's dairy farms that had registered as CAFOs with the Washington State Department of Ecology, 63% had more than 250 animal units, and 40% had 600 to 1800 animal units.

The Tulalip Tribes and Snohomish County agricultural producers have faced common challenges as salmon runs have declined and as agricultural production has become less profitable. Historically, the Tulalip Tribes have issued 130 permits to their commercial fisherman. Today, as the runs have declined, the Tulalip Tribes issue around 30. Boats sit dry-docked on the edge of Tulalip Bay representing a diminishment to the economy and to the culture of the Tulalip.

Dairy farmers have witnessed similar pressures upstream from the Tulalip reservation as historically low milk prices, coupled with increased concentration in the dairy industry, urban sprawl and limitations on waste disposal, have brought increasing economic hardships on Snohomish-area producers. Many of Snohomish County's dairy farms have closed and others are on the brink of closing.

On April 11, 2003, the Tulalip Tribes, Northwest Chinook Recovery, Sno/Sky Agricultural Alliance, and the Washington State Dairy Federation entered into an historic cooperative agreement creating the Snohomish Basin Biogas Partnership (SBBP) and pledging to work together to protect water quality, restore salmon habitat, and support agriculture in Snohomish County. The efforts of the SBBP have subsequently been embraced by the Cascade Land Conservancy, Snohomish County, the State of Washington, and the U.S. Congress.

V. TECHNICAL & ECONOMIC EVALUATION

Based on the Snohomish Basin Biogas Partnership's selection of the Monroe Honor Farm Site, the Tulalip Tribes contracted with RCM Digesters, Inc., to complete two site-specific engineering and economic studies. The purpose of these studies was to develop a preliminary design for the anaerobic digestion system that would be best suited for the Honor Farm site. Two reports were completed:

1. The Preliminary Design Elements Report (January 2004), and
2. The Baseline Analysis of Engineering and Cost Values of an RCM Complete Mix Manure Digestion System (March 2004).

The Preliminary Design Elements Report assessed essential elements for a successful anaerobic digester system at the Monroe Honor Farm site and concluded that methane production is technically feasible. The Baseline Analysis report recommended the installation of a mesophilic, complete mix digester to accommodate dilute dairy manure and the addition of food waste inputs. Results are further summarized below.

Preliminary System Design

The Preliminary Design Elements Report examined the biomass resource data compiled to date, provided empirical calculations for biogas production potential , and identified the essential elements necessary for a successful anaerobic digester system at the Monroe Honor Farm site. The recommended system for the Honor Farm is a complete mix digester.

Complete mix digesters are the most flexible of all digesters as far as the variety of wastes that can be accommodated. Digestible wastes from any source with 2 - 10% solids are pumped into the digester and the digester contents are continuously or intermittently mixed to prevent separation. Complete mix digesters are usually above ground, heated, insulated, round tanks. In-ground rectangular vessels have also been employed as complete mix digesters. Gas recirculation, mechanical propellers or liquid circulation accomplish mixing. A heated (mesophilic) digester is recommended, in order to improve biogas production. mesophilic digestion occurs between 95^{O}F and 105^{O}F. There are about five heated, mixed cow manure digesters currently operating in the United States.

The digester would be sized to allow for a 20-day hydraulic retention time (HRT) to accommodate concentrated wastes from pre-treated flush dairies, raw manure from the scrape dairies, and the industrial feedstock identified in the Biomass Assessment Study. Biogas produced in the complete mix digester would fuel an engine-generator set that has been equipped to run on biogas and sized to match the system's maximum kW production potential. Heat recovered from the engine in the form of hot water would be piped to the digester to assist in heating. Excess heat could also be transmitted to adjacent nurseries and greenhouses.

Baseline Analysis

The second document: The Baseline Analysis of Engineering and Cost Values of an RCM Complete Mix Manure Digestion System (March 2004), established a baseline for the feasibility of biogas production, recovery, and utilization at the Monroe Honor Farm. Based on an engineering approach and the complete mix digester experience of RCM Digesters, Inc., this baseline comparative document evaluated one design approach with a pressure sewer delivering manure from the four dairies immediately adjacent to the Honor Farm site. It also incorporated the food waste inputs as defined in the Preliminary Design Elements Report. The purpose of the Baseline Analysis document was to define the assumptions of a digester system, estimate component costs, and provide the resulting production output estimates. Such information will assist the project's Financial Team to develop a detailed business plan.

IV. MONROE HONOR FARM

In February of 2001, the Washington State Correctional Industries Board of Directors authorized the closure of the 72-year-old Washington State Reformatory Dairy Farm located near Monroe, WA. The 277-acre Monroe Honor Farm is located approximately 4 miles south of the city of Monroe and sits in close proximity to a number of large dairy operations that could potentially be integrated into a biogas facility.

There are already two animal waste storage ponds on the property - one with a capacity of 9.8 million gallons and another with a capacity of 27 million gallons. In addition to the animal waste storage ponds, the property also contains a large covered corral area that could be utilized as part of the biogas facility. Apart from the existing structures, most of the property is flat, native grass pastureland that could support additional dairy cattle to increase input into the biogas facility.

Monroe Area, 5 Mile Radius

During the 2004 session of the Washington State Legislature, the Tribes and area dairy farmers jointly approached the Governor and their state senators and representatives and asked for assistance in securing this piece of surplus state land. The Governor and the state legislature responded positively and the legislature added a provision to the 2004 Supplemental Capital Budget authorizing the transfer of the Monroe Honor Farm to the Tulalip Tribes for the development of a regional biogas facility.

In directing this transfer of state land to the Tribes, the legislature found that:

Aerial Photo of the Monroe Honor Farm

"[I]t is in the public interest to encourage development of a biogas facility at the Monroe honor farm to convert dairy waste, fish processing waste, and other waste products into energy. Such a facility will: help improve water quality in area streams; help restore salmon habitat; create jobs; generate green energy; improve the economic sustainability of area dairy farms; help stem sprawl; serve as a demonstration project for environmental education; reduce on-going costs associated with maintaining state ownership of this facility; encourage greater cooperation between area tribes and agricultural interests; and be a model for other such efforts in the state."

II: BACKGROUND - CONTINUED

As the name implies, the centerpiece of the Snohomish Basin Biogas Partnership is a proposal to jointly develop a biogas facility to help restore salmon runs by converting dairy waste into energy.

In addition to the Tulalip fish hatchery program, the Tulalip Department of Natural Resources has worked for years to restore salmon runs by focusing on efforts to improve water quality and to restore salmon spawning and rearing habitat. Working with upstream agricultural producers is a logical way to accomplish both of these goals. While conversations are on-going with agricultural landowners on a number of complimentary habitat conservation initiatives, the Tulalip concluded that focusing on management of dairy waste and ensuring sustainability of area farms are key methods to improve water quality upstream from the Tulalip reservation.

For their part, Snohomish County dairy producers have concluded that manure management is the "long pole in the tent." Limitations on waste disposal have restricted the ability of dairy operations to increase their herd sizes. As dairies elsewhere in the country attain increased efficiencies from increasing herd sizes, Snohomish-area dairies are placed at a competitive disadvantage. New state and federal CAFO regulations hold the potential to only exacerbate this situation.

Over the past years, it has become increasingly clear to the participants in the Snohomish Basin Biogas Partnership that one potential solution to the Tribes' and the farmers' challenges would be to construct one or more anaerobic digesters in the region to convert dairy waste into energy and into other beneficial by-products such as compost. Such a facility could be coupled with a number of complimentary businesses including a compost packaging facility and a greenhouse utilizing the byproducts from the biogas facility.

> *If you lose the farms, you lose the fish.*
>
> – **John Sayre**
> ***Director of Northwest Chinook Recovery***

Anaerobic Digestion (AD), a distributed energy technology that has been commercially available for over 20 years, has a very low implementation rate in the Pacific Northwest. Currently, there are no significant farm-based biogas generating systems operating in Washington State, and only two systems in Oregon. Anaerobic digestion has much higher implementation rates in other states, particularly on the East Coast, and it is growing in importance in California. Overseas, anaerobic digestion technologies are widely used to dispose of manure and other animal wastes as well as food by-products and lawn and tree trimmings.

It was this interest in restoring salmon runs and helping family farms that led the Tulalip Tribes to apply for the Department of Energy grant and initiate a comprehensive study of the feasibility of constructing one or more anaerobic digesters in Snohomish County, WA.

III. SUMMARY OF BIOMASS ASSESSMENT

As a first step in the feasibility study, the Tulalip Tribes contracted with RCM Digesters, Inc. to conduct a field survey during August of 2003 to assess the organic waste resource base in Snohomish County. The aim of the survey was to identify organic waste sources, locate and map the proximity of the organic waste to potential digester sites, and collect field observations for later characterization of the biogas production potential of each source.

With support from the Washington State Dairy Federation, the field survey team completed onsite assessments of twenty dairy farms and conducted phone interviews with another eighteen dairymen. The remaining six dairymen were contacted by mail to explain the project and to invite them to call for a phone interview. The majority (69%) of all the dairy farms in Snohomish County expressed interest in the feasibility of a biogas project. This countywide support lends a potential organic waste source from over 10,000 cows, which represents over 80% of the dairy cows in the county. Survey results were summarized to indicate the manure quantity and consistency at each farm. The report includes an index of the farm operators' expectations of the digester project and an evaluation of the modifications needed to adapt each farm's system for manure transport.
Table I below shows the distribution of dairies and cows identified in the survey.

TABLE I: SURVEY OF SNOHOMISH COUNTY DAIRY FARMS

WATERSHED	AREA	NUMBER OF FARMS	NUMBER OF COWS	% OF COUNTY COW POPULATION
Skykomish River	Monroe	6	2,270	23 %
Snohomish River	Snohomish	6	3,185	31 %
Upper Stillaguamish	Arlington	10	2,600	26 %
Lower Stillaguamish	Stanwood	7	2,060	20 %
COUNTY TOTAL		29	10,115	

**This table summarizes data only from those dairies expressing interest in the biogas project*

In addition to assessing the biomass resources available on local dairy farms, the field survey team also assessed potential institutional organic waste sources in Snohomish County. The survey evaluated 14 sites countywide to determine potential digester participation. Those sites expressing interest in the biogas project are listed in Table 2. *"Survey of Institutional and Industrial Sites"*. Five sites expressed interest in the project and were interviewed by the field survey team. They are strong candidates to provide high-quality digester feed. Three other sites were identified and offer possible potential although will require more information to fully determine their waste characterization and ultimate level of support to the project. Six additional sites were contacted but were either not interested, had unsuitable organic waste, or had well-developed waste disposal programs that were satisfactory to their current operations.

The five viable institutional sites currently haul their wastes between ten and twenty miles one-way. It is expected that the three other potential sites currently haul waste a similar distance.

Four of the viable institutional sites lie in relatively close proximity to the Monroe Honor Farm - one of the sites evaluated for possible location of a digestor. The Monroe Correctional Facility and the Evergreen State Fairgrounds are within five miles of the Honor Farm site. The Red Hook Brewery is located about thirteen miles southwest of the Honor Farm site in Woodinville and the Edmonds School District sources are another five or more miles further west from Woodinville. Opportunities for Red Hook and the Edmonds School District to share waste hauling to the Honor Farm may prove beneficial and should be explored during planning and design at the biogas facility.

Alternatively, it may be demonstrated that the more cost effective approach for Edmonds School District would be to go into a digester in the north county. The last strong candidate for a good waste stream is the Tulalip Casino for waste cooking oil and grease trap collection. Detailed economic analysis will be needed to determine if the logistics to transport to the digester will be a viable alternative for the Casino. An onsite evaluation is needed to quantify the Casino's waste stream, as this information was not adequately determined during the phone interview.

TABLE II: SURVEY OF INSTITUTIONAL AND INDUSTRIAL SITES

FACILITY NAME	LOCATION
Monroe Correctional Facility	Monroe
Evergreen State Fairgrounds	Monroe
Red Hook Brewery	Woodinville
Edmonds School District	Lynnwood
Tulalip Casino	Tulalip
Other Potential Organic waste Contributors	
Everett Home Port Naval Base	Everett
National Foods Corporation	Sno. County
Boeing - Everett	Everett

Since transport costs of the manure is a significant issue in regional digester projects, the field survey team ranked the proximity of potential biomass sources to possible digester locations and evaluated the possibility of developing multiple digesters in the county.

Based on the biomass assessment and on the active participation in the Snohomish Basin Biogas Partnership (SBBP) of a number of Monroe-area dairy farms, the SBBP decided to focus further study on one potential digester site in Snohomish County conveniently located near a number of dairy farms and viable institutional biomass sources -- the Washington State Department of Corrections Honor Farm near Monroe.

Attachment 7

Biomass Assessment

for:

TULALIP TRIBES

Snohomish Basin Biogas Partnership

Evaluation of Snohomish County Organic Waste Resource Base For Developing Anaerobic Digestion Systems

November 2003

Prepared by:
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Prepared for:
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Washington, DC

Biogas Partnership:
The Tulalip Tribes
Lower Skykomish River Habitat Conservation Group
Northwest Chinook Recovery
Washington State Dairy Federation

DISCLAIMER

This organic waste assessment is provided as a next step in evaluating the technical and financial potential of regional methane recovery technology in Snohomish County Washington and is to be used as guidance only. The results presented are based on limited field data collection and farm operator interviews. Input errors or erroneous information affect the results. Field survey observations are reasonable planning level estimates based on known digester operations for similar projects. However, decisions on the final geographic location of the digester and site-specific characteristics of participating farms may require subsequent detailed study before a final design and cost estimate can be prepared. Qualified designers, engineers and suppliers should be included in the project implementation team. The AgSTAR Handbook may be used for additional reference and guidance in this process.

FULFILLMENTS

The data compiled in this report has been collected through a grant from the Department of Energy; grant number DE-PS36-02 GO 92006 dated May 1, 2003. The report is submitted in fulfillment of the following grant tasks:

- Task 1. Development of Site Screening and Selection Attributes
- Task 3. Inventory of Organic Residue Resource Locations,
- Task 4. Database Development,
- Task 5 Qualification and Ranking of Organic Residue Resources,
- Task 6. Identification and Evaluation of Potential Sites.

Grant Task 2. Digester Technology Identification and Evaluation, has been submitted as a separate letter report to the Clark Group Project Manager.

This report also fulfills elements of Task 7. Final Report including:

- Item 1. Identification of Site Selection Criteria
- Item 4. Compile Contact and Site Data for Database Inputs
- Item 5. Ranking and Prioritization of Waste Sources

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Acknowledgements

This study is the culmination of an extraordinary team effort by a group of people who care about the future of natural and renewable resources and the quality of life in Snohomish County. Numerous contributions to this project have been made by federal, state, and local agencies, industry managers, schools and local institutions, private contractors and consultants, but most importantly, by the private landowners.

Special thanks go to the Tulalip Tribes, the Lower Skykomish River Habitat Group, the Northwest Chinook Recovery, and the Washington State Dairy Federation for having the vision to come together as the Snohomish Basin Biogas Partnership. Without their united platform of support for a holistic approach to community and resource issues, the study would have been impossible to conduct.

Sincere thanks are also extended to each and every dairy operator and institutional manager who spent invaluable time interviewing with the RCM Field Assessment Team. The degree of interest and cooperation to provide vital data for the survey is the true measure for potential success of this project.

The Dairy Federation and the Lower Skykomish River Habitat Group provided valuable scheduling coordination and fieldwork assistance. A final thanks goes to Staff from the Tulalip Tribes and the Clark Group who were instrumental in managing the project and keeping the process moving forward.

Executive Summary

On April 3, 2003, the Tulalip Tribes, the Lower Skykomish River Habitat Conservation Group, the Northwest Chinook Recovery, and the Washington State Dairy Federation signed a cooperative agreement to form the Snohomish Basin Biogas Partnership (SBBP). These groups came together with the common interest in protecting water quality and salmon habitat, providing jobs and infrastructure to support agriculture in Snohomish County Washington, and to support the development of renewable energy sources. To meet these goals, the SBBP requested a study to assess the feasibility of an anaerobic biogas facility to convert waste such as dairy manure and other organic wastes into energy.

Through a grant from the Department of Energy (DOE) the Tulalip Tribes hired The Clark Group, LLC from Washington, DC to manage the project. As a first step in the feasibility study, the Clark Group contracted with RCM Digesters, Inc. to conduct a field survey during August of 2003 to assess the organic waste resource base in Snohomish County. The aim of the survey was to identify organic waste sources, locate and map the proximity of the organic waste to potential digester sites, and to collect field observations for later characterization of the biogas production potential of each source. This field survey summary report will be a baseline document for developing the feasibility of a digester biogas facility in Snohomish County.

With support from the Washington State Dairy Federation, the field survey team completed onsite assessments of twenty dairy farms and conducted phone interviews with another eighteen dairymen. The remaining six dairymen were contacted by mail to explain the project and to invite them to call for a phone interview. The majority (69%) of all the dairy farms in Snohomish County have expressed interest in the feasibility of a biogas project. This countywide support lends a potential organic waste source from over 10,000 cows, which represents over 80% of the dairy cows in the county. Survey results were summarized to indicate the manure quantity and consistency at each farm. The report includes an index of the farm operators' expectations of the digester project and an evaluation of the modifications needed to adapt each farm's system for manure transport. The table below shows the distribution of dairies and cows identified in the survey.

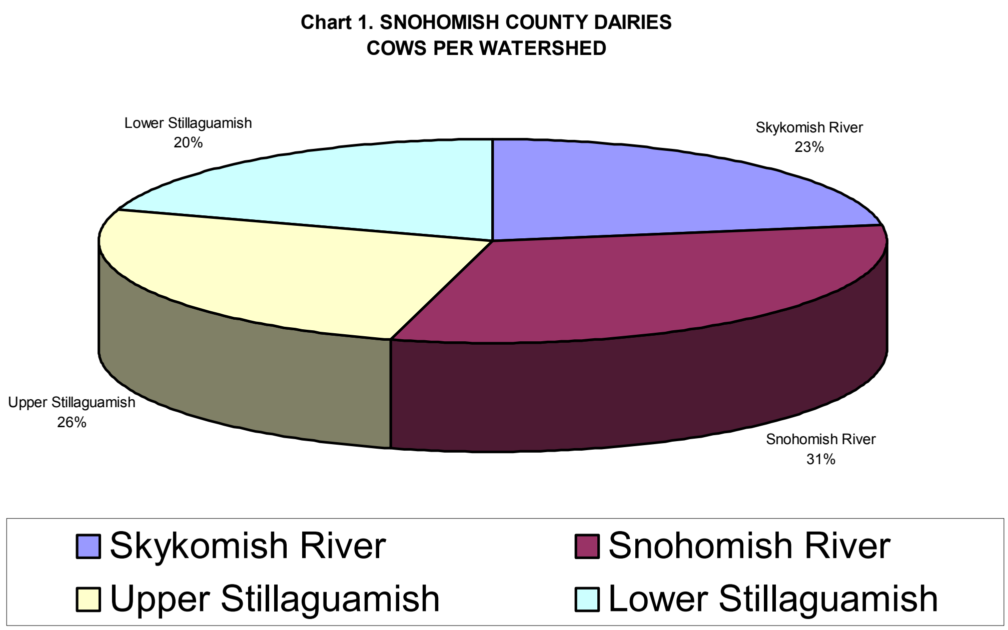
Snohomish County Lactating Cow Population *

WATERSHED	AREA	NUMBER OF FARMS	NUMBER OF COWS	% OF COUNTY COW POPULATION
Skykomish River	Monroe	6	2270	23 %
Snohomish River	Snohomish	6	3185	31 %
Upper Stillaguamish	Arlington	10	2600	26 %
Lower Stillaguamish	Stanwood	7	2060	20 %

COUNTY TOTAL		**29**	**10,115**	

**This table summarizes data only from those dairies expressing interest in the biogas project*

As seen from the table above and depicted in the following pie chart, the distribution of cows in the county is relatively equal amongst all four watersheds. The watershed dairies are grouped within a 5-mile radius. There is a significant distance separating groups of dairies.



Since transport costs of the manure is a significant issue in regional digester projects, the survey team assessed the proximity to possible digester locations. Twelve dairies with 5,455 lactating cows are located in the Skykomish and Snohomish River Basins in southern Snohomish County. There are seventeen interested dairies with 4,660 lactating cows in the Stillaguamish River Basin located in northern Snohomish County. Due to the widely scattered distribution of the dairy farms throughout Snohomish County, the possibility of developing multiple digester sites has been suggested. Two sites were mapped for the Skykomish/Snohomish area. These are the prison farm site south of Monroe and a selected host site farm centered in the Snohomish watershed. An additional site is illustrated on the map of the Stillaguamish basin in the northeast corner of the Tulalip Reservation.

The Washington State Department of Corrections Honor Farm near Monroe, Washington has potential for development into a regional biogas production facility. Early during the field assessment process, the SBBP partners expressed interest in designating the Monroe Honor Farm site as the first priority location for a Snohomish County biogas project. In the immediate area there are two farms that collect concentrated manure by scraping and two that collect more dilute manure by flushing. High strength organic waste co-digestion with dairy manure is common in Europe and is used to increase biogas yield and improve the economics of a regional digester. Supplemental non-dairy organic waste for digester feedstock is available from nearby sources. High quality waste that is distant from the digester site may be a viable input for an Honor Farm digester if it currently has high associated disposal fees. Non-diary organic waste use also applies to the suggested digester site in the Stillaguamish basin.

The Snohomish County Executive Office and the Public Works Department guided the survey team to facilities with organic waste streams, which offer the potential to greatly enhance the biogas production output of the project. These facilities value the biogas partnership because it is an excellent opportunity to turn problematic or expensive waste disposal issues into a valuable renewable resource that is good for the community. Of the 11 institutional/industrial sites surveyed, several show promise to become contributors of organic waste to the centralized digester project. Three sites are shown to be producers of high quality waste and could potentially contribute a significant quantity of generated biogas.

The data and maps provided here are organized around the potential digester sites according to proximity and value of each waste stream to the project. A countywide database has been developed in conjunction with this field survey, which will remain as a tool to compile, compare and prioritize additional organic waste sources as they are identified.

The data presented in this report is intended for use by selected designers and financial analysts in projecting technical and financial performance of a biogas fired cogeneration facility in Snohomish County. The significant dairy waste sources have been identified and characterized. The readily identified industrial/institutional sites have been investigated and were found to represent valuable digester feedstock. Numerous additional sites most likely exist in the area. All of the parties who agreed to an interview support the project concept for its innovative waste utilization in the generation of renewable energy.

1.0 INTRODUCTION

This assessment of potential organic waste sources to feed a regional biogas production facility in Snohomish County, Washington is prepared at the request of The Tulalip Tribes, the Lower Skykomish River Habitat Conservation Group, Northwest Chinook Recovery and the Washington State Dairy Federation, who are known as the Snohomish Basin Biogas Partnership (SBBP).

Snohomish County has a diverse economic base including firms in aerospace, biotech, communications software and manufacturing. The area also supports a large agricultural community including forty-four (44) dairy farms whose waste streams will become a vital input to a regional biogas production project.

Moreover, dairies in Washington are under increasingly intense regulatory scrutiny. Though Snohomish dairy farms are located in rural areas of the county, Washington State regulatory agencies inspect manure management practices on the dairies and the lands receiving the dairy's manure. The dairy farms wish to reduce the environmental risks associated with their manure management, including odor, pathogen and methane emissions. As a proactive solution to these problems, the Washington State Dairy Federation is an active partner in considering the installation of anaerobic digesters to biologically treat dairy manure for environmental purposes and achieving financial returns The regional nature of this project offers a unique opportunity to redistribute digested nutrients onto lands that are under intense crop farming and require additional nutrient applications.

Additionally, Snohomish County offers an exceptional opportunity of mixing several desirable organic institutional waste streams with the dairy manure to further enhance the biogas production from the facility. The digester project concept was well received by institutions as a proactive method to dispose of waste and generate renewable energy.

2.0 BACKGROUND

2.1 Project Goal

The goal of the Tulalip Tribes and the Snohomish Basin Biogas Partners as stated in their cooperative agreement is, "…to protect water quality and salmon habitat, provide jobs and infrastructure to support agriculture in Snohomish County, and to support development of renewable energy sources."

The project objective within the scope of this report is to conduct a countywide organic waste assessment to characterize this resource, which will ultimately support the evaluation by others of the energy potential and overall economic and environmental benefits of the project. The organic waste assessment team contacted all 44 dairies listed in the county and conducted an onsite survey or a phone interview with the majority (86%) of these dairies. Additionally, the survey team contacted 14 institutional organic waste sources for consideration within the project scope. The results of these interviews are summarized in Section 3 of this report.

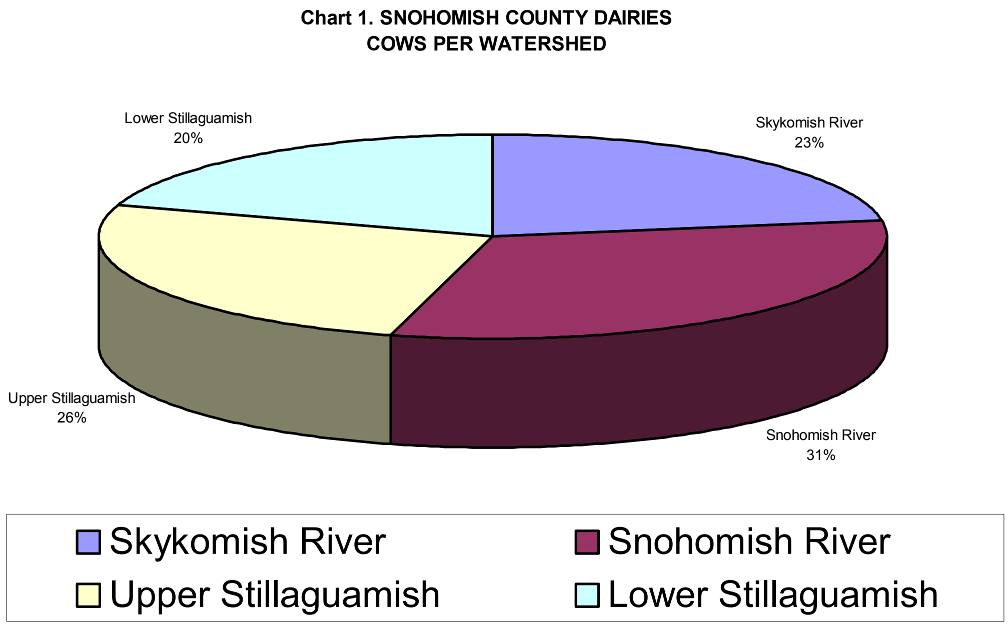
2.2 Project Area

Snohomish County is located in northwest Washington State north of Seattle. The county covers 2,090 square miles, which is an area larger than the state of Delaware. It stretches from the crest of the Cascade Mountains to the shores of Puget Sound. The western lowland of the county has a mild marine influenced climate. Most of the county's development and residents are found along the westernmost Puget Sound lowlands. Rural areas and open spaces complete the county's diverse landscape.

There are two major river basins in the county. The Stillaguamish River and its tributaries drain the northern half of the county into Puget Sound. In the southern part of the county, the Skykomish and the Snoqualmie Rivers converge to form the Snohomish River, which drains northwest through the city of Everett into the sound.

2.3 Farm Locations

There are currently 44 dairy farms registered with the Dairy Federation in Snohomish County. The survey team found three of these either listed for sale or contemplating going out of business in the near future. There were 7 dairies representing a total of approximately 323 cows that were not directly contacted during the limited field survey time. There are 18 dairies in the southern county (Skykomish and Snohomish drainages) of which 12 expressed some level of interest in the project. This represents organic waste from 5,455 milk cows. There are 26 dairies in the northern county in the Stillaguamish watershed. Of these, 17 expressed interest in the project for a total of 4,660 milk cows. Chart 1 Snohomish County Dairies below summarizes the location of the dairies by watershed. Narrative descriptions of each farm are provided in the appendix. Actual site locations are shown on the project maps also in the appendix.



2.4 Institutional Locations

There are numerous potential institutional organic waste sources in Snohomish County. Due to the scattered locations of the Snohomish dairy farms, the concept of multiple digester sites with enhanced organic waste feed from nearby institutional sites was explored. The survey evaluated 14 sites countywide to determine potential digester participation. Those sites expressing interest in the biogas project are listed in Table 1." Institutional Contacts". Five sites expressed interest in the project and were interviewed by the field survey team. They are strong candidates to provide high quality digester feed. Three other sites were identified and offer possible potential although will require more information to fully determine their waste characterization and ultimate level of support to the project. At the time of this report publication, these three sites have been contacted but have not provided additional information as requested. Six additional sites were contacted but were either not interested, had unsuitable organic waste, or had well-developed waste disposal programs that were satisfactory to their current operations.

The five viable institutional sites currently haul their wastes between ten and twenty miles one-way. It is expected that the three other potential sites will also demonstrate this distance. In some cases, the exact proximity to the Honor Farm or to a possible north county digester site therefore becomes less of an issue due to their current expense of hauling wastes a greater distance than the 10 mile circle as shown on the maps in the appendix.

One institutional opportunity is demonstrated by the location of the Monroe Correctional Facility and the Evergreen State Fairgrounds within five miles of the Honor Farm site. Both are shown on the Monroe Area map in the appendix. The Red Hook Brewery is located about thirteen miles southwest of the Honor Farm site in Woodinville and the Edmonds School District sources are another five or more miles further west from Woodinville. Opportunities for Red Hook and the Edmonds School District to share waste hauling to the Honor Farm may prove beneficial and should be explored during the next stage of the project feasibility analysis. Alternatively, it may be demonstrated that the more cost effective approach for Edmonds School District would be to go into a digester in the north county. The last strong candidate for a good waste stream is the Tulalip Casino for waste cooking oil and grease trap collection. Detailed economic analysis will be needed to determine if the logistics to transport to the digester will be a viable alternative for the Casino. An onsite evaluation is needed to quantify the Casino's waste stream, as this information was not adequately determined during the phone interview.

Table 1. Institutional and Industrial Sites

Facility Name	**Location**
Monroe Correctional Facility	Monroe
Evergreen State Fairgrounds	Monroe
Red Hook Brewery	Woodinville
Edmonds School District	Lynnwood
Tulalip Casino	Tulalip
Other Potential Organic waste Contributors	
Everett Home Port Naval Base	Everett
National Foods Corporation	Sno. County
Boeing - Everett	Everett

2.5 Climatic Conditions

Annual temperature and precipitation averages for two USDA Snohomish County thirty - year weather stations are listed in Table 2. The climate of Snohomish County is very mild due to the winds from the Pacific Ocean. In winter, the average temperature at Everett is 40 degrees F and the average summertime temperature is 62 degrees F. Snow and freezing temperatures are not common except at the higher elevations in the eastern half of the county. During the summer, rainfall is fairly light so intensive cropping areas need to irrigate extensively. In late fall and all winter, the rainfall is frequent. Recent years have shown a slight decrease in annual average rainfall.

The average relative humidity in mid-afternoon is typically about 60 percent. The average relative humidity rises during the night and by dawn is typically near 85 percent. In the summer, the sun shines about 65 percent of the time and in the winter the sun shines about 25 percent of the time. Prevailing winds are out of the southwest. The strongest winds occur during the winter. The 24-hour/ 25-year storm event is 8 inches in Snohomish County. The annual average evaporation rate is 40 inches.

Table 2. Monroe and Everett Weather Data

	MONROE	MONROE		EVERETT	EVERETT
MONTH	Ave. Temp	Ave Precip		Ave Temp	Ave. Precip.
January	39.1	6.52		38.7	4.94
February	42.4	4.53		42.0	3.38
March	45.1	4.83		43.6	3.58
April	49.4	3.56		48.5	2.52
May	55.2	2.91		54.2	2.25
June	60.4	2.37		59.2	2.07
July	63.9	1.42		62.9	1.07
August	64.4	1.92		62.5	1.56
September	59.6	3.01		58.1	2.09
October	51.8	4.25		51.3	3.28
November	44.1	6.41		43.9	4.49
December	39.0	6.88		40.4	5.21
TOTAL		48.61			36.44

2.6 Regional Soils and Subsurface

According to the 1983 USDA Soil Survey of Snohomish County, the predominant soil type in the Tualco Valley south of Monroe around the Honor Farm site is Sultan silt loam. This soil is listed as being very deep, moderately well drained soil on flood plains. The top twelve inches is typically silt loam overlaying a layer of silty clay loam about thirty inches thick. The lower soil layers to about 60 inches deep are listed as stratified very fine sandy loam and sand. In some areas of this soil type, the surface is silty clay loam and very poorly drained. Seasonal soil wetness can be a limiting factor for wheeled vehicle access, which would cause soil compaction and severe ruts. The main limitation for building is the risk of flooding and the seasonal high water table. The depth to ground water in the Tualco Valley near Monroe is reported by the area farms to be shallow, seasonal and highly variable. Some area wells produce water at 20 feet. One area storage pond was reported to be 18 feet deep. The soil is listed as moderately permeable with unstable cut banks subject to cave in. In general, all of the river valley land in Snohomish County is similar in characteristic typified by the Puget-Sultan-Pilchuck soil complex. Engineering should take actual site-specific characteristics into consideration the potential for flooding, the load bearing capacity of the soil and the actual seasonal high groundwater table.

2.7 Regional Topography

Nearly level alluvial deposits along the major river valleys characterize the topography of the Monroe site. The valley floor rises to terraces of glacial till and outwash plains in the mid valley elevations. The eastern section of the county continues to climb to steep mountainous areas with narrow river valleys.

Figure 1. Tualco Valley near Honor Farm site.

Figure 2. Valley south of Honor Farm Site

2.8 Facility Description

2.8.1 Typical Dairy Farm Features

For the most part, the lactating herds are housed in free stall barns offering 100% manure collection. The cows walk to the milking parlor in designated groups along cement walkways that are also sources of collectable manure. If the dairy allows the cows out on pasture, the database reflects a reduced percentage of collectable manure to account for this practice. The housing for the dry cows and in some cases replacement heifers, was much more variable from dairy to dairy. If these animals were confined in collectable manure situations for only a portion of the year, this is indicated in the site narrative and the database.

Figure 3. Typical Free stall Barn Housing

Rubber tire tractor scrapers and lagoon water flush systems were the two basic manure collection techniques observed in Snohomish County. The majority of the farms in Snohomish County use the scrape collection method, however, the larger farms representing nearly half of the cows, tended to use a flush system. The scrape dairies were observed to use a rubber scraper mounted on a tractor that mechanically moves the manure to a collection pit.

Figure 4. Typical Rubber Tire Scraped Manure Collection

The flush dairies pump recycled water from their waste ponds through the barns alleys and walkways to wash the manure away. Flush systems can be set up to automatically cycle, but in some instances, the dairyman chooses when to activate the system. Flushing cycles are usually scheduled when the cows are out of the barn and in the parlor for milking. The narratives in Appendix 1 describe in detail the flushing system at each flush collection farm. Flush systems from farm to farm were highly variable and should be evaluated on a site-specific basis.

Figure 5. Flushed Manure Collection System

2.8.2 Site Development Limitations

There are several factors to be considered for site development of a regional digester in Snohomish County. In a regional digester scenario, the interest is to receive as much digester feed as possible each day. The proximity of the farms to one another is a significant issue affecting digester feed inputs. To this end, the survey team looked at the possibility of centralized sewering near the Monroe Honor Farm site. While sewering is a good approach, many potential obstacles were noted that would require specific engineering considerations. In other projects nation-wide where a regional concept has been developed, a hauling distance of approximately five miles was found to be a practical economic limit. This limit is calculated by factoring the local hourly trucking rate with an evaluation of the time it takes to load the truck, drive the haul route, and unload the truck at the digester site. The regional digester project at Tillamook, Oregon was evaluated and shows a haul radius of about 2.5 miles.

As shown in the project maps in the appendix, the Snohomish County dairies have a disadvantage of scattered locations over four watershed areas. However, within the watershed areas of Snohomish County, the dairies grouped well with a preliminary 5-mile radius test. In this convention, there are grouping possibilities with limited crossings of major roads and minimal travel through towns and major population centers. The project maps have been drawn to suggest various dairy farm groupings within a five-mile radius and are intended to serve as a preliminary assessment tool to support the financial feasibility analysis. These groupings will require an additional detailed transportation study to evaluate the local area economics associated with transporting digester feeds. Once haul routes have been determined, additional study will be needed to measure the actual road miles to the chosen digester site, as well as consideration of any issues such as bridge loading limits, road weight limits, and local area commute traffic issues.

Manure quality will need careful site-specific consideration. The percent of digestible solids from the flush dairy systems will need further consideration by the design engineer. The site survey contains flush volume information based on farmer interviews. Gallons per day flush volumes were estimated and based on the reported number of flushes, the number of valves in the flush system, and the pump rates and valve output values. Actual manure dilution from each flush system may vary dramatically and may need more precise measurements as well as certain unique technologies for design criteria.

Rainwater dilution is another factor requiring detailed study. Each farm has a unique facility layout that will allow for varying amounts of rainwater to fall on manure collection areas. Additionally, the annual average rainfall within Snohomish County can vary from 36 to 48 inches. When the candidate farms have been selected for a regional digester, engineering may need a detailed site-specific evaluation to measure the potential for rainwater dilution of the manure. The farm site narrative descriptions contain preliminary information regarding the level of rainwater exclusion observed at each farm. All dairymen interviewed demonstrated keen awareness of the need to control rainwater inclusion into their manure stream.

Finally, each farm will need engineering consideration to determine site-specific requirements for manure off loading facilities once the details for manure transport to the digester have been determined. In nearly all cases, the farms have a central point of collection and some pumping ability. These facilities will need further evaluation to determine capacity, accessibility and overall suitability for collection and transport to the digester site.

2.9 Rations

Production animal rations were reported to be very similar to those used at comparable facilities in other dairy regions. The ration is generally a mixture of silage, hay, and grain. Additionally, some farms also feed cottonseed and distillers grains. The reported daily pounds of dry matter (DM) intake ranged from 43 to 58 pounds. Most dairies interviewed could not readily provide the DM measurement.

2.10 Milk Production

The majority of the herds are milked twice a day. Nine of the farms reported milking three times per day and three of the farms milk four times per day. The average milk production was calculated at approximately 76 pounds per day per cow. Milk production ranged from 48 pounds per cow per day for an all Jersey herd up to 108 pounds per cow per day for an all Holstein herd.

2.11 Bedding

Most of the cows are housed in free stall barns with feed alleys. A dairy in the Lower Stillaguamish Watershed is noted as being the inventor of the free stall barn concept. Sawdust or wood chips were a prevalent choice of bedding, however five of the larger farms are using sand to bed the cows. The specific information is recorded for each farm in the project database and the site narratives in the appendices.

2.12 Animal Population

Animal populations by watershed are listed in Table 3. Chart 2 below summarizes the population of milking herds found in each of the four Snohomish County watersheds. Individual farm current populations are compiled in the database and discussed in the site narratives that follow. It should be noted that cow populations might vary somewhat from the numbers collected during the August 2003, interviews and should be taken into consideration by the design engineer.

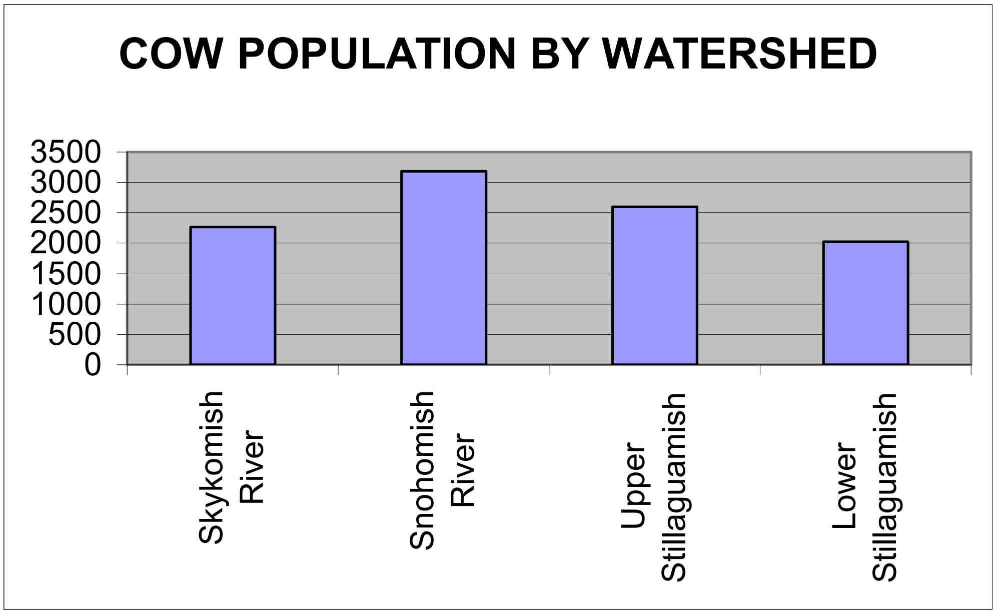
Table 3. Snohomish County Lactating Cow Population *

WATERSHED	AREA	NUMBER OF FARMS	NUMBER OF COWS	% OF COUNTY COW POPULATION
Skykomish River	Monroe	6	2270	23 %
Snohomish River	Snohomish	6	3185	31 %
Upper Stillaguamish	Arlington	10	2600	26 %
Lower Stillaguamish	Stanwood	7	2060	20 %

COUNTY TOTAL		**29**	**10,115**	

**This table summarizes data only from those dairies expressing interest in the biogas project.*

Chart 2. Lactating Cow Populations



2.13 Water Management

Water management was discussed with the dairies during the field survey. In all cases, potable water for the cows and wash down of the milk parlor was provided to the dairies from an on-site well(s). This water was not metered and there was little idea of the actual quantity of water used. The most common practice reported was parlor wash water originating after each milking using a one-inch hose for an average of 20 minutes per wash. Some interim hand spraying in the parlor occurs on an as needed basis to maintain cleanliness.

An average consumption for mature Holsteins would be an expected 23-26 gallons of water per cow day. The Natural Resource Conservation Service (NRCS) estimates in the Agricultural Waste Management Handbook, approximately 0.6 cubic feet of water is used in milk house and milk parlor cleanup per animal unit milked. This is about 6 gallons per mature Holstein.

Rainwater management is highly variable from site to site. Each farm visit included discussion of existing strategies and facilities to control rainwater inclusion with manure. All dairymen are aware of the need to address storm water management as a manure storage issue and nearly all sites have some measures in place. The database compiles a preliminary assessment of rainwater dilution potential. However, each site for digester consideration will require a detailed onsite survey to accurately measure the annual gallons of rainwater dilution and to further determine the need and ability for additional diversion methods.

2.14 Manure Characteristics

The scrape method of manure collection adds no dilution water into the manure stream. Parlor and equipment washing adds some dilution leaving the scraped manure typically in the range of 11% to 13% solids. Maintaining this concentration results in a greater potential gallon for gallon than diluted manure to produce biogas. It was estimated that dairies using the scrape method for manure collection in Snohomish County produce 82,800 gallons of manure per day.

In a conservative and controlled flush system, approximately 200 gallons per cow per day will yield a waste concentration of 3% solids. Eight dairies use the flush method in Snohomish County. Based on interview data collected about current flushing practices, on average these dairies are pumping over 400 gallons per cow per day through their barns. Farms with flush manure and sand bedding use the greatest volumes of flush water per cow. It was estimated that flush dairies in Snohomish County are handling 1,992,000 gallons of manure-laden wastewater per day. These factors will necessitate additional technology inputs and engineering considerations to account for the very dilute nature of the waste and to ensure that sand bedding is adequately separated before entering a digester. Table 4 below lists the total number of dairies and cows per watershed, and itemizes the number and location of the flush dairies compared to the scraped dairies.

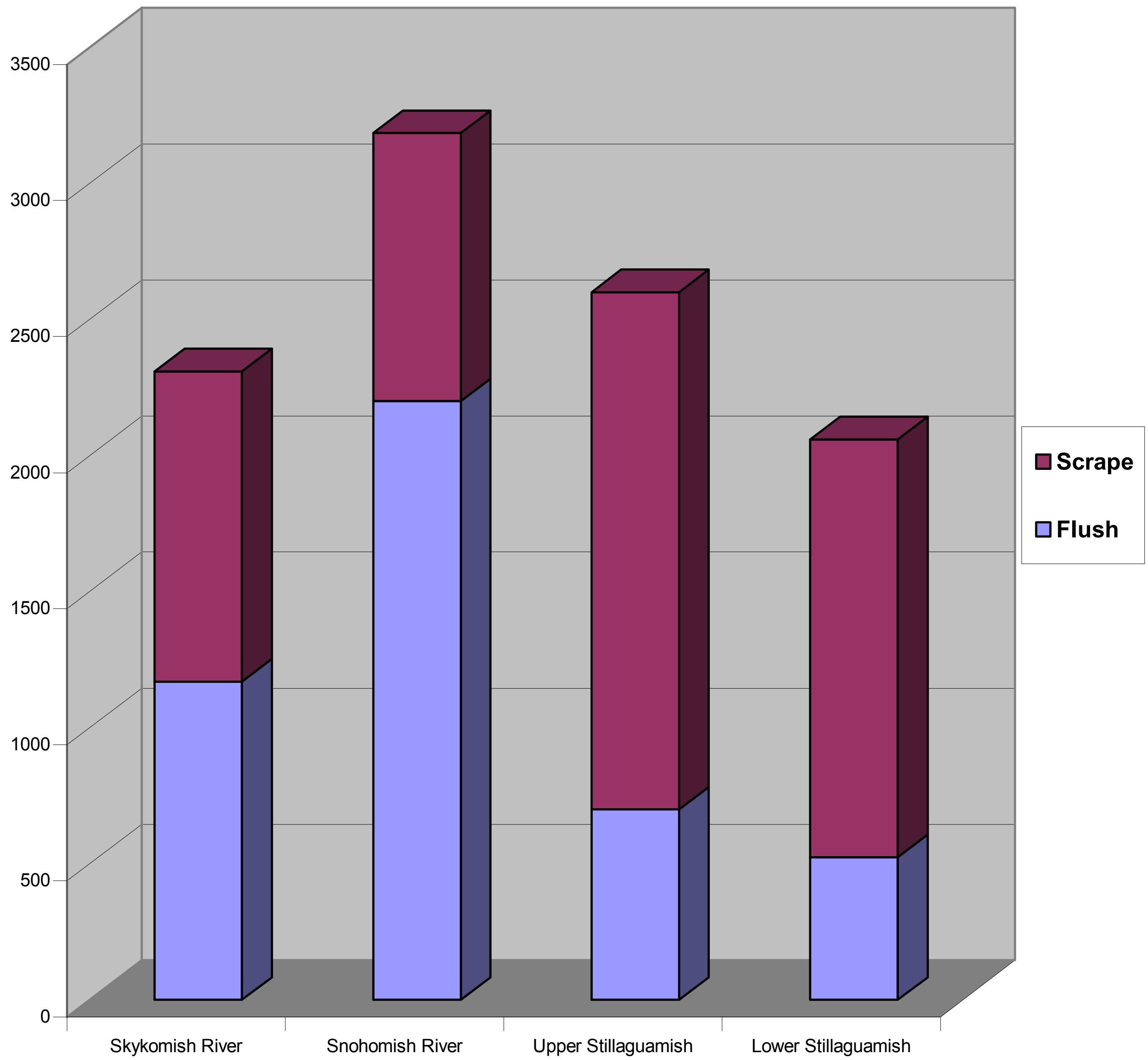
Table 4. Snohomish County Manure Collection System Comparison

	FLUSH DAIRIES				SCRAPE DAIRIES		
WATERSHED	**Number of Dairies**	*Number of Cows*	**Gallons per Day**		**Number of Dairies**	**Number of Cows**	**Gallons per Day**
Skykomish River	2	1170	681,000		4	1100	16,500
Snohomish River	3	2200	915,000		3	985	14,775
Upper Stillaguamish	2	700	196,000		8	1900	28,500
Lower Stillaguamish	1	525	200,000		6	1535	23,025
COUNTY TOTALS	**8**	**4,595**	**1,992,000**		**21**	**5,520**	**82,800**

2.15 Manure Collection

Chart 3 below summarizes the ratio of scrape dairies to flush dairies by location in the major watershed areas in Snohomish County. Site-specific data is compiled in the appendix. .

Chart 3. MANURE HANDLING SYSTEMS



3.0 SITE SUMMARY DESCRIPTION

3.1 Lower Skykomish Dairy Group - Monroe

Map 1. Monroe Area in the appendix at the end of the report shows two flush dairies and two scrape dairies totaling 1,780 cows with proximity locations that could potentially pump suitable digester feed to a digester at the Honor Farm. All other dairy manure in the area would require trucking to the site. The immediate area south into King County was also surveyed but did not produce any viable contributors for the Honor Farm Site. Table 5 below summarizes the dairy waste identified within a 5-mile radius of the Monroe Honor Farm site. There are two additional farms in the Monroe Group that lie outside of the 5-mile radius. They are shown in Table 6 and also appear on the Monroe Area Map in the appendix.

Table 5. Dairies Within a 5-mile Radius of the Monroe Honor Farm

	FLUSH SYSTEMS				SCRAPE SYSTEMS		
WATERSHED	**Number of Dairies**	***Number of Cows****	**Gallons per Day**		**Number of Dairies**	**Number of Cows***	**Gallons per Day**
Skykomish River	2	1170	681,000		2	610	9,150

**Table does not include dry cow populations*

Each dairy compared in Table 6. "Lower Skykomish Group Site Data" below is identified with a corresponding alphanumeric map locator label as shown on the project maps in the appendix. A narrative description with detailed information for each site is also provided in the appendix. Table 6 provides summary data on all farms in the Monroe/Lower Skykomish area that have expressed some level of interest in the biogas project.

Table 6. Lower Skykomish Group –Monroe Area; Site Data Comparison

Site Map Code	Collection System	Bedding Material	Number Milk Cows	% Manure Collected	Number Dry Cows	% Manure Collected	Number Milkings Per Day	Scrape Waste Gal/Day	Flush Waste Gal/Day	Estimated. Annual Rain Gal.Dilution	Digested Nutrient Pref.
M2	Flush	Sand	610	100	70	100	4	N/A	345,000	606,000	Export
M4	Scrape	Shavings	140	100	25	50	2	2,288	N/A	Unknown	Export
M5	Scrape	Shavings	470	100	70	90	2	7,995	N/A	Unknown	Export
M6 *	Scrape	Saw dust	190	50	30	50	2	1,650	N/A	Unknown	Import
M7	Flush	Sand	560	100	60	50	3	N/A	336,000	909,000	Export
M8 *	Scrape	Saw dust	300	100	100	0	2	4,500	N/A	30,300	Import
	TOTAL:		**2,270**		**355**			**16,788**	**681,000**	**1,545,300**	

* Dairies located outside of the 5-mile Monroe Honor Farm radius.

3.2 Snohomish Dairy Group

The next dairy group is shown on **Map 2. Snohomish Area** located in the appendix. A five-mile radius was drawn centered on the largest dairy in that area to help evaluate proximity for a potential alternative host site within that group. This site was selected based on the central location and higher level of interest shown by the dairy operator.

Another possible scenario that becomes apparent when these dairies are located on the map is to consider the cost to haul wastes from the Snohomish group and combine it with the Skykomish group. If the Skykomish and the Snohomish dairies are deemed a collectively viable combined group, there are approximately 5,155 lactating cows for consideration. This combination is shown on a map in the report appendix labeled **Map 3. Monroe-Snohomish Area.** This map depicts an area within a 10-mile radius to the Honor Farm and is intended to provide a visual tool to facilitate the development of a detailed economic analysis. As can be seen from the map, the actual road miles required to transport wastes to a central digester site may be further than the "10-mile radius" and will require additional study to determine the actual practical haul limit. About 1,785 of the cows in this area are on scrape manure collection systems, which produce high quality waste for anaerobic digestion and gas production. The 5 larger dairies have approximately 3,370 lactating cows on flushed systems with sand bedding. These 5 flushed dairies are pumping a combined calculated waste volume of 1,572,000 gallons per day. Table 7 below summarizes the dairy waste identified within a 10-mile radius of the Monroe Honor Farm. The number of cows reflect only lactating cows.

Table 7. Dairies Within a 10-mile Radius of the Monroe Honor Farm

	FLUSH SYSTEMS				SCRAPE SYSTEMS		
WATERSHED	**Number of Dairies**	***Number of Cows***	**Gallons per Day**		**Number of Dairies**	**Number of Cows**	**Gallons per Day**
Skykomish & Snohomish	5	3,370	1,572,000		6	1,785	26,775

The Snohomish area dairies are labeled in the Site Narratives and on the project maps in the report appendix with the designation "SN" and a number. Table 8 on the following page provides a site-by-site summary data comparison of the group of dairies located around the town of Snohomish in the Snohomish River drainage. Specific site data can be found in the appendix.

Table 8. Snohomish Group – Site Data Comparison

Site Map Code	Collection System	Bedding Material	Number Milk Cows	% Manure Collected	Number Dry Cows	% Manure Collected	Number Milkings Per Day	Scrape Waste Gal/Day	Flush Waste Gal/Day	Estimated. Annual Rain Gal.Dilution	Digested Nutrient Pref.
SN1	Flush	Sand	700	100	60	100	3	N/A	360,000	Unknown	Export
SN2	Flush	Sand	600	100	60	100	3	N/A	195,000	909,000	Export
SN3	Scrape	Shavings	85	100	10	50	2	1,350	N/A	515,100	Import
SN4	Flush	Sand	900	100	Unknown	0	3	N/A	360,000	151,500	Import
SN7	Scrape	Sawdust	600	100	80	100	3	10,200	N/A	575,700	Export
SN8	Scrape	Sawdust	300	100	40	50	2	4,800	N/A	Unknown	Import
	TOTALS:		**3,185**		**250**			**16,350**	**915,000**	**2,151,300**	

3.3 The Stillaguamish Watershed Dairy Group

A 10-mile radius drawn from the northeast corner of the Tulalip Reservation near a point called Stimson Crossing encompasses the large majority of the Upper and Lower Stillaguamish watershed dairies. This is shown on **Map 4. The Upper and Lower Stillaguamish** located in the appendix. This radius could potentially provide manure from about 3,800 lactating cows. Scraping collects the manure from about 2,575 of these cows. The three flush system farms in this area pump a calculated waste volume of 396,000 gallons per day.

There is a 520-cow scrape dairy about 2.5 miles further north of Stanwood, just outside of the delineated 10-mile radius area and another 200-cow scrape dairy is just outside the radius northeast of Arlington. The closest proximity group of dairies found in the county is along the lower Stillaguamish River southeast of Stanwood. The majority of these dairies collect manure using scrape systems.

Table 9 below summarizes the combined dairy waste found within a 10-mile radius proximity in the Upper Arlington and Lower Stanwood areas of the Stillaguamish Watershed. There are approximately 615 lactating cow in the watershed that lie outside of this proximity. Data on the total watershed can be found in the following comparison tables 10 and 11 as well as the narrative data in the appendix. The Stillaguamish Map 4 in the appendix shows both a 5-mile and a 10-mile radius line centered on a central point at Stimson Crossing to help visualize the proximity and potential digester opportunities for the dairy waste in this part of the county. Alternatively, the compiled site data can be factored into the Monroe Honor Farm project site if the economic analysis can demonstrate support for the option to transport wastes from the Stillaguamish watershed to Monroe.

Table 9. Stillaguamish Watershed Dairies Within a 10-mile Radius

	FLUSH SYSTEMS				SCRAPE SYSTEMS		
WATERSHED	**Number of Dairies**	***Number of Cows***	**Gallons per Day**		**Number of Dairies**	**Number of Cows**	**Gallons per Day**
Upper and Lower Stillaguamish	3	1,225	396,000		12	2,775	41,625

The Stillaguamish dairies are described in the site narratives and shown on the project maps in the report appendix. Those labeled with an "A" are in the Arlington area (Upper Stillaguamish) and those with "ST" are in the Stanwood area (Lower Stillaguamish) area.

3.3.1 Upper Stillaguamish Group – Arlington Area

Table 10 on the following page provides a site data comparison of the dairies located in the Upper Stillaguamish Watershed around the city of Arlington.

Table 10. Upper Stillaguamish Group, Arlington Area – Site Data Comparison

Site Map Code	Collection System	Bedding Material	Number Milk Cows	% Manure Collected	Number Dry Cows	% Manure Collected	Number Milkings Per Day	Scrape Waste Gal/Day	Flush Waste Gal/Day	Estimated. Annual Rain Gal.Dilution	Digested Nutrient Pref.
A1	Scrape	Sawdust	225	100	35	50	2	3,638	N/A	136,200	Export
A2	Flush	Sawdust	280	100	40	50	2	N/A	108,000	499,400	Balanced
A4	Flush	Shavings	420	100	90	100	4	N/A	88,000	Unknown	Balanced
A5	Scrape	Sawdust	200	50	0	0	2	1,500	N/A	90,800	Import
A7	Scrape	Sawdust	270	100	30	0	3	4,050	N/A	68,100	Import
A8	Scrape	Sawdust	115	50	15	50	2	975	N/A	Unknown	Import
A9	Scrape	Sawdust	450	100	0	0	3	6,750	N/A	Unknown	Import
A10	Scrape	Sawdust	140	50	10	50	2	1,125	N/A	Unknown	Export
A11	Scrape	Sawdust	400	50	100	50	2	3,750	N/A	397,250	Import
A12	Scrape	Sawdust	100	50	15	50	2	863	N/A	0	Balanced
	TOTALS:		**2,600**		**335**			**22,651**	**196,000**	**1,191,750**	

3.3.2 Lower Stillaguamish Group – Stanwood Area

Table 11 following provides a site data comparison of the dairies located in the Lower Stillaguamish Watershed around the city of Stanwood. This group is in the northwest corner of the county north of the Tulalip Reservation lands.

Table 11. Lower Stillaguamish Group, Stanwood Area – Site Data Comparison

Site Map Code	Collection System	Bedding Material	Number Milk Cows	% Manure Collected	Number Dry Cows	% Manure Collected	Number Milkings Per Day	Scrape Waste Gal/Day	Flush Waste Gal/Day	Estimated. Annual Rain Gal.Dilution	Digested Nutrient Pref.
ST1	Flush	Sawdust	525	100	60	100	4	N/A	200,000	158,900	Import
ST5	Scrape	Sawdust	150	100	20	50	2	2,430	N/A	Unknown	Export
ST6	Scrape	Shavings	170	100	20	50	2	2,700	N/A	68,100	Balanced
ST7	Scrape	Sawdust	175	100	25	50	2	2,813	N/A	Unknown	Balanced
ST8	Scrape	Sawdust	260	100	30	50	2	4,125	N/A	181,600	Balanced
ST11	Scrape	Sawdust	260	100	30	100	3	4,350	N/A	113,500	Export
ST12	Scrape	Sawdust	520	100	80	50	3	8,400	N/A	681,000	Balanced
	TOTALS:		**2,060**		**265**			**24,818**	**200,000**	**1,203,100**	

3.4 Institutional Sites

Several area "institutional" facilities were contacted to determine whether they produced an organic waste that might be suitable for the digester project. The following narrative descriptions summarize the key sites identified during the field survey conducted in August 2003. Since each site presented unique data, no summary comparison table was developed. As noted earlier, these sites only represent a few of the possibilities that exist in the area. Once the digester site has been definitely determined, undoubtedly institutional possibilities will need to be revisited.

3.4.1 Nestlé-Carnation Farm (King County)

This facility is a retreat and training facility for corporate staff. There is no processing of any kind on the site. Formerly there was a pet food research facility with up to 1,000 dogs and cats. Currently there is a herd of 100 cows being milked on the site. Manure collection is primarily by flushing. There is a small amount of dry manure and bedding "screenings" that the operators would like to transport off site. All other waste is disposed of on site. This facility is greater than 5 miles from the Monroe Honor Farm and is not a likely candidate for the digester project.

3.4.2 Twin City Foods, Inc.

Twin City Foods is located in Stanwood in the lower Stillaguamish watershed. The plant produces frozen vegetables labeled for Safeway, Albertson's and others for domestic and export markets.

From early July to mid August the plant processes locally harvested peas and their waste spikes at 1.5 million pounds during this period. The remainder of the year the plant does partial processing and packaging of corn (nibblets), green beans, lima beans and French fries producing waste amounting to one million pounds.

The waste is usually in water suspension and is pumped to a "waste reel" that has a 20-micron screen for dewatering. From there it is handled in bulk for use as animal feed. There is a plan to do further dewatering with a screw press.

Most of the time the waste is sold but seasonally there may be added costs to the disposal. The corporate office (at the same address) was contacted for more details on the waste handling and desirability of working with a digester project. They confirmed that the wastes are sold and that they would not be interested in contributing to a digester project as long as there is no net disposal cost.

3.4.3 National Foods

This office deals with the disposal of chicken manure from multiple sites in western Washington. They are interested in the potential of a regional digester project to help with waste disposal but had no data on his quantities or freshness of the manure. They are open to be contacted in the future as the project developed to the waste handling and production stage.

3.4.4 Monroe, WA School District

The district does some waste separation of paper, cardboard and aluminum cans for recycling, but there is no effort to sort kitchen waste and plate scrape waste. His assessment of the cooked food waste was that it was a small fraction of the total waste stream and it had significant amounts of plastic and paper/cardboard packaging material mixed in.

Waste Management Northwest currently hauls the district's waste. Before the expense of food waste sorting was to be explored, the district will need to know specific tipping fees and any other advantages that the digester project could offer.

3.4.5 Sea Growth, Inc.

820 47th St., Everett, WA 98203

This reference came from Terry Williams at the Tulalip Tribe through Dave Somers. It was thought that they were a "fish processor."

This company uses fish waste in an established European process to produce fish-based plant fertilizer products in both liquid and solid form. The only waste materials from their operation are fish bones and a very small quantity if fish waste that may be characterized as digestible.

Sea Growth commented on a test at the Renton, WA sewage plant that used the liquid fertilizer product in a laboratory scale test in what sounded like a 50-gallon anaerobic digester. They said that the test showed a 12% increase in digester "activity" with the fertilizer added, but there has been no further interest from Renton. They are interested in the regional digester as a vendor selling his product to enhance the digester output.

3.4.6 Naval Station Everett

The waste on the base s sorted "somewhat" to recover cardboard, paper and aluminum for recycling. There is no effort to separate food waste, either cooked or uncooked. It is all combined in dumpsters of various sizes and types for removal by a local contractor (Rubatino Refuse Removal, Inc. 425-259-0044).

There are no recent characterizations of the waste stream, but over two years ago there was a study of the waste produced on the base. It is in electronic format and Gary said he would email it to us. To date, this report has not been received.

This office is responsible for the port facility as well as waste removal from an annex in Marysville and a radio station in Arlington. Since the cost of removal is based on the number of trips as well as tonnage, there are plans to revise procedures with the next three months to centralize the waste removal to a central point. Compactors at the central location point are to reduce the number of trips.

Some "seasonality" was described although it comes with the docking of an aircraft carrier with a crew of 5,500 rather than conventional seasons.

3.4.7 Edmonds School District 15

10,000 meals per day are prepared in six kitchens located in the larger high schools and middle schools. The food is distributed to a total of 27 serving operations throughout the district (School district municipalities include Brier, Lynnwood, Montlake Terrace, Woodway and Edmonds).

Plate scrape waste was described as highly contaminated with plastic and some cardboard and did not contain much digestible food waste. Further, it is scattered out among the twenty-seven sites in relatively small quantities so consideration can be centered on the six kitchen sites where the un-cooked and cooked waste is uncontaminated and high in digestible content.

The kitchens have been contacted by the municipal waste treatment people to encourage them to eliminate fats and oils from disposal in the drains. Also they are to limit the amount of food waste sent through the garbage disposals that discharge to drains. The district management has considered use of "pulpers" to grind all the waste before sending to the landfill and presses to remove water. This is on hold for now but will be reconsidered if it can reduce weight and volume to hold down transport costs.

The waste from the six kitchens was quantified as follows:

Two large kitchen	240 gal. /day for	480
Three kitchens at	180 gal. /day for	540
One smaller at	150 gal. /day for	150
		Total 1,170 Gallons per day.

Since the schools were not in full operation there was no opportunity to characterize the waste for composition, water content, weight (or density). Besides the obvious seasonality of the nine-month school year September through June 20), Ms. Lloyd said that the summer session (July through August) accounted for 10% of the annual waste and this percentage was expected to increase in the coming years.

The school district is very interested in the project. They feel the potential benefits could expand beyond simply solving a waste disposal issue to include good community public relations and provide a unique educational opportunity for the district. They want to be kept in the loop as the project develops.

3.4.8 Monroe Correctional Complex

The facility currently has 2,500 beds with a planned increase of 200 beds to be completed next year. There are four separate facilities within the prison compound. Prison waste is sorted for recyclables and it was offered that additional sorting would be possible if required in the scope of a digester project.

Total waste production was reported to be fairly consistent at 120 tons per month with about 70% (or 80 to 84 tons) being food waste. Within the food waste there is about 3,000 pounds per day (45 tons per month) of uncooked waste (called "green chop" by the staff) consisting of peelings, lettuce cleanup, etc. In the cooked waste and plate scrapings there are few bones (mostly chicken and rarely ribs) that could be targeted for additional sorting.

Most of the cooking is done in one kitchen with hot food sent out to the other facilities. The waste is packaged in plastic bags (approx 33 gallon) and put into two-yard dumpsters. The prison's three trucks take the waste every other day to a transfer station in Arlington. They are very interested in shortening the trip and cutting tipping fees on the digestible portion of the waste.

Additional study should concentrate on the waste volume from the main kitchen. The other facilities waste is almost all plate scrapings with no preparation waste, which results in lower quality wastes for the digester.

3.4.9 Red Hook Brewery

The Red Hook Brewery is located south of Woodinville, which is approximately 13 miles from Monroe. They are very interested in the opportunity that a regional digester project could offer for their waste disposal program. They have provided the following waste characterization information for consideration. The waste is spent non-autolyzed yeast. The pH is 3.9 and the solids content is about 17%. The BOD is 150,000 mg/L and the Total Suspended Solids are 110,000 mg/L. The brewery uses a tanker truck to dispose of about 8,200 gallons per week.

Both the Red Hook Brewery and the Edmonds School District are more than 15 miles from the Honor Farm. However, there could be some opportunity to combine waste transport efforts and share the cost. A possible route would bring School District wastes down Highway 405 to the Intersection with Highway 522 near the Brewery in Woodinville. If the wastes could be combined at that point, they could then share the cost of transportation along Highway 522 to Monroe and then south to the Honor

Farm. Any method to reduce the transportation and disposal costs will be an enticement to send their waste to the regional digester.

3.4.10 The Evergreen State Fairgrounds

The Evergreen State Fairgrounds in Monroe is within the 5-mile radius of the Honor Farm. The Fairgrounds management provided details on the livestock waste from the facility during a phone interview. The food waste was reported to be heavily contaminated with paper and plastic service items and would not be suitable for the digester.

On an annual basis the fairgrounds produces an average of 10,000 cubic yards (cy) of animal waste. Examples are 10,908 CY in 2001 and 9,540 CY in 2002. About 15% of this waste is produced in the four weeks from mid-August to mid-September during the Evergreen State Fair event. Throughout the remainder of the year there are numerous events that mainly involve horses.

Fair event manure is mixed cow and horse manure with a very small and unspecified amount of manure from small animals (rabbits, chickens etc.). All of this waste is mixed with a large quantity of bedding that is roughly 40% straw and 60% coarse fir and hemlock shavings.

The bedding for horses is wood shavings. It tends to be used more heavily with these animals so this waste is predominantly shavings. This is true for the fair and almost all of the remainder of the year's events.

The waste is removed with trucks 25 to 30 CY at a time for $2.50 per CY. The waste tends to pile up during the surge at fair time and there is some composting action taking place in the piles.

There is no analysis to describe in exact terms the concentration of manure in the mixed waste, but the impression given is that the bedding content is quite high, perhaps approaching 40% to 50% by volume.

3.4.11 The Tulalip Casino

As described by telephone, most kitchen waste is bagged and transported as a mix of food and packaging material. It is thought that an effort to sort the pre-cooked and plate scrape waste to any extent would be too expensive. One waste product that creates a discrete expense is the oils and fats from deep fat fryers and the casino's central grease trap. It is collected and hauled away by a disposal service for a fee. This material is produced at a consistent rate and is high in biogas potential. More detail is needed to estimate quantities, consistency and describe handling methods. This waste offers a potentially high quality digester input. Further onsite quantification is needed to calculate the effect of this input to the digester performance.

3.4.12 Other Opportunities

Numerous digestible food waste resources exist in the nearby Everett area. Several organic waste inputs could be further quantified for a regional biogas project. According to a Snohomish County Waste Composition Report from 1998, after recyclables are removed, food waste is the single largest item remaining in the solid waste stream. Food waste feedstock has good potential to enhance the biogas production from a regional dairy manure digester.

3.5 Biogas Production

NRCS estimates in the Agricultural Waste Handbook: one 1000 lb. mature dairy cow (dry or in production) excretes about 10 lb. VS per day. Snohomish County Dairy Farm mature Holstein animals weigh on average of 1400 lb. per animal. As noted in the project database there are a few herds with Jersey animals that weigh on average about 1000 pounds. In addition to bedding and other wastes, mature Holsteins produce about 14 lb. of volatile solids per day. Between 35 and 40% of the manure volatile solids will be converted to biogas (60% methane, water saturated). The suitable institutional wastes for the digester will need case-by-case evaluation to estimate their respective biogas potential. Final digester design will necessarily include provisions to mix these wastes with the available dairy manure to optimize biogas production.

3.6 Liquid Nutrient and Fiber Utilization

After fiber is removed from the digester effluent, both the fiber and the liquid nutrient will be available for utilization. Table 12 contains an estimate of liquid nutrient and fiber characteristics.

These estimated ranges are based on currently operating dairy digesters similar to that envisioned for the Snohomish County Regional Digester project; the values are not exact; actual values may vary significantly.

Table 12. Characteristics: Fiber and Digested Liquid

	Fiber*	Liquid+
	*Lb./CY	+Lb./1000 gal
N	4.5-6.0	30-40
NH4+	2-3	15-20
P2O5	2-3.5	10-15
K2O	2-3.5	20-30
S	0.5-1.5	2-4
Mg	1-2	5-8
Ca	3-4.5	7-10
TS	20% - 30%	4.5%-5.5%
pH	7.8-8.5	7.5-8.2
Density	800-1000 lb./CY	8.5-8.6 lb./gal.
Viscosity	"Moist peat moss"	"Chocolate milk"

It is anticipated that the fiber will be marketed as a potting soil or soil amendment product. The greater

Everett metropolitan area offers tremendous local area marketing potential for this product. Numerous new housing developments with yards and landscaped property were observed in the area. The planning staff at the Snohomish County Solid Waste Management Division of Public Works reported that they have local contacts applicable to this effort and are willing to help with a marketing strategy.

4.0 SITE SCORING ANALYSIS

A project database format has been developed as a companion document to this report. A sample sheet of this database is contained in the appendix. It is anticipated that the database will remain as a separate and active tool to compile additional data if the status of Snohomish County Biogas projects expands in the future. Currently, the site survey narrative information contained in Appendix 1 has been tabulated into the database. The database has been constructed to summarize the dairy site data into a numerically ranked priority list for the overall project. The institutional sites are incorporated separately into the database, since ranking and scoring factors are much different from those considered at the dairy farms. A section has been developed to collect data and prioritize sites related to salmon habitat improvement and river quality improvement. It is anticipated that the database will generate these associated ranking scores when salmon restoration experts enter salmon habitat evaluation data.

The database consists of a series of worksheets in an excel spreadsheet format. The sheets are linked and are able to actively compile a ranking score for each site as new data is entered. This format was discussed and agreed upon with Dave Somers, Tulalip Tribe Coordinator. The worksheets include the following collection of data.

Sheet one is titled: "CONTACT LIST". The contact list is intended to identify the site and owner or primary contact of sites that have expressed some level of interest in the project. Sites that were contacted and were not interested in possible project participation have been deleted from the contact list. This sheet can be developed into a project mailing list since it includes a mailing address, phone number, and if available, Lat/Long coordinates to aid in site location.

Sheet two is titled: "PROXIMITY GROUP". The intent of this sheet is to summarize the apparent "clusters" of sites by proximity to one another within major watersheds. This sheet supports the project-maps that are included in this Organic waste Assessment Report appendix. A "Mapping Identification Number" has been assigned to each site. That alphanumeric number remains on all of the subsequent database sheets as well as all project maps. It also corresponds to the site labels in the narrative descriptions in Appendix 1.
It is expected that the concept of proximity groups and the associated site mapping as shown in the appendix will enhance the ability to determine potential digester sites. It is provided as a tool to analyze the cost and feasibility of waste hauling or transport to central digester sites.

Sheet three is titled: "SITE DATA". This sheet collects site observations into a tabular and consistent format. The intent is to summarize the most key information for the digester designer and to facilitate placing a ranking priority score on site attributes as they relate to expected digester performance. Comparison Site Data tables have been developed in the body of the report in Section 3.

above that combine summary key data from the Proximity Sheet and the Site Data sheet contained in the database.

4.1 Digester Score

Sheet four is titled: "DIGESTER SCORE". The digester score sheet builds from the preceding site data sheet to score the facility attributes as they relate to potential biogas production in a digester. The attributes are not weighted but scored equally on an even scale. Once a final digester design concept has been selected, these attribute scores should be revisited and scored with a weighted ranking to mesh with selected critical design considerations. An example of this scoring sheet is located in Appendix 2.

4.2 Environmental Score

Sheet five is titled: "OTHER SCORE". This sheet collects additional site attributes into a score that can be included in the site ranking. One section is collectively called "Environmental Score". It has been constructed to compile and score area specific data from salmon restoration and water quality experts. It can be used to identify where digester related project sites are likely to support priority habitat restoration projects. It includes consideration of each site's Nutrient Balance to support the idea for the project to become a Nutrient Bank and to be able to identify suitable receptor locations for the digester effluent. It could be developed in more detail as the project unfolds and participating landowners are clearly identified. More local input and a study of relative land ownership beyond the scope of this field survey are needed to provide a site-by-site score for these elements.

The Nutrient Bank concept offers a significant benefit to sites that are nutrient limited as well as supporting overall good public relations the environmental community. The site data summary tables in Section 3 show a preliminary comparison of each site's nutrient preference. If the table listed "export", the dairy has expressed a desire to reduce its overall nutrient load. If the site is listed as "import", the dairy has indicated that they might be interested in securing more digested nutrients for their land application program. For those sites that indicated they want only an equal amount of liquid back to that originally provided to the digester, the table listed "balanced".

The Salmon Stock Inventory (SaSI) compiled by the Washington State Department of Fish and Wildlife was reviewed during the field survey work to determine if the anticipated digester project area supported the common goal of the SBBP members to protect salmon habitat. The SaSI clearly identifies both the Snohomish River Basin and the Stillaguamish River as having depressed salmon stock. Additionally, both the summer and the fall Chinook salmon runs throughout the Puget Sound Region have been listed as threatened by the Endangered Species Act. Further, the Northwest Indian Fisheries Commission has reported a steady decline of all salmon species since the mid 1980's. In the early 1990's, State and Tribal leaders adopted the Wildstock Restoration Initiative in response to the declining salmon stocks in western Washington. The Initiative concluded that: "Fish and wildlife resources and the ecosystems on which they depend must be managed in a holistic manner that recognizes that all things are connected." The regional digester project and the associated nutrient banking not only support the stated goals of the SBBP but those of governing agencies as well.

Further development of the database environmental score, will also track how the regional digester project affects currently identified impaired water bodies. In 2003, the Washington State Clean Water

Act, Section 305(b) Water Quality Assessment Report listed over 30% of the large streams and over 60% of the small streams in Snohomish County as "impaired". A primary indicator for use impairment in these streams is attributed to fecal coliform bacteria. It is expected that once waste generating site proximity is determined, the Biogas Project river quality improvement ranking score could be more fully developed. The database is designed to compile and calculate this score once a priority ranking process has been agreed upon and developed by the project partners. These water quality and salmon habitat environmental scores could be used to rank the intrinsic value of improving Snohomish County ecosystems during the economic analysis for the regional digester project and later factored into support of the overall project business plan.

4.3 Financial Score

Sheet Five in the database also includes financial scoring categories related to costs of each site to participate in a regional digester. The vast majority of farms indicated that they were not interested if participation required significant financial burden to build new facilities. A category has been developed to score each site's existing facilities as they pertain to central and pumpable manure collection structures. The intent is to offer the design engineer and financial analyst an indicator to site-specific costs that may be needed provide a waste offload structure. Tied to this score is a category labeled the Waste Access score, which further summarizes the site for the ability to access the existing waste collection structure with a waste hauling tanker truck. In short, it will summarize and suggest whether additional pumps, pipes, roads, or other site renovations need to be considered.

4.4 Site Ranking

Sheet six is titled: "SITE RANK". This linked sheet in the database provides a place to compile a total site score from the digester, environmental, and financial scores as compiled above. The current site rank reflects only a flat score with no priority significance "weighting" factored into the score. This could be easily developed as the project moves into more detailed designing and financial analyses. Further, the process to turn the Individual Site Rank Score into an overall project "Priority Rank" has not been agreed upon nor developed by the project partners.

With an early project consensus that the Monroe Honor Farm property is the priority digester site for consideration, the countywide Priority Ranking process has become less important at this stage of project development. If the decision is made at a later date to move forward with another Snohomish County digester site, the basic data compiled within this database format could be activated and more fully developed to generate a countywide Priority Ranking as needed.

5.0 NON-MONETARY PROJECT BENEFITS

Several non-monetary benefits can be expected from a regional Biogas Project. During the field survey work, a genuine interest in the overall project was noted. The large majority of the people interviewed are very supportive of the concept of turning waste into renewable energy. The idea of utilizing currently idle State owned dairy farm facilities at the Honor Farm was also widely supported. Many spoke of the benefits in terms of a site to demonstrate and further develop anaerobic digestion technology. Additionally, the potential to use the site as a teaching model for the schools was viewed as an exciting community learning opportunity. Most significantly, the mere concept of this project has numerous and widely varying interest groups already at the table anxious to discuss options to make the project become reality.

Moreover, recovery and combustion of methane from the biogas reduces uncontrolled release of methane, which is a highly reactive greenhouse gas, into the atmosphere. Biogas from a stable digester contains from 60 to 80% methane. Anaerobic digestion of cow manure will reduce biological oxygen demand (BOD) and total suspended solids (TSS) by 80-90%. Odor is virtually eliminated. Pathogen reduction can be as much as 99%. Digesters are very effective in killing weed seeds that may be present in undigested raw manure soil additives. Half or more of the organic nitrogen is mineralized to ammonia which makes the nutrient much more available for plant uptake during land application. In short, the digester reduces raw wastes into much more desirable, usable and valuable commodities all while generating a source of renewable energy.

6.0 SIGNIFICANT ISSUES, PITFALLS AND RECOMMENDATIONS

6.1 Haul Distance

6.1.1 Issue

No single large concentration of dairy or institutional organic waste was found in Snohomish County. Four general areas of waste concentration have been delineated.

6.1.2 Significance

The scattered location of the organic waste will necessitate hauling wastes to a central regional digester facility. The associated costs of transportation will have a negative effect on the financial feasibility of the project.

6.1.3 Recommendation

One possibility might entail eventually building more than one “regional” biogas facility to minimize the distance required to transport area organic waste into a digester. In addition to the Monroe Honor Farm site, there may exist a favorable potential to site a facility within the dairy cluster labeled “Snohomish Dairy Group” and another opportunity exists in the northern part of the county to encompass the Stillaguamish Dairy Group. Nearby institutional wastes could be more readily identified and secured once these additional digester sites were located.

Another option would be to conduct a detailed evaluation of the cost to contract with an existing waste hauler. Some of the institutional organic waste sources may actually see a cost benefit to truck to a nearby digester site instead of the current practice of hauling to a remote waste transfer station. Additionally, it may be valuable to closely compare the cost of transporting manure away from a nutrient limited dairy farm against the lost financial opportunity to expand the size of their dairy operation.

Finally, an additional possibility might exist to develop an organic waste related hauling company within the overall Biogas Project. By forming a non-competitive trucking company specifically targeted to haul organic waste to the digester, perhaps trucking fees could be lower than from other commercial haulers. This additional business enterprise could also provide a few more project related jobs, which was one of the stated project goals.

6.2 Water/Manure Volume

6.2.1 Issue

Problematic manure dilution could result from excess barn flushing, parlor wash down, and rain or "run-on" water.

6.2.2 Significance

It can be difficult to consistently generate adequate biogas to fuel the engine-generator with extremely dilute manure. It is costly to design an adequately sized system for large dilution volumes. Highly diluted manure adds unnecessary expense to pump and transport large volumes of digester effluent.

6.2.3 Recommendation

Prior to moving further on the project, determine all sources of dilution water that could be diverted directly to on-farm storage rather than collected for the digester. Evaluate acceptable modifications to current excessive water use practices at each dairy. Consider technology options to concentrate dilute manure before it enters the digester. Utilize appropriate digester engineering to match these manure characteristics. Define necessary site-specific water management techniques to make certain adequate % solids manure is consistently available for digestion.

6.3 Sand Bedding

6.3.1 Issue

Sand bedding is used in five of the larger dairies surveyed in Snohomish County.

6.3.2 Significance

Sand will settle in a digester, reducing the time between cleanouts. Pump equipment can experience addition wear. Settling sand prior to the digester will reduce the % digestible solids available for the digester. Removing sand bedding with a flush system requires large volumes of water.

6.3.3 Recommendation

Approach sand bedded dairies to determine if any alternative digestible bedding materials would be acceptable. If no alternatives are acceptable, study the current sand bedding characteristics to determine if a different sand texture or other modification could improve conditions for the digester project. Conduct a detailed evaluation of the current sand separation techniques to determine how effectively the sand is being separated. Consider technology to enhance sand separation, as well as alternative strategies to reclaim digestible manure solids from the separated sand. Evaluate flushing practices to determine the minimum volume required to adequately remove sand bedding from the flush lanes. Consider methods to minimize the amount of sand that gets wasted into the flush lanes.

6.4 System Designers

6.4.1 Issue

The history of farm digesters in North America shows that about 75% of all past manure digestion systems failed. Each location has unique design demands. Attempting to duplicate construction (aside from the legal implications) may result in installations insensitive to site-specific realities. Most often designs were found to be inappropriate or experimental. Often projects were proposed, designed, and built by well-intentioned individuals or firms that simply lacked solid and proven animal manure digester experience.

6.4.2 Significance

Financial considerations require the enticement of an outside investor to build a regional facility. That investor must have absolute confidence the investment is sound. Success is expected with a regional organic waste digester, if a good designer is chosen. The Tulalip Tribes wish to increase profitability while protecting salmon habitat through a renewable energy digestion system. The Tulalip Tribes must have a system that can function reliably from the beginning.

6.4.3 Recommendation

Request the services of a firm with documented experience in the field. The firm should have worked with a similar organic waste characteristic, in a similar setting, and at a similar scale. The firm should be able to make output projections based on empirical information from similar projects. The firm should be able to provide energy balances and mass balance. These balances will permit assessment of project technical feasibility.

6.5 System Management

6.5.1 Issue

A regional digester will be significantly more complex to operate than a single farm facility.

6.5.2 Significance

Immediate attention to unexpected maintenance as well as daily observation and detailed record keeping will be necessary. Equipment may not receive the timely attention needed and runtime may suffer.

6.5.3 Recommendation

The project owners should develop an operations and maintenance contract and hire adequate staff to run the biogas facility. Daily operations staff could contract for time to routinely maintain and managing the system while the engine and generator repairs and service needs could be through qualified outside vendors.

APPENDIX

1. Site Narrative Descriptions (By Watershed Group)
2. Sample Project Database Sheet with Preliminary Digester Score
3. USDA Soils Map – Monroe Honor Farm
4. Photographs – A Flush Dairy Process Flow
5. Watershed Site Maps

APPENDIX 1.1 Lower Skykomish Group

DAIRY M2

This dairy is milking 610 Holsteins with 70 dry cows. All this manure is collected by flushing the free stall barns. Flushed lanes also collect manure from 120 calves aged from 3 to 7 months. All bedding in flushed areas is sand.

Milk production is 31,000 lbs. for the 305-day rolling herd average. The farm milks 4 times per day. Feed rations average 57 pounds dry matter (DM) per day. Operators hope to increase herd by10% to 15% per year.

The manure flush system cycles 4 times per day. There are 16 valves that are 15" in size. They flush 1 minute per valve, delivering 5,800 gallons per minute (gpm)totaling 345,000 gallons per day (gpd). The parlor is hand washed with a 1-inch hose 12 times per day. There was no estimate on time or volume of water used.

All waste lows to a settling basin (approx 100x100 x very shallow) and then is pumped over locally built "Albers-type" drag chain screen separator." The settling basin is quickly cleaned (2 hours with front-end loader) and put back on line. Separated sand is sold for 2.00 per ton; manure solids are hauled out for free.

The storage lagoon is 300 x 300 x 18 deep (5.1 million gal).

The irrigation force main system goes south through the dairy's land and over roadway easements to remote fields. It passes the farm designated **M5** and comes to within ¼ mile of the Honor Farm.

It is felt by the dairy management that additional pipe could be laid to the Honor Farm facility (easements for the pipe were not thought to be a problem for a project like this). The lines would pass by the **M5** farm and offer the chance to pick up the scraped manure there if technically feasible.

Dead animals are composted on site with straw and manure from calf hutches.

The owners feel that sand is the "gold standard" for bedding and would never consider changing to manure solids for bedding. The dairy is not designed for nor are the owners inclined to convert to a scrape collection system.

DAIRY M4

The owner is actively supporting the regional digester project. He farms 300 acres, which includes 100 acres of corn, and with the digester in place he hopes to be able to increase his herd by 10% without increasing the size of the existing lagoon.

He milks 140 cows (1350 to 1400 pounds) (mostly Holsteins with 15 Jerseys) twice per day. Production averages 75 pounds per day at 5.5% butter fat. There are 25 dry cows that are out on pasture for 5 to 6 months of the year. Manure is not collectable from the dry cows during the pasture time.

The sawdust-bedded barns are scraped with a steel blade two times per day to two pits that collect 70% of the farms manure and pump the slurry to the storage lagoon. This is held until it can be sent to the fields with a spreader truck. The remaining manure is considered “solid” which is much drier and contains straw bedding. It is sent to the fields with a conventional spreader at the rate of 500 bushels per week.

Parlor wash down amounts to twenty minutes with a one-inch hose after each milking. This flows to a separate pit for pumping to the lagoon.

He spreads up to 300 wagonloads at 2,800-gallons each per year.

The owner feels that he could easily join the two manure pits and load directly to a truck for transport. He could take most of the digested liquid back but is looking to lower the impact to storage in order to increase his herd. However he may be reluctant to build a manure pump out facility without financial help.

Barn gutters need some work. Even so there is about 13,000 ft^2 open to collect the rain and potentially dilute the manure.

DAIRY M5

This is a scrape dairy milking 470 cows two times per day with 70 dry cows on site. All manure is collectable by scraping once per day with a rubber tire. Based on the volume of the scrape pit he expects 30,000 gallons of manure per day. This includes parlor wash of one hour per day from 1” hose. During the 5 wet months add manure from 80 to 100 heifers 16 to 27 months old. Rainwater from 6,000 ft^2 runs into the manure.

Only sawdust and shavings are used for bedding – no sand. Solids are separated with a roller press and hauled away for free. Liquid is pumped to a lagoon system (two 3 million gal. cells) and stored for land application.

Milk production is averaging 21,500 for 305-day rolling herd average. Feed is 54 pounds DM per day. Animal size estimated to average 1,400 to 1,450 pounds. Rations include malt, cottonseed, and 25% alfalfa hay. No herd increase is planned.

Deads are buried on site. Last quote was $80.00 per animal for disposal. It was noted that the charge is higher for horses.

DAIRY M6

The owners are supportive of the project but feel that there may be little benefit to be gained since they have adequate cropland to use all of their manure and have ample storage. They also expressed concern that they might be too far away from the Honor Farm site to feasibly haul manure to the digester.

They milk 190 cows twice per day averaging 62 pounds of milk per cow per day. The animals are confined for approximately seven months per year and are on lanes that are scraped twice per day. In the hot months (approximately 5 months) they are on pasture, and the feed lanes are scraped only once per day. Summer rations are 90% grass silage with 10% hay with 10 pounds per day of grain. In the winter, the silage ration is switched to corn.

All buildings have gutters and downspouts with minimal amounts running to the manure stream. Rainwater is well diverted.

The manure is scraped to a five-foot deep collection pit behind the milk barn. From there it is pumped to a solids separator (trammel screen) with the liquid flowing to the storage pond in the months when he cannot directly apply on the fields. During the months of application there is a loading facility for a tanker to haul directly to the fields.

Long-term future plans include a 20-stall rotary milk parlor. No significant herd increase is expected.

DAIRY M7

This flush diary captures separated fiber floating on two settling ponds before it is discharged to the storage pond. This is mixed with scraped bedding and waste feed and is composted one turn. It is sold for $10.00 / cu yd.

The dairy milks three times per day for the six groups of cows. Production averages 80 pounds/day. The feed ration is 50 to 52 pounds DM. The ration is comprised of 40 pounds silage, 12 pounds hay, 4 pounds cottonseed, 10 pounds corn silage, 26 pounds grain (corn, canola, distillers grain, soy) and mineral supplements.

The farm currently milks 560 Holsteins that are housed in free stalls with 100% manure collection. There are 60 dry cows with collectable manure between 4 to 5 months per year, but they are on pasture for between 7 and 8 months per year. There is no other collectable manure from other animals. The dairy expects to milk 650 within 2 to 3 years. The longer-term plan is to expand to 1,000 milking cows, but needs help to reduce the farm land nutrient loading to get permit for this expansion.

Special needs area is bedded with sawdust and shavings. All other areas bedded with sand.

Flushing is cycled 6 times per day through 12" valves that deliver 2,000 gpm for four minutes per alley as described below.

The barns flush four lanes to two settling ponds that are in series and then discharge to a lagoon. It is estimated that 80% of the manure from the milk cows flows through both settling ponds, but the remainder from two lanes flush directly to the second settling pond. During the winter wet four to five months, the dry cows are kept in the free stalls that flush an additional two lanes directly to the second pond. After the settling ponds, the manure flows by gravity to the 4 million gallon lagoon. There are plans for a new 20 million gallon lagoon but the permits are on hold

The parlor is hosed down by hand using approx 3,500 gallons per day. Approximately 12,000 ft^2 are susceptible to rain fall contribution to the manure stream.

Output from the lagoon is pumped north for field application. The 6" irrigation force main goes to within 1,500 feet of the Honor Farm site.

DAIRY M8

The owners are interested in the project if the enhanced nutrient management would allow them to increase the herd. The concern then would be for failure of the project potentially leaving them with too much nutrient on the farm. Additionally, there was some concern about the distance to haul manure to the Honor Farm site. Currently, most of the manure is used on the farm. Any excess is sold to local crop farmers.

They milk approximately 300 cows twice per day averaging 22,500 pounds of milk. Dry cows and heifers are housed off site. Daily rations include 15 pounds of hay, grass silage and grains consisting of corn, soy, canola and five to six pounds of cottonseed.

The cows are bedded with sawdust. The free stalls and feed lane manure is removed with a rubber tire scraper once per day to a 25,000-gallon underground tank. It is pumped from there to a storage lagoon (16' deep – 2 ½ million gallons). For six to seven months of the year extra water is added to pump the manure. There is adequate access for a tanker to load from the collection tank.

Plate cooler water is used for drinkers and parlor wash down. Wash down is with a 1" hose for 15 to 20 minutes after each milking which flows to the manure collection tank. Rainwater is effectively diverted with less than 4,000 ft^2 of collecting area.

Appendix 1.2 Snohomish Area Group

DAIRY SN1

The dairy milks 700 cows three times per day for a 90 to 93 pounds per day milk production average. . The milk herd plus 100 dry cows manure is collected by flushing. There are 50 head in special needs, 50 springers and 100 calves (three to six month old) that produce collectable manure. All other calves and heifers (six months to calving) are off site. Within two years they would like to be milking another 100 cows. Nutrient loading is the limiting factor. The dairy had been at 800 milkers before and they feel that they could milk 900 with the existing crew.

Bedding is sand except in special needs where it is straw. The calf area is flushed once per day. The barns average five flushes per day at two minutes per flush for eighteen valves. The flush pump is rated at 2,000 gallons per minute. In their farm plan there is an estimate of 4,000,000 gallons per year of dilution in parlor flush and rainwater.

The sand settling pit is a 200' x 32' silage pit that averages 2 ½' in depth. Solids are separated with a drag screen and the liquid sent to storage (4 million gallons in one lagoon and 26 million in the new one). All manure flow through the barns and to storage is by gravity

NOTE: Some of the barns are suitable for scraping. 430 cows are collectable if converted. The dairyman expressed some willingness to consider this level of conversion to scrape collection.

DAIRY SN2

They send manure solids to the local composting operation. The dairyman did not seem overly enthusiastic about the project. He needs all the water and nutrient from his manure collection system for his crops. If it were to be digested, the resulting liquid and solids must be brought back.

The dairy milks 600 cows three times per day averaging 28,000 pounds production (305 day rolling average). The dry matter intake was said to average 58 pounds per day. Any herd increase would be 10% or less.

The parlor holding area and free stalls are flushed five times per day through eleven valves. The cycle averages fifteen minutes per flush at 3,000 gallons per minute. The parlor is hosed down by hand after each milking (no estimate on time or quantity). Bedding is "mostly sand" with some sawdust for the 60 dry cows. The flush water flows to a 51 x 30 x 2 sand-settling basin and then to a 100 x 10 x 12 solids settling basin before flowing to the two storage ponds of six million and 13 million gallons.

It was estimated that there was about 30,000 ft^2 of open area that would contribute rainwater to the manure. There was little concern about dilution since all of the volume was used to irrigate the 450 acres of cropland (predominantly corn). In fact the dairy had been running his 300 gpm well into the lagoon for several days to maintain his irrigation system requirements. He is not inclined to minimize water use nor divert rainwater run-on.

DAIRY SN3

The dairy milks 85 cows averaging 70 to 75 pounds per day. Manure is collected by scraping two times per day from the milk cows and during the five winter months is also collected from the 10 dry cows. All the manure collection is done in the free stall barns and feed lanes. The owner would like to be able to increase the herd to 125 milk cows over the next two to three years. Rations consisted of haylage (wrapped bales) with very little grain added.

The scraped manure is pulled to a 45,000-gallon underground tank. From there is pumped to storage without any solids separation. The farm owns an inclined screen separator (purchased from the prison farm sale), but has not yet installed it. A loading facility could be installed at or near the pit pump. In the summer months the manure can be quite thick and there is the capability to divert the rainwater to the lagoon to make it easier to pump. The farm plan estimated almost one-half million gallons of rain that may be getting to the storage pond.

The owner is cautious about participation in the project. He would like to be kept informed but doubts that his farm is close enough to be worthwhile to transport his manure. He does not mind giving away most of the manure solids but must have the liquid back for field application.

DAIRY SN4

This company consists of a dairy farm milking 900 cows with a composting business. The owner's attitude toward the project is cautious. For any investment he would expect "50% profit." Since a possible output of the system is digested fiber, there may be a sense of competition with his composting business. This dairyman expressed some interest in exploring an option to become a host site for a digester system.

Production average was given as approximately 100 pounds per day with a 305 day rolling average at 33,000 pounds milking the five groups three times per day. Rations were said to consist of haylage, silage and mixed grains with no details as to dry matter intake.

The milk cows are on flushed lanes. The cows on the flushed lanes are all bedded with sand. The fifteen alleys are flushed six times per day for an average of two minutes per flush at 600 gallons per minute. The holding area is flushed for five minutes at 600 gpm after each milking (three times per day). Buildings are guttered with the rainwater diverted. There is approximately 5,000 ft^2 of open area that sends water to the manure collection system (45" annual rain). All flushed manure goes to a sand-settling basin south of the parlor. The common collection point is the exit pipe from this basin. This pipe passes under a county road to four more settling basins in series (all basins are 25' x 100') before flowing to a 400 x 800 x 22 storage basin.

These four basins are cleaned with a dragline to provide solids for the composting business. The farm's solids are mixed with sawdust the manure solids from the neighbor dairy next door.

Dry cow manure is in pasture (not collectable for digestion). Scraped manure from 800 heifers is sent directly to compost. Scraped manure from the heifers has sawdust bedding.

DAIRY SN7

This farm milks 600 cows with approximately 80 dry cows, all of which have the manure scrape collected from the free stall barns. Previously 900 cows were milked here but the current herd is limited due to nutrient issues. There is capacity for as many as 1,200. Manure is not collectable for digestion from the 100 heifers that are kept in corrals and pasture. Bedding is sawdust and shavings.

Milking three times per day the 305 day rolling average is 24,000 pounds. Feed rate is 52 pounds dry matter per day. Feed is a total mixed ration (TMR) consisting of grass and corn silage, alfalfa hay and grain including corn, dry distillers grain and eight pounds of cottonseed per day.

Parlor wash water and system cleaning water (clean-in-place or CIP) is included in the collected manure. Parlor wash down is with a one-inch hose for fifteen minutes after each milking. System cleaning water amounts to one gallon per cow per milking (1,800 gallons per day). There is a plate cooler in use and this water all goes to drinkers and parlor wash.

There is an area about 18,000 square feet collecting rainwater that can get into the manure. Misters are used in the summer for barn cooling. Output is four gallons per hour for each of the 68 heads. Mist was very fine with dramatic temperature drop indicating a lot of evaporation.

Alleys are scraped three times per day to a pit where it is pumped to a solids separator (drag screen) mounted on the rim of an 80' diameter by 20' high Slurry Store tank. All manure liquid goes to storage in the two lagoons totaling nine million gallons and then is applied seasonally to the farms land (365 acres owned, 50 acres rented). Solids are hauled away by top soil/compost dealers for free. Herd size is limited by the nutrient loading of the land.

DAIRY SN8

This dairy milks 300 Holsteins (1,400 pounds) twice per day averaging 70 pounds per day production. Forty dry cows are the only other animals on site and they are on pasture from June through September with feed lane access. There is a plan to increase the herd by 30% this year and another 30% in two years. Rations are corn silage and alfalfa hay with thirty pounds of grain per day.

Feed lanes and free stalls are scraped once per day. There is a flush system in place that is used once per week for extra cleaning after scraping. Bedding material is sawdust. The manure flows from the scrape pit to a pump pit and then to a roller separator. Liquid goes to storage.

There is a fifteen-minute parlor flush with a one-inch hose twice per day. Gutters on all buildings control further dilution. Slab runoff is diverted away from the manure to a buffer zone.

There is good access to the scrape pit area for a loading facility. The farms lands take all of the nutrients and may be able to take more.

Appendix 1.3 Upper Stillaguamish Group – Arlington Area

DAIRY A1

The farm has no more access to land and is in a flood plain so there is no option for other use than farming. The owner is interested in the project since it would provide an option for nutrient export that may allow a herd increase. Also he would be able to bring his heifers in from off-site and further decrease his costs. He cautioned that if involvement in the project was tied to him being responsible for riverbank or habitat improvements, he is not interested.

The farm milks 225 cows averaging 63 pounds of milk per day. Animals were said to average 1,400 pounds. The manure is all collected by scraping the free stalls and feed lanes twice per day, but the 35 dry cows are only collectable seven months of the year. If the calves and heifers were to be brought on site, they amount to 75 animals of 700 pounds plus 40 springers and 80 smaller animals of 600 pounds or less. They would be on pasture with the dry cows for at least five months out of the year. The bedding is sawdust/shavings.

The scraped manure falls into a 65,000-gallon tank and then is allowed to flow by gravity to the storage pond. There is already a pump installed that could supply a loading facility for haul out.

The barns are guttered and open slab area is small (3,000 ft^2 or less). Dilution is low and the manure was described as thick on all but the wettest days of winter.

DAIRY A2

This farm has 280 Holsteins that are milked twice per day averaging 77 pounds of milk per day. The free stall barns are bedded with sawdust and are flushed twice per day. A flush cycle is two minutes at 4,500 gpm on each of the six lanes. The 40 dry cows are on pasture for five months of the year but still access flushed feed lanes. Rations are half grass silage and half corn silage with corn, barley cottonseed, beet pulp and minerals added.

Some of the barns are guttered and a quick estimate of run-on rainwater showed about 22,000 ft2 that can drain to the manure system. The parlor is flushed twice per day with a hose for twenty minutes per flush. The flush waters pass over a drag screen separator and the liquid goes to the six million gallon pond. Solids are spread on the farms fields. A single point for manure access is near the separator. This is one of the few flush dairies in the area. The dairy estimated 1,000 to 1,200 cows in the area are on scraped lanes.

DAIRY A4

The farm milks 420 cows four times per day to average 87 pounds of milk per day. Rations are corn silage with alfalfa, beet pulp cottonseed, molasses and mineral supplements. All bedding is with sawdust.

The milk herd is in free stall barns that are flushed four times per day through 10 valves with one minute per flush. The flush pump is rated at 2,200 gpm. Parlor and wash pen are hosed out four times per day with a hose for 30 minutes (assume one inch). Plate cooler water is used in this wash down. Flush water goes to a 26,000-gallon tank where it is pumped over a drag screen separator and sent to storage.

The rest of the herd is housed in barns that are scraped once per day. There are 65 dry cows, 30 closeups, 30 bred heifers, 25 fresh and 4 or 5 in special needs. Calf manure and bedding straw is hauled to the field.

All rainwater is diverted according to the herdsman and all slab and walkways were roofed and guttered. If the scrape manure were to be collected for digestion, all nutrients are needed back on the farm. They have an average of 270 acres in corn and 180 acres of grass.

The farms milk stays on site where there is a bottling facility. The facility also makes ice cream and sour cream for sale in the on-site retail outlet and distribution to stores in the area. The herdsman thought that the plants cleanout water was sent to the scrape pit but it was verified later by the owner that this wastewater went to the city sewer

DAIRY A5

The dairy milks a herd of 200 Jerseys that weigh an average of 1,000 pounds. Milk production is 17,000 pounds for a 305-day average with twice per day milking. Dry cows are kept off site. There is a plan to increase the herd by 100 cows in approximately two years. Rations consist of haylage, grain and intermittently beet pulp.

Free stalls are collected once per day by scraping. The feed lanes are not collected regularly and the manure is picked up dry and spread on the fields. Parlor wash down is with a hose and was reported to be 200 gallons per milking. Roof water is diverted away, but there is about 4,000 ft^2 of slab contributing run-on water to the manure.

The 70-acre farm and 100 acres of rented land are situated near the river. The farm is installing a screw press solids separator and a manure loading facility to transport to other croplands.

DAIRY A6

Dairy was contacted by phone. They are not interested in the project. The farm may go out of business in two to five years.

DAIRY A7

Discussed disposal of dead animals into a digester. The current disposal cost is $75.00 per animal.

The dairy milks 220 Holsteins three times per day with an average milk production of 82 pounds. The milk herd is in free stall barns with sawdust bedding. The rations are standard mixed rations of hay, corn silage and grains that include cottonseed. There is no planned herd expansion.

Thirty dry cows and the heifers are let out to pasture for the five or six dry months of the year. There are 300 animals in this group ranging from small calves to springers.

Manure from the milk cows is scraped twice per day to a pit and pumped to a storage pond. When the dry cows are in from pasture approximately six months of the year, their manure is scraped twice per day to a separate pit and flows to a storage pond on the facility. The heifer manure is scraped once per day to a pit and pond that is on a separate facility about one quarter mile away. Construction tanker loading facilities requires piping for the milk cows, but pumps and piping for the dry cows and heifers.

The barns are reported to be well guttered and there is little area (3,000 to 4,000 ft^2) to capture rainwater. Parlor wash water goes to the milk cow manure pit and comes from a one-inch hose running for fifteen minutes, three times per day.

Future plans for the manure system include a screw press for solids separation.

If the farm were to have its manure digested the nutrient are needed back in the fields. This means all of the liquid and at least some of the solids.

DAIRY A8

The farm milks a mixed herd of 105 Holsteins and 10 Jerseys with an average herd weight of 1,500 pounds per animal. They are milked twice per day to average 60 pounds milk production. Dry cows are kept with the milk herd. April through August they all are let out on pasture, but have access to feed lanes. There is no plan to increase or decrease the herd.

Rations consist of 45 to 50 pounds of corn silage per day plus alfalfa. They are fed mixed (corn, barley, canola meal) grains only in the parlor amounting to 20 pounds per head per day.

Free stalls and feed lanes are scraped once per day to a pit and then pumped to storage without solids separation. Sawdust bedding is used. Dilution from parlor flush is 800 gallons per day. Water from milk system cleaning (CIP) is 240 gallons per day. Roof water is diverted but there is 5,000 ft^2 of open slab run on water.

A loading facility would have to be constructed. Access to the area is tight and suitable for straight truck or possibly 20-foot semi tanker.

DAIRY A9

The farm milks 450 cows with a 305 day rolling average of 26,000 pounds. The milk cows average 1,450 pounds. There are no other animals on site. The 60 dry cows are three quarters of a mile away on scraped lanes. Dry manure with bedding straw from calves and other young stock is handled separately and sent directly to the fields. No major changes to the herd are planned.

Rations consist of corn and grass silage with corn and cottonseed and beet pulp.

Manure is scraped from the free stall barns and feed lanes at least once per day. At times there are two scrapes per day and rarely three if a lane has been crowded. Bedding is sawdust.

Parlor wash water comes from a one-inch hose running for at least 20 minutes, three times per day. Rainwater goes to the manure pit and is pumped to the lagoon, but it is managed on the heaviest rain days. The rainwater is pumped from the pits before scraping so the manure is relatively undiluted. No changes are planned for the manure system. A loading facility could be easily constructed with good access for the tanker. The dairy is interested in digester technology.

The farm has cropland available for all of the nutrients in the manure. If involved in a digester project the farm needs all of the equivalent fiber as well as the liquid nutrients. There is a possibility of taking more but the nutrient balance would have to be investigated carefully.

DAIRY A10

The owner is interested in the project in that it will help meet nutrient management requirements. He exports some of his manure now and would take less volume back than he would send to the digester.

The farm milks 140 Holsteins with an average of ten dry cows on the facility. These are the only animals on the site. In the summer months (four to five months per year) the herd is on pasture with access to feed lanes. Milk production is 22,700 pounds for a 305-day rolling herd average. Rations in the feed lanes is corn silage and alfalfa hay. Grain is fed only in the parlor. There is no plan to increase or decrease the herd.

The free stall barn is scraped with a continuous system. The feed lanes and holding area is scraped once per day to another pit. Manure is pumped to a single pit to combine the waste where it is pumped to the storage lagoon. There is no solids separation. All bedding is sawdust

Dilution from the parlor flush amounts to two ten minute wash downs per day with a one-inch hose. The buildings are guttered to divert most of the rainwater but there is approximately 4,000 ft^2 of open slab with potential to run onto the manure collection.

There is good access to the area of the final manure pit that is pumped to the lagoon. At one time there was a tank loading facility there but it was badly corroded and was capped off. New construction would be required.

DAIRY A11

The dairy milks 400 head of Holsteins that average 65 pounds per day (25,000 lb 305 day average was also reported). Milking is twice per day. There are 100 dry cows, but no heifers on site. Manure is scraped from barns and feed lanes once per day, BUT all the cows are allowed out to pasture for daylight hours during the six or seven dry months. They are confined to the barns at night and all day during the wet months. Bedding is sawdust.

Rations are grass and hay silage with some rolled corn with pasturing as described.

Manure is scraped to an underground pit that is downhill from the barns and open slab. From there it is pumped to storage. Diversion to tanker is possible at the pit with good truck access. Dry manure scraped from the steep slopes and special needs area is hauled away as solid and spread.

The roofs are about 80% guttered with about 17,000 ft^2 of slab open to drain to the manure pit. Pit management is required to prevent excessive dilution. Twice per day the parlor is hosed out with a one-inch hose running about one hour each time. This is also potential dilution. There are no planned herd increases or upgrades to the manure system.

DAIRY A12

The farm milks 100 cows consisting of Holsteins, Red Holsteins and a few Jerseys. The animals average around 1,300 pounds and produce 50 pounds of milk per day on a 2X schedule. They are fed silage and hay and grain only sparingly. The cows have access to pasture seven months of the year and are supplemented with silage on the feed lanes. In these summer months the feed lanes are scraped only twice per week. The rest of the year lanes are scraped once per day.

Fifteen dry cows and about 20 heifers are on the same schedule for pasture access. All of the animals are confined October through April.

Manure is scraped off of the lanes and is allowed to flow down to the lagoon. A loading facility would require a pump to be installed in the existing pit to load the fresh manure. Parlor flush is by hose for fifteen minutes, twice per day and it runs to the lagoon. There was no estimate of rainwater dilution.

The farm has adequate capacity for the nutrients and needs at least the liquid back.

Appendix 1.4 Lower Stillaguamish Group – Stanwood Area

DAIRY ST1

The owner/operator is very interested in the project and would consider converting to scraping his manure if the project starts up.

The dairy milks 520 cows four times per day with production averaging 92 pounds of milk. Mixed rations are standard with grass and corn silage, alfalfa hay and grains.

Manure is flushed twice per day from the free stall barns that are bedded with sawdust. The flush water carries the manure to a central pit of 45,000 gallons. From here it flows to another pit before being pumped over a drag screen separator. For 130 of the milk herd, the manure is scraped to a separate pit where it is pumped to the separator pit to mix with the flush stream. After the separator the liquid flows to storage ponds of 8 million and 4 million gallons. Flush water is recycled from the smaller pond.

The two daily flush cycles total 50 minutes at 1,000 gallons per minute (100,000 gallons per day). Rainwater is effectively diverted except for approximately 7,000 ft^2 of open slab area.

If the dairy were to convert to scrape in the current configuration, it may need an additional pit and pump to gather the manure from the 130 head. The central pit would allow relatively easy construction of a tanker loading facility.

Most of the nutrients are needed back on the farm for the crops but slightly less manure hauled back to the farm would aid in nutrient and storage pond management.

DAIRY ST5

The owner was willing to give the assessment interview, but didn't seem to have much confidence in the economic feasibility of the project in terms of potentially long haul distances of the dairy waste.

There are 150 milk cows weighing an average of 1,400 pounds. Milk production is 19,090 on the 305-day rolling average milking twice per day. There are between 15 and 20 dry cows on site. There are 100 heifers ranging from 8 months to springers. Dry cows and heifers are on pasture for five months per year. Rations were not described, but are assumed to be fairly typical for the area. Butterfat content was said to be 7.5. There is no plan to increase or decrease the herd.

The free stalls and feed lanes are scraped twice per day to a single pit where it is pumped to a three million gallon storage pond. From there it is taken out by vacuum truck and sent to fields approximately a mile away. Bedding is sawdust. Solids are not separated.

The single free stall barn measures 180' x 45' and is partially guttered. About half of the roof water can get to the manure. There is about 3,000 ft^2 of open slab draining to the manure. Parlor flush is twice per day with a ¾-inch hose operating from a pump at 100 psi.

A loading facility would have to be constructed near the pump that sends the manure to storage. Access to this area is fair through a gate.

DAIRY ST6

The dairy milks 170 Holsteins twice per day for a 22,000 pound 305 day rolling herd average. Animal weights were reported to be averaging 1,500 pounds. There are 20 dry cows and 44 heifers in site that are between four months and one year. ALL cows are on pasture from April through September. Rations are silage and grains with a dry matter intake averaging between 45 and 50 pounds per day. Bedding is shavings and sawdust.

Manure is scraped once per day to two tanks of 30,000 and 50,000 gallons. Manure is moved from the smaller tank to the larger. From there all of the manure is pumped under the county road to an above ground storage tank (100' dia. x 20 tall). No solids separation is performed. Water is added to the 50,000-gallon tank in the hottest months to improve pumping. The buildings were described as well guttered to divert the roof rainwater and there is estimated to be only about 3,000 ft^2 of open slab that could contribute to the manure stream.

There is good truck access near the road to load from the pipe that passes under the road. The loading facility would have to be constructed.

The owners seem cautiously interested in the project. The above ground tank indicates that they are have recently invested substantially in nutrient management. All farms in the valley flood to some extent and watch their nutrients. The digester project may help increase the herd for the next generation of owners.

DAIRY ST7

The farmer is supportive of the project and interested.

This farm milks 175 Jerseys (900 to 950 pounds in weight) that average 48 pounds per day (2X milking). Rations are corn and grass silage with alfalfa hay and ten pounds of grain per cow with an additional four pounds of grain fed in the parlor (grain tests 18% protein).

There are 25 dry cows on site as well as 35 heifers that range from 300 to 600 pounds. These animals are on pasture five months of the year with feed lane access. Other small animals are in sheds or corrals where the manure is handled dry. All bedding is sawdust.

Feed lanes and free stalls are scraped twice per day to a pit. In the two hottest months it is not unusual to have a garden hose running in the pit continuously to ease pumping effort. The holding area is scraped so parlor flushing is only about ten minutes, twice per day with a one-inch hose. About 40% of the roof water (total 50,000 ft^2) is diverted away from the manure leaving effectively 30,000 ft^2 plus 4,000 ft^2 of open slab contributing to the manure stream. The manure stream is pumped directly to storage without solids separation.

The manure pump was in the rear center of the barns, but there is truck access through one of the feed lanes. Straight truck access is acceptable, but a semi truck would have difficulty.

DAIRY ST8

Not very interested. He is well east of the Stanwood group and doesn't have confidence that his manure could be collected economically.

260 cows are milked two times per day averaging 80 pounds per day (23,000 pounds was the stated 305 day rolling average). Rations are a mix of corn and grass silage with alfalfa hay and grain (rolled corn, cottonseed). Additional stock includes 30 dry cows and heifers (80 at 6 to 15 months, 20 from 15 to 24 months)

For the milk cows, the feed lanes and free stalls are scraped to a collection pit twice per day. Dry cows and heifers are out on pasture for at least five months of the year with access to feed lanes. During these dry months, their feed lanes are scraped only twice per week. This dry manure is dry enough to be sent to the fields in a spreader.

Parlor flush is with a one-inch hose for twenty minutes after each milking. This runs to the manure collection pit. About 7,000 ft^2 of open slab collects rainwater that enters the manure pit. The barn roofs are well guttered to divert the rain.

The pump at the manure pit is sufficient to load the manure, but the tanker would have to load close to the front entrance. This requires at least 150 ft of pipe to get to a loading point.

DAIRY ST11

The dairy milks 260 Holsteins three times per day to average 85 pounds of production. The milk cows and approximately 30 dry cows are kept in free stall barns that are bedded with alder sawdust. The heifers are on a separate facility. Daily ration for the milk cows is 60 pounds of silage (50%grass, 50% corn), 30 pounds of grain and 10 pounds of hay.

The manure is scraped from the free stalls and feed lanes with a rubber tire scraper twice per day to a 30,000-gallon underground pit. From there it is agitated and pumped to the storage pond without solids separation. At times in the hot months, water is added to the pit to aid in handling.

Parlor and holding area flush is with a one-inch hand held hose for approximately 15 minutes after each milking (3 X day) which flows to the manure pit. Rainwater from the roofs is directed away from the manure, but there is about 5,000 ft^2 of open slab to collect the rain.

A loading facility for the manure could be constructed near the parlor. This would use the existing pump, but would require laying approximately 130 to 150 feet of pipe. Truck access is good around the parlor.

The farmer is interested in the project if it offers a way to increase his herd (currently limited by his lagoon size). He feels that he needs the nutrients for growing feed crops. He commented that other crop farmers in the immediate area might take additional nutrients.

DAIRY ST12

The dairy milks 520 Holsteins (avg. 1,450 pounds) three times per day producing 28,500 pounds on a 305-day rolling herd average. Manure is scraped three times per day from the feed lanes and free stalls. Scraped manure from 80 dry cows and 50 pregnant heifers is available seven months of the year. Only sawdust bedding is used. There is no solids separation.

Dilution from the parlor wash down amounts to a 30-minute wash with a one-inch hose after each milking (approximately 1,200 gallons per day.). There is a large area (near football field size) collecting rainwater, but rain and parlor flush is sent to a separate pit from the scraped manure.

Manure from the scrape pit is pumped to storage. Manure is sent to the farms corn and grass fields. At the pit it would be easy to construct a loading facility with good access for a large truck.

APPENDIX 2. Sample Project Database Ranking and Scoring Sheets

SHEET 4. DIGESTER SCORE – SNOHOMISH COUNTY DAIRIES

MAP CODE	Manure Quality	Manure Quantity	% Collectable	Bedding Type	Gas Potential	Rainwater Dilution	DIGESTER SCORE
A1	5	3	4	5		3	**20**
A2	1	3	4	5		3	**16**
A4	3	5	5	5		4	**22**
A5	5	2	3	5		3	**18**
A6	0	0	0	0		0	**0**
A7	5	3	5	5		4	**22**
A8	5	2	3	5		3	**18**
A9	5	5	5	5		4	**24**
A10	5	2	3	5		4	**19**
A11	5	4	3	5		3	**20**
A12	3	1	2	5		3	**14**

MAP CODE	Manure Quality	Manure Quantity	% Collectable	Bedding Type	Gas Potential	Rainwater Dilution	DIGESTER SCORE
M2	1	5	5	1		3	**15**
M4	5	2	3	5		2	**17**
M5	5	5	4	5		3	**22**
M6	5	1	2	5		4	**17**
M7	1	5	4	1		2	**13**
M8	5	3	5	5		4	**22**
SN1	1	5	5	1		1	**13**
SN2	1	5	5	2		1	**14**
SN3	5	1	4	5		3	**18**
SN4	1	5	5	2		4	**17**
SN7	5	5	5	5		3	**23**
SN8	4	3	5	5		5	**22**
ST1	3	5	5	5		3	**21**
ST5	5	2	3	5		3	**18**
ST6	5	2	4	5		4	**20**

MAP CODE	Manure Quality	Manure Quantity	% Collectable	Bedding Type	Gas Potential	Rainwater Dilution	DIGESTER SCORE
ST7	5	2	5	5		2	**19**
ST8	5	2	3	5		3	**18**
ST11	5	3	5	5		3	**21**
ST12	5	5	4	5		2	**21**

ONLY SITES EXPRESSING INTEREST IN THE PROJECT WERE SCORED.

SCORING KEY:

1 IS LOW FAVORABILITY TO DIGESTER SYSTEM RANGING TO 5 AS HIGH FAVORABILITY TO DIGESTER SYSTEM

MANURE QUALITY: RELATES TO TYPE AND FREQUENCY OF MANURE COLLECTION SYSTEM

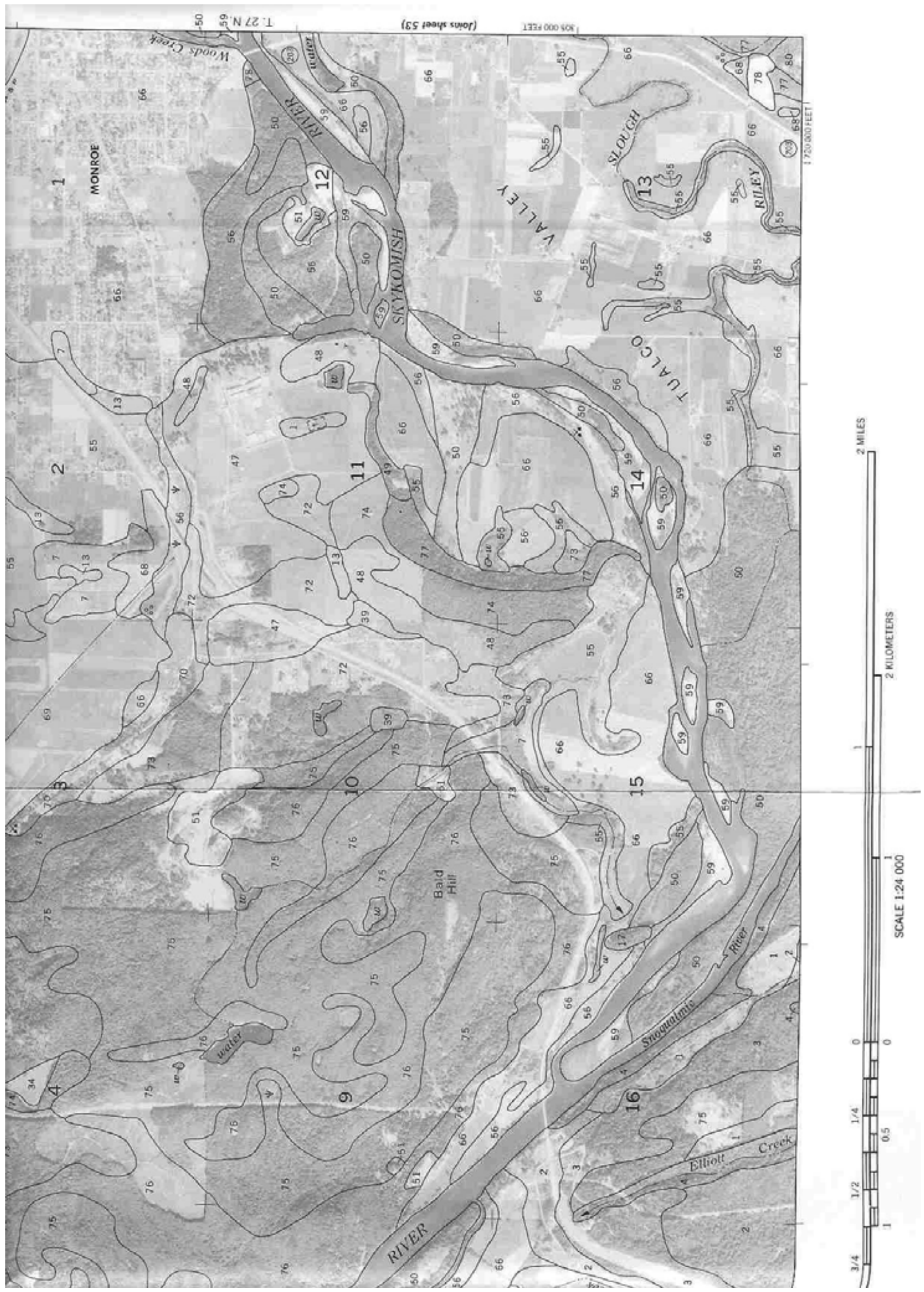
MANURE QUANTITY: RELATES TO NUMBER OF COWS ON SITE

PER CENT COLLECTABLE: RELATES TO TYPE OF ANIMAL HOUSING AND PASTURE TIME

BEDDING: RELATES TO DIGESTABILITY OF BEDDING

RAINWATER DILUTION: RELATES TO HOW MUCH CONTROL SITE HAS OVER RAINWATER DIVERSION

APPENDIX 3.Map 1: USDA SOILS MAP – MONROE HONOR FARM AREA



APPENDIX 4. Fig. 6: FLUSH DAIRY PROCESS FLOW

Pipe under the grass flows from gutter to sand settling pond

Flush lanes from ba

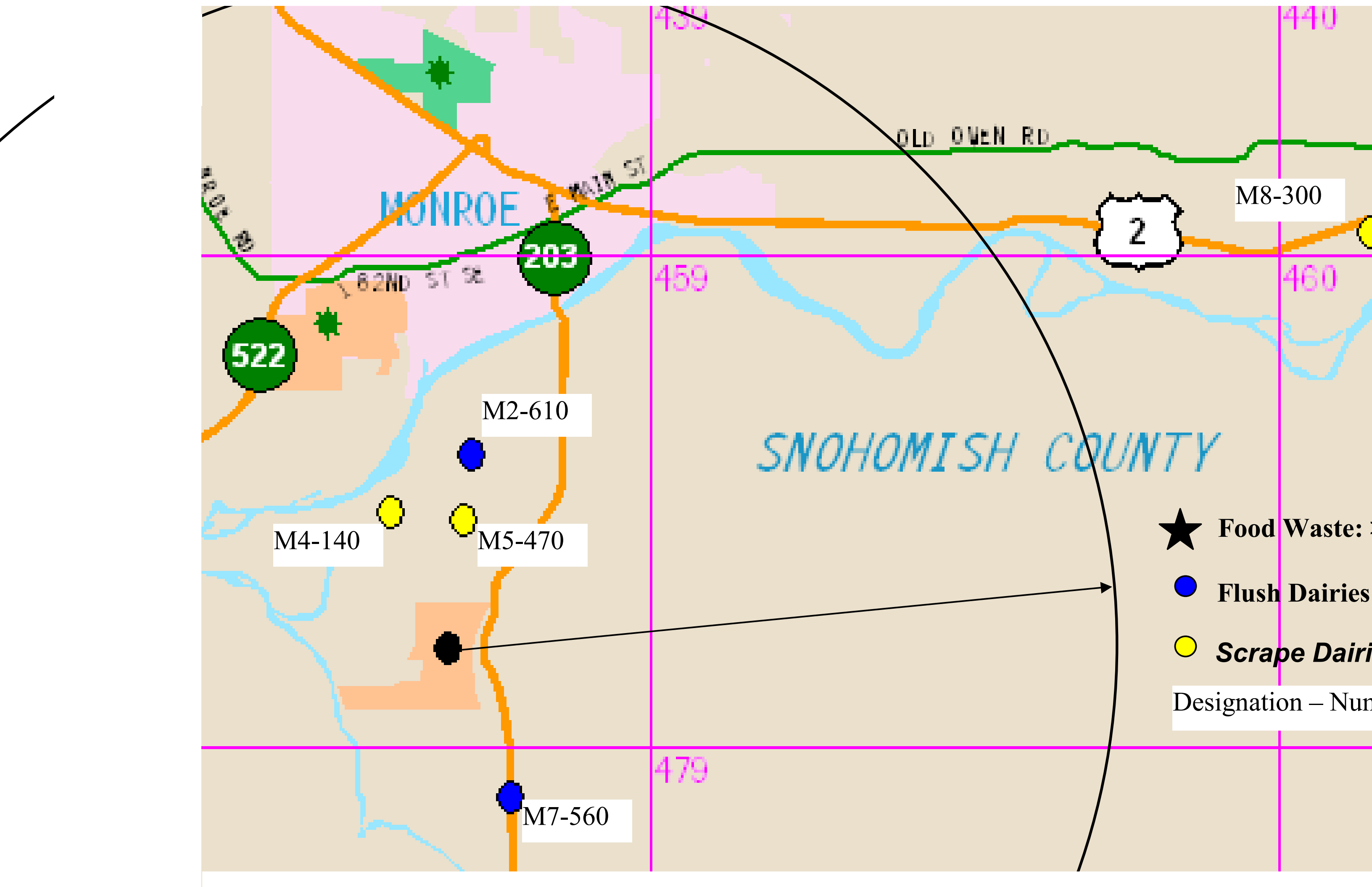
Settling basin liquid flows to pump and then to separator

Manure solids separated at far e

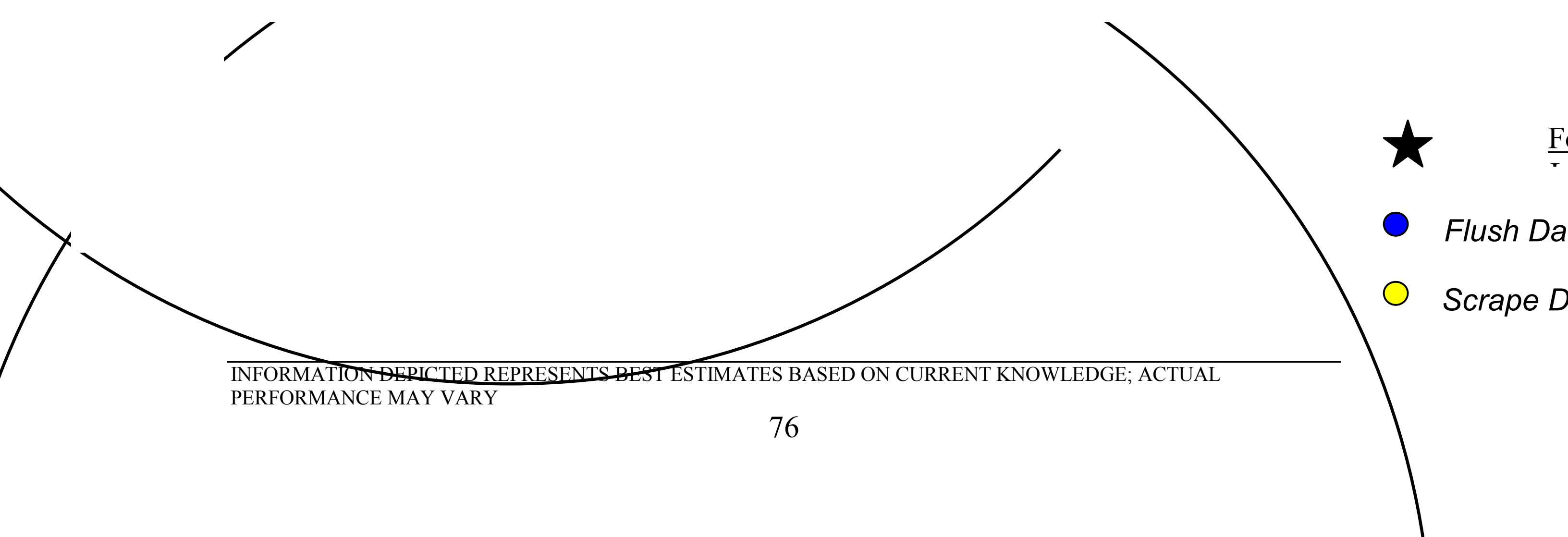
Storage pond receives separated liquid.

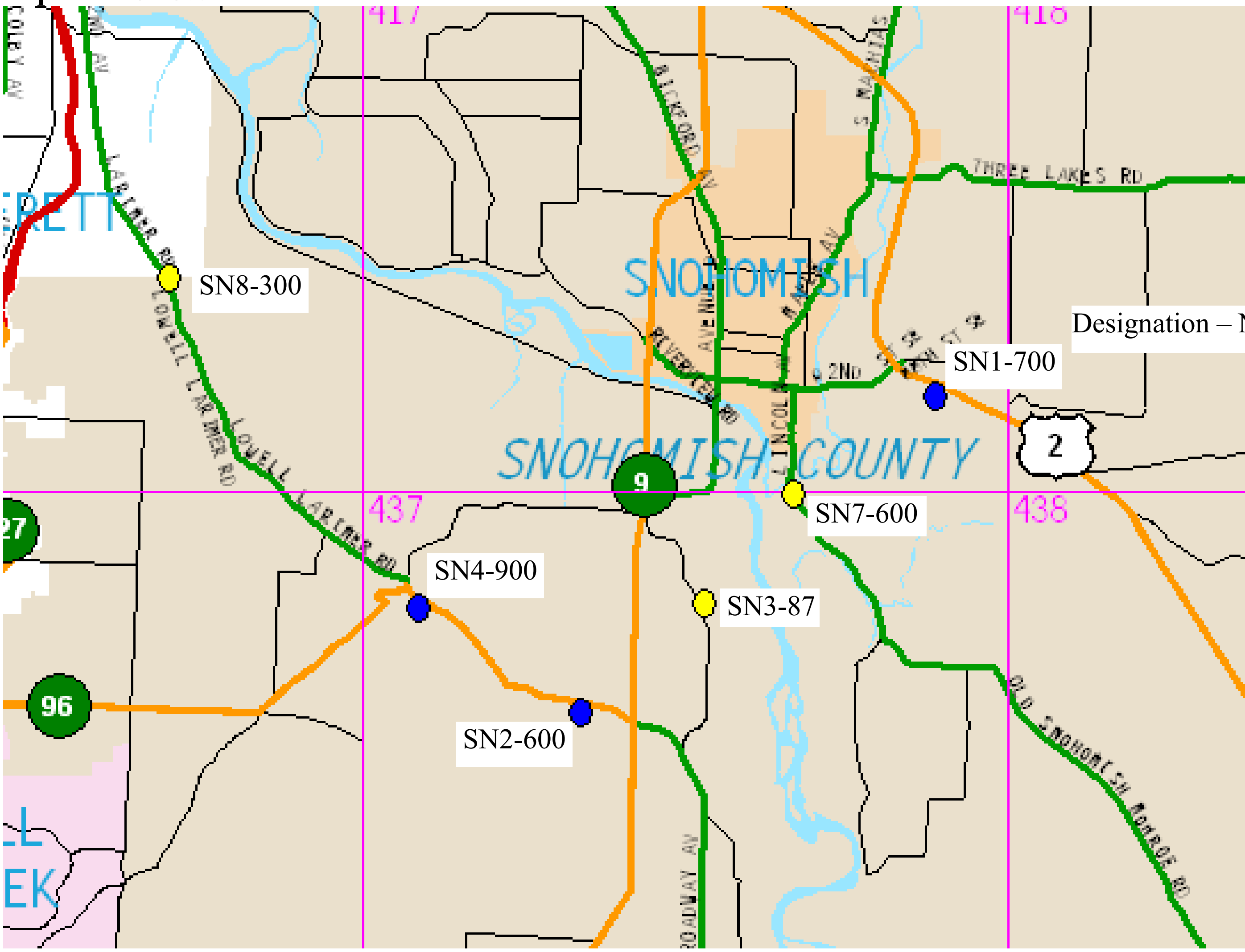
Liquid from storage is sent b

Appendix 5, Map 1: Monroe Area, 5 MILE RADIUS

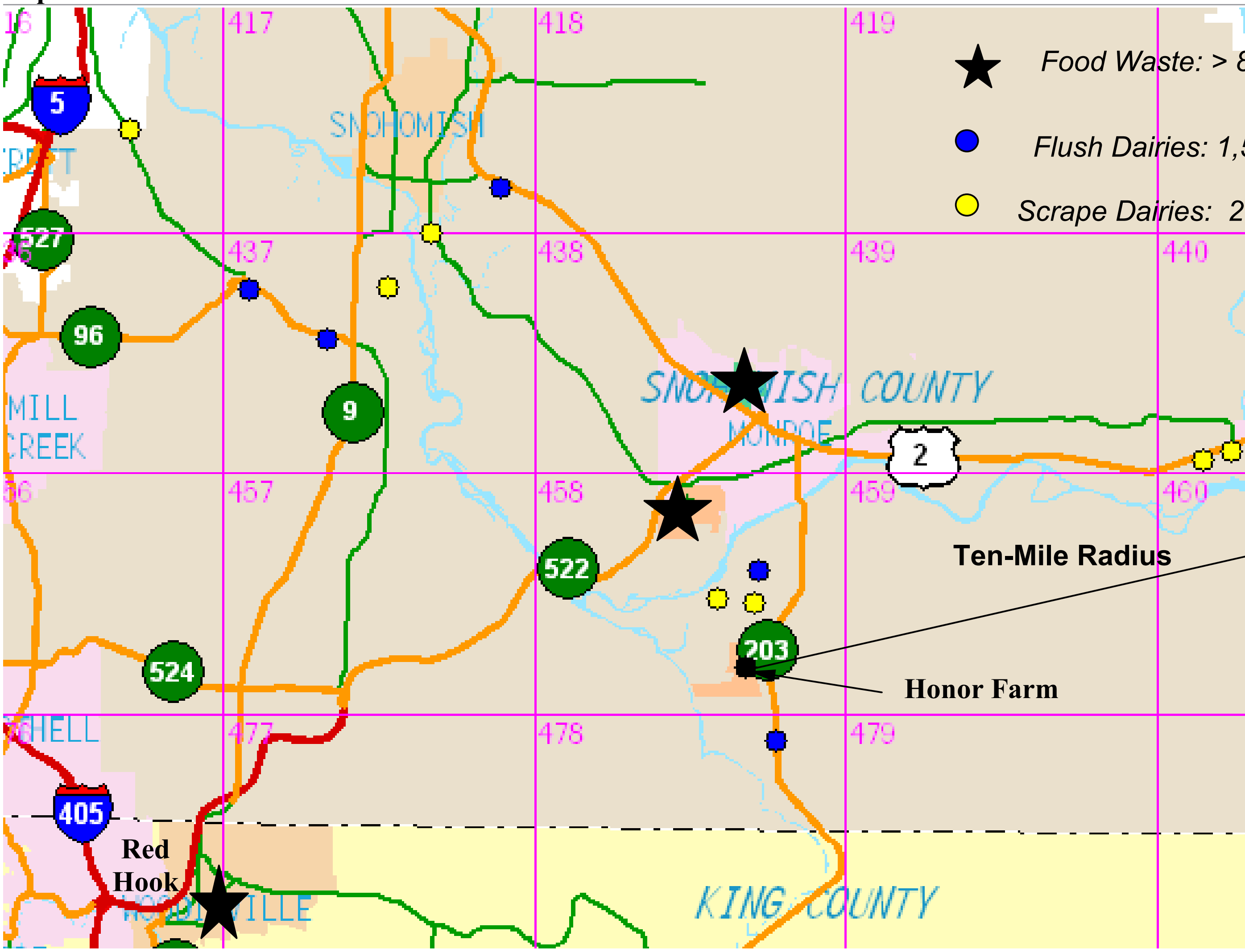


Appendix 5, Map 2: Snohomish Area: 5 Mile Radius

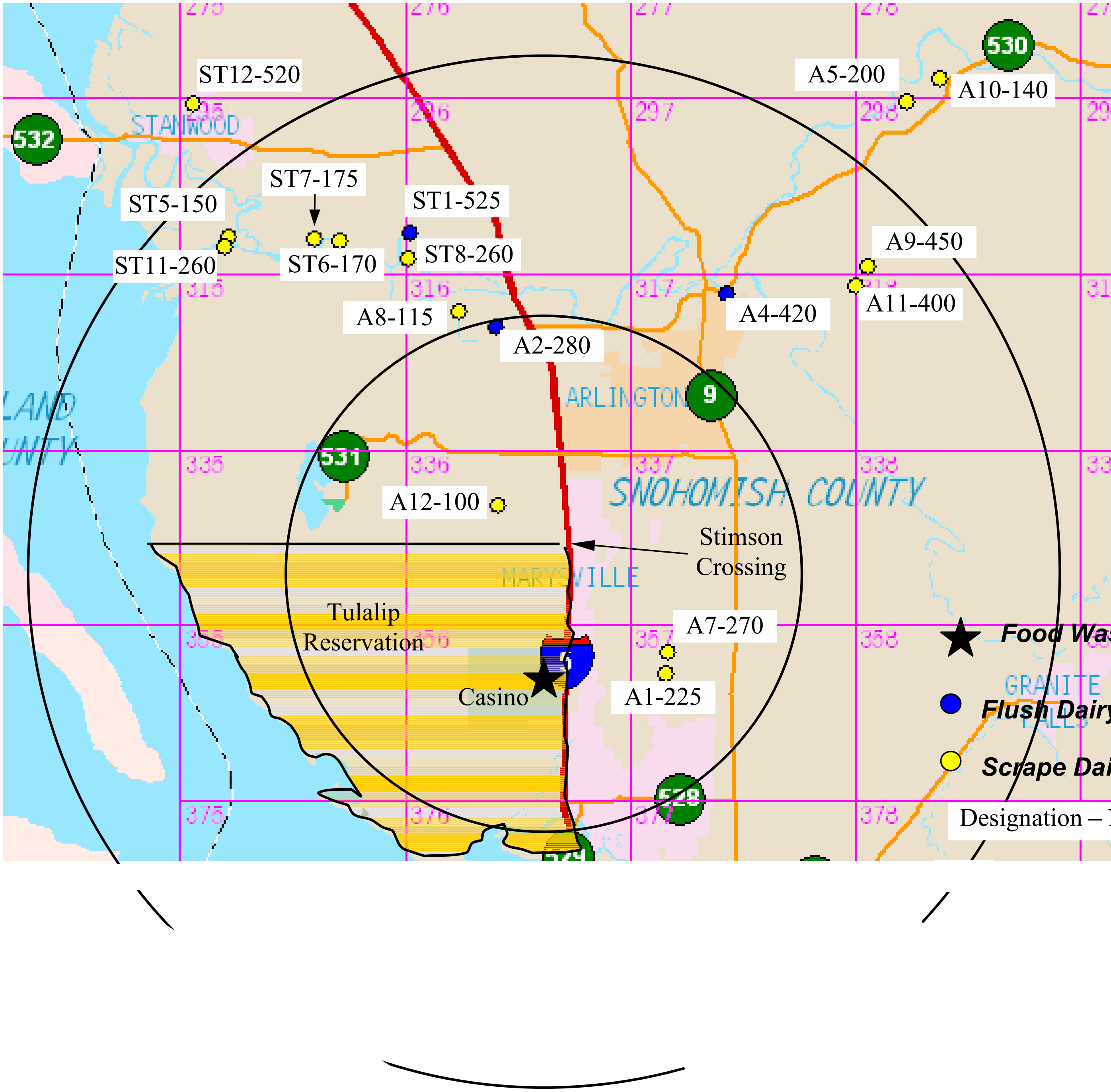




Appendix 5, Map 3: Monroe-Snohomish Area, 10-Mile Radius


Food Waste: >
Flush Dairies: 1,
Scrape Dairies: 2
Ten-Mile Radius
Honor Farm
Red Hook
SNOHOMISH
MILL CREEK
KING COUNTY
5
405
527
96
9
522
524
203
2
417
418
419
437
438
439
440
457
458
459
460
477
478
479

Appendix 5, Map 4: Upper and Lower Stillaguamish Areas



Attachment 8
Anaerobic Digestion Technology

Characterization of Anaerobic Digesters

Anaerobic Digestion Process

Manure consists of partially decomposed feed, metabolic wastes and water. Raw Manure or dilute manure with flush water is generally too concentrated to be decomposed aerobically in a manure treatment or storage structure, because oxygen cannot diffuse into solution fast enough to support aerobic bacteria. Therefore, manure is broken down sequentially by groups of anaerobic bacteria.

Anaerobic digestion is a complex process that can be simplified and grouped into two stages, summarized in Figure 1. The first stage decomposition is performed by ubiquitous and fast growing acid forming bacteria. Protein, carbohydrate, cellulose, and hemicellulose in the manure are hydrolyzed and metabolized into short chain acids such as acetic acid, butyric acid, and proprionic acid, and longer chain organic acids. This stage is easy to recognize because the decomposition products have noticeable, disagreeable, effusive odors.

Organic acids can be metabolized by methane forming bacteria, producing a mixture of methane and carbon dioxide called biogas. Methane bacteria or methanogens are a small group of slow-growing, environmentally sensitive bacteria. These bacteria require a pH greater than 6.5 and adequate time to convert organic acids into biogas. Methanogen growth and methane production slows as water temperature decreases. Ideal operating temperatures for anaerobic digesters are either at 99^{o}F (mesophilic digestion), or at 135 ^{o}F (thermophilic digestion). Most digesters are designed to operate at mesophilic temperature due to the ease of operation and the better stability as compared to thermophilic operation. The amount of time manure remains in a digester is called the hydraulic retention time (HRT) and is defined as the digester volume divided by daily influent volume. Typical mesophilic digesters are designed to operate with a 20-day HRT.

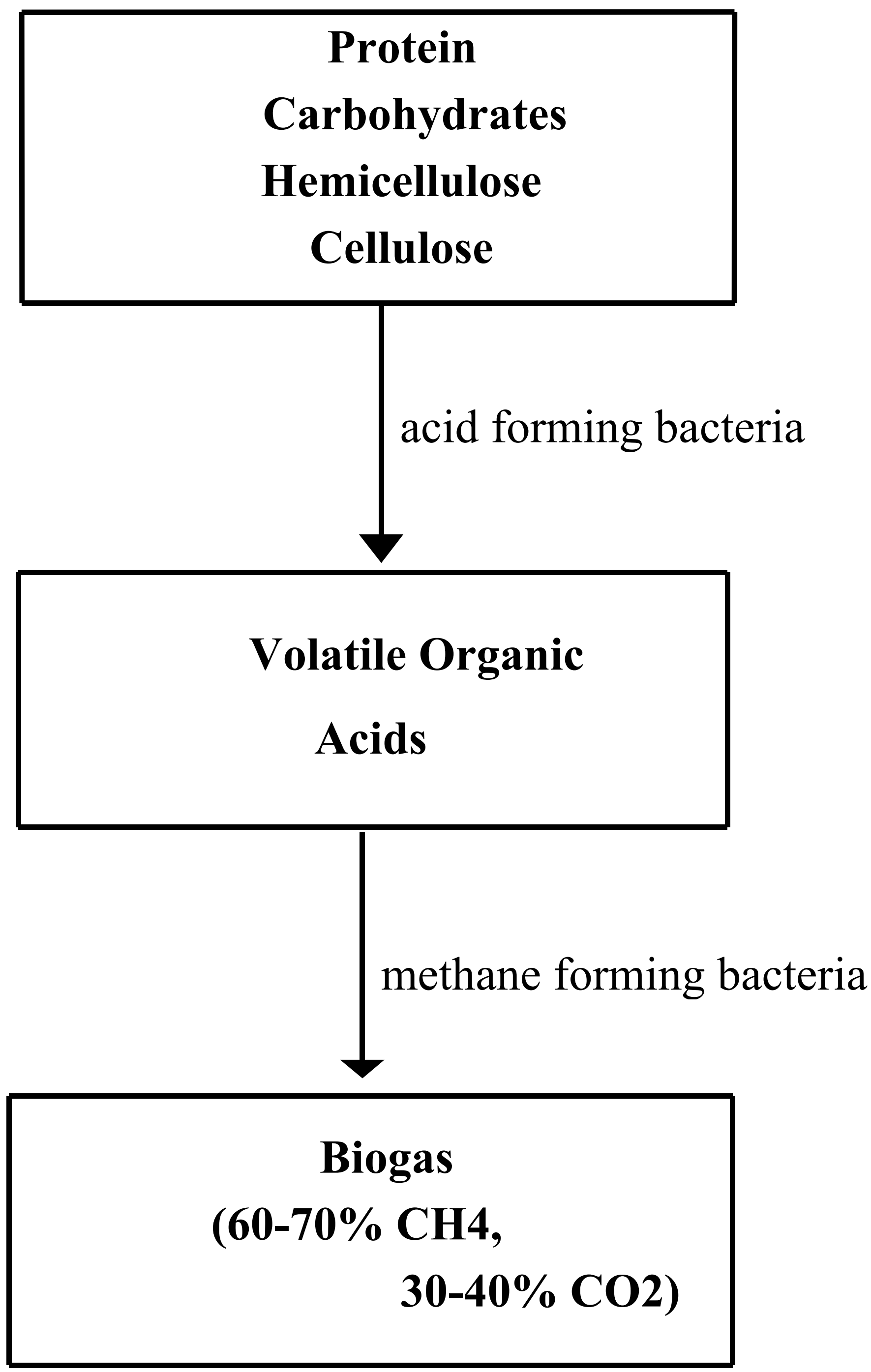
Biogas from a stable methane production process contains approximately 60% methane and 40% carbon dioxide. Traces of hydrogen sulfide and water are also present.. Biogas is virtually odorless but contains some mercaptans that odorize the gas.

General Effect of Digestion on Nutrient, Pathogen and Weed Seed Content in Waste

A digester will have minimal effect on the total nutrient content of the digested manure. However, the chemical form of some of the nutrients will be changed. A digester will decompose organic materials converting half or more of the organic nitrogen(Org-N) into ammonia (NH_3-N). Some phosphorus (P) and potassium (K) are released into solution by decomposing material. The majority of the P and K are bound in solids form in the suspended material. Dissolved and suspended nutrients will flow through the digester.

Digesters are very effective in denaturing weed seeds and reducing pathogens. Weed seed destruction is virtually at 100%, whereas, pathogen reduction is greater than 99% in a 20 day HRT mesophilic digester.

Figure 1. Simplified Processes of Biogas Production



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Anaerobic Digester System Components

An anaerobic digester system is designed to optimize methane bacterial growth and biogas production. The system includes manure collection, pretreatment, the anaerobic digester itself, solids separation and byproduct recovery, biogas recovery, biogas handling and biogas use. The components are described in the following sections.

Manure Collection

Manure must be collected fresh on a regular schedule for digestion. In most dairy regions, manure is collected as a semi-solid or solid with a tractor scraper or as a thin slurry by flushing water over a curbed concrete alley where manure is deposited. A very important consideration is the amount of process water included in the manure collection. Process water includes all water from all sources that mixes with manure.

Pretreatment

Collected manure may undergo pretreatment prior to introduction in a digester system. Pretreatment is used to adjust the manure or slurry contents to meet process requirements of the selected digestion technology. A collection/mix tank may be used to accumulate manure, process water and/or flush water. Proper design of a mix tank prior to the digester can limit the introduction of sand and rocks and provide for more consistent digester feedstock.

A collection/mix tank is a concrete or metal structure where manure is deposited by a manure collection system. For digesters requiring thick slurry, a mix tank serves as a control point where water can be added to dry manure or dry manure can be added to dilute manure.

For digesters where solids should not be introduced, manure mixed with flush and process water can be pumped from the collection/mix tank to a solids separator. A variety of solids separators are available and are currently used on farms.

Anaerobic Digester

An anaerobic digester is an engineered containment vessel designed to promote the growth of methane bacteria. The digester may be heated or unheated, mixed or unmixed, a simple tank or a very complicated media packed column. Manure characteristics and collection technique determine the type of anaerobic digestion technology that can be used. Manure can be digested at three different temperature ranges: psychrophilic digestion occurs at ambient temperatures generally ranging from $40^{o}F – 80^{o}F$; mesophilic digestion occurs between $95^{o}F$ and $105^{o}F$; and thermophilic digestion occurs at operating temperatures between $135^{o}F$ and $145^{o}F$. The primary difference in digestion at the three temperature ranges is the speed at which biogas is generated and the degree of pathogen reduction. The higher temperature thermophilic process has the highest biogas generation rate and the highest degree of pathogen reduction. However, it also requires a greater degree of process control and therefore more expensive control equipment than mesophilic or psychrophilic digesters. The next section describes the characteristics of various anaerobic digestion technologies. It

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should be noted that theoretically any digester could be operated at either one of these operating temperatures.

Byproduct Recovery

It is possible to recover digested fiber from the effluent of some ruminant manure digesters. There is no valuable solid byproduct that is easily recoverable from digestion of non-ruminant manures. Digested solids are a valuable product for cattle bedding or sale as a soil amendment in the form of compost with much better characteristics than the typical composted manure. Composted-digested solids are odor free, weed-seed free and nearly pathogen free.

Biogas Recovery

Biogas formed in a digester bubbles to the surface and may be collected by a fixed rigid top, a flexible inflatable top or a floating cover depending on the type of digester. The collection system directs biogas to gas handling components.

Biogas Handling

Biogas may be filtered for mercaptan and moisture removal. Biogas is usually pumped or compressed to operating pressure and then metered to the gas use equipment.

Biogas Use

Recovered biogas can be used as a boiler fuel, fuel for heating, adsorption chilling or as fuel for an engine to drive an electric generator.

Available Anaerobic Digestion Technologies

Many configurations of anaerobic digesters have been developed that may or may not be commercially available for farm applications. This section briefly describes digester types. Table 1 lists the operating characteristics of various digester technologies based upon the type of waste they can treat (soluble vs suspended particulates), the range of normal influent solids concentration, whether supplemental heating is necessary, the hydraulic retention time, and other environmental factors.

Table 1. Types of Digesters and Their Characteristics

Type of Digester	Level of Technology	Influent Solids Concentration	Solids Allowable	Supplemental Heat	HRT (days) (1)
Packed Reactor (2)	Medium	0.1 - 2%	Soluble	Yes	2+
Upflow Anaerobic (2) Sludge Blanket	High	0.1 - 2%	Soluble	Yes	2+
Ambient Temperature Covered Lagoon	Low	0.1 - 2%	Fine	No	40+
Complete Mix	Medium	2.0 -10%	Coarse	Yes	15+
Plug Flow	Low	11.0 -13%	Coarse	Yes	15+
Anaerobic Sequencing Batch reactor (2)	Experimental	0.5 - 8%	Coarse	Yes	2+
High solids	Experimental	20 - 35%	Coarse	Yes	15+

(1) HRT = Hydraulic Retention Time = digester volume/daily influent volume
(2) Attached growth reactors

Digesters For Soluble And Suspended Solids

Attached Growth - Packed Reactor or Upflow Anaerobic Sludge Blanket (UASB)

Packed bed digesters are considered experimental for manures but could be considered for treatment of screened flushed manure and parlor process water. Anaerobic bacteria are retained in the digester either on the surface of packing materials or in a sludge blanket and digest material from solution as it passes by. A packed reactor will contain spheres, plastic baffles, or wood bats as media.

This approach is most successful for dilute, soluble organic wastes. Wastes with particulates plug or overload these digesters. These designs are often used where space is limited. Tank volume is substantially reduced compared to other digester designs, while the amount of equipment to operate the digester is substantially increased.

A pilot scale packed bed reactor was operated at a dairy in Florida for 6 months in 1994. A full-scale attached media dairy reactor has been constructed with plastic media and operated at the University of Florida for over 3 years. The University digester successfully treats flushed dairy manure after removal of settled solids. The average winter ambient temperature is above 53 degrees F.

At this time, full-scale use of this technology has not been demonstrated on farms in the United States and therefore cannot be considered as available.

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The Horizontal Baffled Reactor

The anaerobic baffled reactor is a horizontal version of the upflow anaerobic sludge blanket reactor. The anaerobic bacteria are growing on pellets approximately the size of a pea and digest material from solution as it passes by. This digester is not effective in digesting particulate waste, as the particulate solids tend to settle and clog the reactor. It is most effective with soluble organic wastes. The pilot scale unit of this reactor suggested it would not be successful with dairy wastewater.

Ambient Temperature Covered Lagoon

Properly designed anaerobic lagoons are used to produce biogas from dilute wastes with less than 2% total solids (98% moisture) such as flushed dairy manure, dairy parlor washwater and flushed hog manure. The solids within the waste stream tend to be fine and highly digestible. The lagoons are not heated and the lagoon temperature and biogas production varies with ambient temperatures. Coarse solids such as hay and silage fibers in cow manure must be separated in a pretreatment step and kept out of the lagoon. If dairy solids are not separated, they float to the top and form a crust. The crust will thicken, reducing biogas production and eventually filling the lagoon.

More than 35 unheated, unmixed anaerobic lagoons have been fitted with floating covers for biogas recovery from hog waste. Industrial and dairy covered lagoons are located across the southern US in warm climates. A successful digester will be deeper than 14 feet and in a climate with an average monthly temperature greater than 50 degrees. This approach might be considered for treatment but is less successful in cold climates. According to EPA FarmWare, Snohomish County has 2 months of the year with average temperatures below 50 degrees.

Digesters for Wastes with Soluble, Suspended and Settleable Solids

Complete Mix Digester

Complete mix digesters are the most flexible of all digesters as far as the variety of wastes that can be accommodated. Digestible wastes from any source with 2 - 10% solids are pumped into the digester and the digester contents are continuously or intermittently mixed to prevent separation. Complete mix digesters are usually above ground, heated, insulated, round tanks. In-ground rectangular vessels have also been employed as complete mix digesters. Gas recirculation, mechanical propellers or liquid circulation can accomplish mixing.

One intermittent mix digester has been built at a dairy in California and operated with varying results due to seasonal pasturing of cows. Another complete mix digester has been built in New York on a dairy and is being fed a mixture of cow manure and food waste. The digester has been operating with excellent results for nearly two years. A third one was built for layer manure and functioned well for four years. A complete mix digester can be considered a viable option in Snohomish County.

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Contact Digester

The contact reactor retains solids within the reactor system by separating and concentrating the solids in a secondary reactor and returning them to the influent of the primary reactor. The primary reactor is completely mixed and can be operated in the thermophilic or mesophilic temperature range. Gravity separation is typically the means that is used to concentrate the digester effluent solids. The advantage of this system is the conservation of the bacterial mass within the primary reactor resulting in more of the biodegradable waste being converted to gas. This technology is experimental in the treatment of dairy manure.

Anaerobic Sequencing Batch Reactor (ASBR)

At this time ASBR technology is experimental. An ASBR treats waste in small batches. Waste is pumped into the partially filled digester. The batch is mixed for several hours then mixers are shut off and particulates are allowed to settle. Soluble organics are rapidly decomposed while solids that are not readily treated settle in the digester and are decomposed over a longer period. Treated effluent is decanted off the top of the digester and excess sludge is wasted from the bottom of the digester. The batch process is then repeated.

ASBR technology takes advantage of high microbial concentration for rapid decomposition of solubles and retention of solids for later decomposition. The process requires significant equipment and process control. At this time, full scale use of this technology has not been demonstrated on farms in the United States.

Phased Digesters

Acid phased digestion separates the acid forming bacteria and the methane forming bacteria into two separate reactors. It maximizes the growth of each set of bacteria by maintaining optimum conditions in each tank for that particular group of bacteria. The first group, the acidogenic bacteria, is grown in the acid digester where the pH is kept low and the residence time is maintained between 1-3 days. The second group, the methanogenic bacteria, is grown in the methane digester where the pH is naturally much higher and where residence time can be between 7-10 days, depending upon waste characteristics. This process has been developed by the Gas Technology Institute (GTI) in Chicago and is called the HIMET process. The advantages claimed by GTI are more stable digestion as compared with other digestion technologies allowing a higher throughput of waste and also reduced reactor sizes. This technology has been proven in the treatment of waste water and pig manure though it has not been used for the treatment of dairy manure.

Digesters for Undiluted Scrape Collected Dairy Manure

Plug Flow Digester

Plug flow digesters are used to digest thick wastes (11 - 13% solids) from ruminant animals. Coarse solids in ruminant manure form a viscous material and limit solids separation. If the waste is a less than 10% solids, a plug flow digester is not suitable. If

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the collected manure is too dry, water or a liquid organic waste such as cheese whey can be added. This approach is most successful with scraped cow manure.

Plug flow digesters are unmixed, heated rectangular tanks. They function by displacement of old material by new material horizontally through the digester. New material is usually pumped in, displacing an equal portion of old material out of the digester.

High Solids Digester

High solids digestion of animal manures has not been demonstrated. High solids digestion at 18 - 35% total solids has been developed for sorted municipal solid waste (MSW) only. Flow through and batch systems have been built for MSW in the US and Europe, principally for volume reduction rather than energy recovery. The systems are complex and expensive. Tipping fees offset the high capital and materials handling costs.

These designs may be adaptable for cattle manure, however the rheological properties of manure are quite different than MSW. At concentrations above 14% total solids, cow manure cannot be pumped with conventional pumps. At concentrations higher than 25% total solids, cow manure does not contain free water and liquid recycle is not possible. It is possible that a continuous feed digester could be developed; however there are no known pilot studies and batch operation of several digesters is beyond the ability of a typical farm.

Summary - Anaerobic Digester Technology

Ambient temperature covered lagoon, plug flow digester and complete mix digester technologies are known, demonstrated and available for digestion of livestock manure.

Attached growth systems are common for dilute soluble wastes not typical of manures. ASBR, horizontal baffled reactors, contact reactors and high solids technology are experimental for the digestion of manure at this time. None of these systems have been commercially demonstrated using livestock waste and so will not be considered further. The phased digester has been demonstrated with pig manure which has a fine consistency of solids, though not with dairy manure where the waste consistency is coarser. Therefore the phased digester will not be considered further either.

Technology Providers

The following is a select list of anaerobic digester technology providers in the US and in Europe. The source for the US technology providers is the USEPA's Agstar Program website (www.epa.gov/agstar). The source for the European technology providers is the Biogasworks website (www.biogasworks.com)

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Table 2. Listing of US Anaerobic Digestion Technology Providers

Name	Location	Type of AD Technology
AgriWaste Technology Inc.	Raleigh, NC	Covered Lagoon
Applied Technologies Inc.	Brookfield, WI	Industrial Complete Mix
Environmental Energy Company	Olympia, WA	Industrial Complete Mix
Environmental Treatment Systems	Smyrna, GA	Attached Media
Environomics	Riverdale, NY	Plug Flow, Complete Mix, Covered Lagoon
Feldmann & Associates	Spring Bay, IL	Complete Mix, Plug Flow
Fox Engineering Associates, Inc.	Ames, IA	Complete Mix
GHD Inc.	Chilton, WI	Plug Flow
Hadley and Bennett Inc.	Henniker, NH	Plug Flow
Orgo Systems Inc.	Sellingsgrove, PA	Complete Mix
Oswald Green Inc.	Concord, CA	Covered Lagoon
RCM Digesters Inc.	Berkeley, CA	Plug Flow, Complete Mix, Covered Lagoon
Sharp Energy Inc.	Tulare, CA	Covered Lagoon
University of Florida	Gainesville, FL	Attached Media
Williams Engineering Associates	Los Osos, CA	Covered Lagoon

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Table 3. Listing of European Anaerobic Digestion Technology Providers

Name	Location	Type of AD Technology
Bioscan A/S	Odense, Denmark	Complete Mix
Burnmeister & Wain Scandinavian Contractors A/S	Allerod, Denmark	Complete Mix
Carl Bro Environmental A/S	Glostrup, Denmark	Complete Mix
DRANCO Organic Waste Systems	Gent, Belgium	Complete Mix
Eco-Technology JVV OY	Espoo, Finland	Complete Mix
Entech Umwelttechnik GmbH	Fussach, Austria	Complete Mix
Enviro-Control Ltd.	Cardiff, United Kingdom	Complete Mix
Farmatic Biotech Energy AG	Nortorf, Germany	Complete Mix
Ferm Tech Inc.	Neunkirchen, Germany	Complete Mix
Kompogas AG	Glattbrugg, Switzerland	Complete Mix
Krieg & Fischer Ingenieure GmbH	Gottingen, Germany	Complete Mix
Kruger A/S	Abyhoj, Denmark	Complete Mix
Linde-KCA-Dresden GmbH	Dresden, Germany	Complete Mix
Lipp GmbH	Tannhausen, Germany	Complete Mix
Nellemann, Nielsen & Rauschenberger A/S	Vibe J, Denmark	Complete Mix
Paques Solid Waste Systems BV	Balk, Netherlands	Complete Mix
Prikom/HKV	Herning, Denmark	Complete Mix
Risanamento Protezione Ambiente, SpA	Perugia, Italy	Complete Mix
Schwarting-UHDE GmbH	Flensburg, Germany	Complete Mix
Steinmuller Valorga	Montpellier, France	Complete Mix

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Manure Digesters in the United States

The following is a list of manure digesters in the United States by technology type. The source of this data is the USEPA Agstar website (www.epa.gov/agstar).

Table 4. Complete Mix Digester Installations in the United States

Complete Mix					
Location	Year built	Animal type and population	Manure handling	Installed cost	Biogas end-use
NC	1983	Caged layers; 70,000	Scrape	$225,000	Electricity
NY	1985	Dairy; 270 milkers	Scrape	$5,000,001	Electricity and hot water
PA	1985	Swine; 1,000 sows farrow-to-finish	Scrape	$325,000	Electricity and hot water
CT	1997	Dairy; 600 milkers	Scrape	$450,000	Electricity
IL	1998	Swine; 8,600 finishing hogs	Pull plug	$152,300	Hot water and flare
IA	1999	Swine; 5,000 sows farrow-to-wean	Pull plug	$546,000	Electricity
CO	1999	Swine; 5,000 sows farrow-to-wean	Pull plug	$368,000	Electricity
NY	2000	Dairy, 925 cows, organic	Scrape	$625,000	Electricity, heat, steam

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Table 5. Covered Lagoon Installations in the United States

Covered Lagoon					
Location	Year built	Animal type and population	Manure handling	Installed cost	Biogas end-use
CA	1982	Swine; 1,650 sows farrow-to-finish	Flush	$220,000	Electricity and hot air
CA	1984	Swine; 900 sows farrow-to-finish	Flush	$120,000	Electricity and hot air
CA	1986	Swine; 550 sows farrow-to-finish	Flush and gravity drain	$75,000	Electricity and hot air
VA	1993	Swine; 600 sows farrow-to-feeder	Flush and pull plug	$85,000	Electricity
NC	1997	Swine; 4,000 sows farrow-to-ween	Pull Plug	$290,000	Electricity and hot water
NC	1999	Swine; 400 sows Farrow-nursery	Flush	$22,150	Flare
IA	1998	Swine; 3,000 nursery pigs	Pull plug	$15,000	Flare
CA	1998	Dairy; 200 cows	Flush	$150,000	Flare
MS	1998	Swine; 120 pigs	Hose wash	$19,000	Flare
WI	1999	Dairy; 1,100 milkers	Scrape	$37,300	Flare
WI	1999	Dairy; 1,300 milkers	Scrape	$122,000	Flare

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Table 6. Plug Flow Installations in the United States

Plug Flow-Straight Flow Configuration					
Location	**Year built**	**Animal type and population**	**Manure handling**	**Installed cost**	**Biogas end-use**
MI	1981	Dairy; 720 milkers	Scrape	$150,000	Electricity
VT	1982	Dairy; 340 milkers	Scrape	$185,000	Electricity and hot water
CA	1982	Dairy; 400 milkers	Scrape	$200,000	Electricity and hot water
OR	1997	Dairy; 1,000 milkers	Scrape	$287,300	Electricity
NY	1998	Dairy; 1,000 milkers	Scrape	$295,700	Electricity
MN	1999	Dairy; 1000 milkers	Scrape	$329,851	Electricity
Plug Flow-Slurry Loop Configuration					
Location	**Year built**	**Animal type and population**	**Manure handling**	**Installed cost**	**Biogas end-use**
IA	1972	Swine; 150 sows	Flush	$20,000	Flare
PA	1979	Dairy; 2,000 milkers	Scrape	$260,000	Electricity and hot water
PA	1983	Caged layer; 70,000	Scrape	$140,000	Electricity and hot water
PA	1983	Dairy; 250 milkers	Scrape	$120,000	Electricity and hot water
CT	1997	Dairy; 200 milkers	Scrape	$149,000	Hot water and flare
MD	1994	Dairy; 450 total head	Scrape	$5,000,001	Flare

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Attachment 10

MONROE HONOR FARM
Snohomish County, WA

BASELINE ANALYSIS

Engineering and Cost Values of an RCM Complete Mix Manure Digestion System

March 2004

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Biogas Partnership:
Tulalip Tribes
L.Skykomish Group
NW Chinook Recovery
WA Dairy Federation
Clark Group, LLC

DISCLAIMER

This assessment is provided as a next step in evaluating the financial and technical potential of methane recovery technology and is to be used as guidance only. The results presented are based on over 20 years experience, limited data collection and cost estimating functions. Input errors or erroneous information affect the results. Cost estimates are reasonable planning level estimates based on recent pricing for similar materials. However, geographic location, labor costs and materials price changes will affect the results. A final design and cost estimate must be prepared. Qualified designers, engineers and suppliers should be included in the project implementation team. The AgSTAR Handbook representing the livestock, energy and government sectors, may be used for additional reference and guidance in this process.

PROJECT GOAL

The goal for the Monroe Honor Farm regional project is to install an anaerobic digester system to biologically treat local area dairy farm manure and certain appropriate institutional wastes both for environmental and financial purposes. The intention is to generate renewable energy, while reducing the environmental risks associated with manure management, including odor, pathogens and methane emissions. Additionally the project wishes to explore options to compost the separated solids to market as a soil amendment product.

1.0 INTRODUCTION

Many engineering considerations and design approaches exist for a regional digester project at the Monroe Honor Farm site. The basic site parameters and anticipated feedstock descriptions as quantified and summarized in the November 2003 Waste Assessment Report will be utilized for the design assumptions presented in this Baseline Analysis. Additional engineering considerations, feed stock qualifications, and biogas and electricity production estimates have been presented in the companion January 2004 Preliminary System Design Elements Report.

This document will establish a baseline analysis for the feasibility of methane production, recovery and utilization at the Monroe Honor Farm. It is based on an engineering approach and the complete mix digester experience of RCM Digesters, Inc. This baseline comparative document will evaluate one system design approach with a pressure sewer delivering manure from the four dairies immediately adjacent to the Honor Farm site. This study will also incorporate the food waste inputs as defined in the Preliminary Design Elements Report, January 2004. The analysis will develop unit processes, list system cost estimates, and estimate the projected revenues from electricity and byproduct production. The purpose of this analysis is to define the baseline assumptions of a digester system, estimate component costs, and provide the resulting system production output estimates. It is anticipated that the project’s Financial Team will utilize these values in structuring the development of a detailed business plan.

1.1 SUMMARY AND UNDERLYING ASSUMPTIONS

This study will establish for the Tulalip Tribes and the Biogas Partners a comparative baseline analysis of methane production at the Monroe Honor Farm Site. Preliminary analysis as reported in the “Preliminary Design Elements Report” has demonstrated that methane production is technically feasible. The study will consider a mesophilic, complete mix type of digester based on similar RCM system designs and biogas experience, to accommodate diluted dairy manure and the addition of food waste inputs. Digestion of dairy manure collected from four adjacent farms and transported to the digester with a pressure sewer will be evaluated based on budgetary estimates of typical private scale contractor costs. The study will account for the anticipated introduction of food waste into the digester. The study will also examine the effects of grant funding on the digester project costs for Monroe Honor Farm.

Direct economic benefits from the project would be production of renewable energy in the form of electricity and hot water. After meeting the site electrical needs, excess biogas could also be used for drying manure solids to enhance the production of marketable fiber. Accepting food wastes into the digester may also generate tipping fees in addition to enhancing the biogas production. Non-economic benefits from completion of the project are waste utilization, odor control, pathogen and weed seed reduction, and a more readily useable liquid nutrient for crop fertigation.

The study options considered in this report for the Monroe Honor Farm include:

1. 2,005 mature Holstein equivalents (MHE) with food waste
2. 2,005 MHE/food waste with 25% grant funding

Facility design assumptions presented in this study are based on over 20years of RCM engineering experience. The digester system described in this report is based on approaches similar to those employed in other comparable successful RCM digester operations. A table summarizing the system component design assumptions is presented in the appendix. Specifically, the report is developed using information from:

1. Interviews with potential participants in a regional digester at the Honor Farm,
2. Data as reported in the November 2003 Waste Assessment Report,
3. Engineering assumptions as reported in the January 2004 Preliminary System Design Elements Report,
4. Proprietary RCM estimates based on over 20 years of experience with waste collection systems and resulting biogas production,
5. Similar facility layout, plumbing, process flow, and wiring design cost comparisons,
6. Interview with underground utility contractor to establish budgetary cost estimates

1.2 COST AND BENEFIT SUMMARY

Estimated Costs

Costs were developed for a digester with electricity production and excess hot water available for on-site facility use. Costs of construction were assumed using typical private contractor cost estimates for construction of on farm projects in the area.

The heated, complete mix digester system sized for a hydraulic retention time of 24 days for 2,005 mature Holstein equivalents (MHE) and the identified food waste should cost about $2,066,284.

Estimated Potential Benefit

The annual sale of excess electrical energy in the amount of $81,493 is assumed in this analysis. Additionally, the marketable value of fiber was assumed to be approximately $36,884 per year. An annual greenhouse tax credit was calculated at $24,672.

2.0 PROJECT DESCRIPTION

The regional project analysis for this study will consider digester feed inputs from the dairy farms adjacent to the Monroe Honor Farm site identified as M2, M4, M5, and M7 and fully described in the November 2003 Waste Analysis Report. Additionally, feedstock from the Edmonds School District, The Monroe Correctional Facility, and the Red Hook Brewery will be incorporated into the analysis. These sites were also described in the November Waste Assessment Report. These digester feed stocks have been further characterized in the January 2004 Preliminary Design Elements Report.

An area sketch depicting the pressure sewer is shown in the appendix to establish the relative location and proximity of these dairies to the Honor Farm Site. The distance between the farms is represented using The Thomas Guide Digital 2003 mapping software. No actual onsite measurements or area field survey was conducted. The pressure sewer sketch assumes all new pipelines and does not attempt to utilize existing irrigation lines. Currently, manure is collected from the freestall barns and feed lanes at these farms by either scraping or flushing practices.

2.1 PROJECT LOCATION

The Monroe Honor Farm is located approximately 4 miles south of the city of Monroe, Washington on State Highway 203. The site is in Section 24, Township 27 North, Range 6 East, W.M. of Snohomish County. The site is comprised of about 270 acres in the lower Skykomish River watershed. The topography surrounding the area is very flat terrain and is more fully described in the Preliminary System Design Elements Report. The site and associated dairy farms were not surveyed for this analysis.

2.2 OWNERSHIP, MANAGEMENT, AND STRATEGY

Many factors remain to be developed in terms of the ownership and management structure for a regional digester at the Monroe site. For purposes of this baseline analysis, it will be assumed that the identified dairies have formed a consortium designed to deliver a specified quantity and quality of their dairy manure to the digester project on a daily basis. It is also assumed that satisfactory agreements have been made with the identified institutions to ensure reliable delivery of their waste streams to the digester site. Further, it is assumed that an on-site management entity has been hired to operate and provide for the overall system maintenance.

2.3 CLIMATIC CONDITIONS

Temperature and precipitation averages compiled over thirty years at the USDA weather station at Everett, WA are listed in Table 1. Design calculations and projected system performance are based on these weather conditions. A complete evaluation of the prevailing weather conditions affecting the design considerations are described in the Field Survey and Waste Assessment Report submitted in November 2003.

Table 1. Temperatures, Precipitation

	Temperature ^{O}F	Precipitation, in
January	39.1	6.52
February	42.4	4.53
March	45.1	4.83
April	49.4	3.56
May	55.2	2.91
June	60.4	2.37
July	63.9	1.42
August	64.4	1.92
September	59.6	3.01
October	51.8	4.25
November	44.1	6.41
December	39.0	6.88
Annual Avg. and Total	51.2	48.61

2.4 SOILS AND SUBSURFACE

The prevalent soil type at the Monroe Honor Farm as shown in the USDA Soil Survey for Snohomish County is Puget silty clay loam. A soil evaluation is provided in the companion document, "Preliminary Design Elements Report". Shallow depth to ground water and seasonal flooding are critical design elements that must be considered. Engineering should take into consideration the load bearing capacity of the soil, depth to bedrock and depth to ground water.

2.5 DAIRY FACILITY DESCRIPTIONS

DAIRY M2

This dairy located about 1 ½ mile north of the Honor Farm is milking 610 Holsteins. Milk production is 31,000 lbs. for the 305-day rolling herd average. The farm milks 4 times per day. Feed rations average 57 pounds dry matter (DM) per day. Operators hope to increase the herd by10% to 15% per year.

The milking herd and approximately 70 dry cows are housed year around in several adjacent free stall barns. All this manure is collected by flushing the lanes in the free stall barns. Flushed lanes also collect manure from 120 calves aged from 3 to 7 months.   All bedding in flushed areas is coarse sand that is imported from a nearby sand and gravel operation.

The manure flush system cycles 4 times per day. There are 16 valves that are 15" in size. They flush 1 minute per valve, delivering 5,800 gallons per minute (gpm) totaling 345,000 gallons per day (gpd). The parlor is hand washed with a 1-inch hose 12 times per day. There was no estimate on time or volume of water used during the parlor wash downs.

All flushed waste flows to a gutter that runs perpendicular to the west end of the free stall barns. The cement lined gutter flows to a settling basin (approx 100x100 x very shallow) and then is pumped over locally built “Albers-type” drag chain screen separator. The settling basin is quickly cleaned (2 hours with front-end loader) and put back on line. Separated sand and manure slurry is sold for $2.00 per ton to local area landowners. The screened manure solids are hauled out for free.

The existing storage lagoon is 300 x 300 x 18 deep (5.1 million gal). It is located west of the free stall barns just north of the sand separation pit and the drag screen separation area.

The irrigation force main system goes south through the dairy’s land and over roadway easements to remote fields. It passes the farm designated **M5** and comes to within ¼ mile of the Honor Farm property.

It is felt by the dairy management that additional pipe could be laid to the Honor Farm facility (easements for the pipe were not thought to be a problem for a project like this). The lines would pass by the **M5** farm and offer the chance to pick up the scraped manure there if technically feasible.

Dead animals are composted on site with straw and manure from calf hutches.

DAIRY M4

This Dairy is located northwest of the Honor Farm. The owner is actively supporting the regional digester project. He farms 300 acres, which includes 100 acres of corn, and with the digester in place he hopes to be able to increase his herd by 10% without increasing the size of the existing lagoon.

He milks 140 cows (1300 to 1400 pounds) (mostly Holsteins with 15 Jerseys) twice per day. Production averages 75 pounds per day at 5.5% butter fat. There are 25 dry cows that are out on pasture for 5 to 6 months of the year. Manure is not collectable from the dry cows during the pasture time.

The sawdust-bedded barns are scraped with a steel blade two times per day to two pits located west of the parlor. These pits collect 70% of the farms manure until it is pumped to the storage lagoon. The farm does not separate any of these manure solids. The existing pond is about 1.5 million gallons and currently provides about 9 months of storage. The waste is held until it can be sent to the fields with a spreader truck. He spreads up to 300 wagon loads at 2,800-gallons each per year. The remaining manure is considered “solid” which is much drier and contains straw bedding. It is sent to the fields with a conventional spreader at the rate of 500 bushels per week.

Parlor wash down amounts to twenty minutes with a one-inch hose after each of the two daily milking. This flows to a third and separate pit and is pumped to the lagoon.

The owner feels that he could easily join the two manure pits and load directly to a truck for transport. However he may be reluctant to build a manure pump out facility without financial help. His current pumps have difficulty in moving the pit slurry and would require an upgrade for a pump out. He could take most of the digested liquid back but is looking to lower the impact to storage in order to increase his herd. He is also interested in receiving back some digested solids for his corn production fields. Barn gutters need some work. It was estimated that there is an area about 13,000 ft^2 open to collect the rain and that could potentially dilute the scraped manure.

DAIRY M5

This dairy is located just south of dairy M2 and is about 1 mile north of the Honor Farm. This is a scrape dairy milking 470 Holsteins two times per day with 70 dry cows on site. Milk production is averaging 21,500 for 305-day rolling herd average. Feed is 54 pounds DM per day. Animal size was estimated to average 1,400 to 1,450 pounds. Rations include malt, cottonseed, and 25% alfalfa hay. No herd increase is planned. During the 5 wet months add manure from 80 to 100 heifers 16 to 27 months old.

The milk cows are housed in free stall barns. Only sawdust and shavings are used for bedding – no sand. All manure is collectable by scraping once per day with a rubber tire. There are 10 scrape alleys that are 12 feet wide by 200 feet long. The manure is scraped to the east end of the barn lanes into a 25,000 gallon manure tank located behind the parlor. Based on the volume of the scrape manure tank, the Dairy estimated that they collect 30,000 gallons of manure per day. This includes parlor wash of one hour per day from 1” hose. Rainwater mixes with the manure from about 6,000 ft^2 of uncovered area over the manure scrape lane that is perpendicular to the east end of the barns.

Solids are separated with a rotary screen separator and hauled away for free by local farmers and a top soil company. Liquid is pumped to a lagoon system (two 3 million gal. cells) and stored for land application.

Deads are buried on site. Last quote was $80.00 per animal for disposal. It was noted that the charge is higher for horses.

DAIRY M7

The farm is located about 1 mile south of the Honor Farm and currently milks 560 Holsteins that are housed in free stalls with 100% manure collection. There are 60 dry cows with collectable manure between 4 to 5 months per year, but they are on pasture for between 7 and 8 months per year. There is no other collectable manure from other animals. The dairy expects to milk 650 within 2 to 3 years. The longer-term plan is to expand to 1,000 milking cows, but needs help to reduce the farm land nutrient loading to get permit for this expansion.

The dairy milks three times per day for the six groups of cows. Production averages 80 pounds/day. The feed ration is 50 to 52 pounds DM. The ration is comprised of 40 pounds silage, 12 pounds hay, 4 pounds cottonseed, 10 pounds corn silage, 26 pounds grain (corn, canola, distillers grain, soy) and mineral supplements.

The barns flush four lanes to two settling ponds that are in series and then discharge to a lagoon. Special needs area is bedded with sawdust and shavings. All other areas bedded with sand. It is estimated that 80% of the manure from the milk cows flows through both settling ponds, but the remainder from two lanes flush directly to the second settling pond. During the winter wet four to five months, the dry cows are kept in the free stalls that flush an additional two lanes directly to the second pond. Flushing is cycled 6 times per day through 12” valves that deliver 2,000 gpm for four minutes per alley. There are 6 or 7 valves activated depending on whether the dry cows are in the barns. Separated fiber floating on two settling ponds is captured before it is discharged to the storage pond. This is mixed with scraped bedding and waste feed and is composted one turn. It is currently sold for $10.00 / cu yd.

The parlor is hosed down by hand using approx 3,500 gallons per day. Approximately 12,000 ft^2 are susceptible to rain fall contribution to the manure stream. After the settling ponds, the manure flows by gravity to the 4 million gallon lagoon. There are plans for a new 20 million gallon lagoon but the permits are on hold. Output from the lagoon is pumped north for field application. The 6” irrigation force main goes to within 1,500 feet of the Honor Farm property.

2.6 ANIMAL POPULATION

Animal populations under consideration for this study are listed in Table 2. The animal population is a total derived for this study from reported farm numbers from the M2, M4, M5, and M7 dairies. These populations and associated herd management practices were fully described in the November 2003 Waste Assessment Report. Estimated herd increases were projected by each farmer and described in Section 2.5 for each farm. These estimated population increases have been provided for consideration when the facility reaches final design stages. However, only collectable manure from the free stall barns and feed lanes as reported in November of 2003 will be considered for this digester design analysis. Pen pack manure and pastured animals will not be considered in this analysis. The animal population table considers herd management practice and associated factors as discussed and summarized in the Preliminary System Design Elements Report, January 2004.

Table 2. Animal Population

TYPE	NUMBER	Avg. Wt., lbs	Total Wt., lbs
Cows, lactating	1,780	1,400	2,492,000
Cows, dry	225	1,200	270,000
Heifers	0	750	0
Calves	0	-	0
Totals for Digester	2,005		2,762,000

2.7 WATER MANAGEMENT

United State Department of Agriculture/ Natural Resources Conservation Service (NRCS) estimates in the Agricultural Waste Management Handbook that approximately 0.6 cubic feet (17 liters) of water is used in milk house and milk parlor cleanup per animal unit (1,000 lb. equivalent) milked. This is about 6 gallons (22.7 liters) per mature Holstein. Control of water use is needed to maintain proper solids content in any digester project.

Maintaining optimum solids content by minimizing dilution is important for a few reasons. High water use increases the required size and cost of the digester. High water use also increases required storage volume for the digester effluent. Storage facility capacity should be evaluated to accommodate any anticipated increase in herd sizes, changes in water use practices, and the consideration to import and digest various food wastes.

Management of wash down water volumes, sprinkler timers and maintenance of water troughs can be critical to limit excess water entering the waste stream. Reducing water use will save the cost of pumping fresh water, ensure required minimum solids content in the digester, save electricity and allow adequate retention time the waste storage. Addition of unneeded water adds to the volume and cost of digester effluent requiring ultimate land application. Cost of land application of manure in most cases is $0.005-0.015 per gallon.

2.7.1 Fresh Water Use

Typical water use at dairies varies greatly**.** RCM recorded the current Monroe Honor Farm dairies water use practices in the farm descriptions in the November 2003 Waste Assessment Report. The milking parlors are typically hand washed with hoses after each milking. Drinking water is fresh make up water from wells. The drinking water quantity is not added into the waste stream since it goes out in the milk and in the urine that will be accounted for in the waste output estimates calculated by RCM. The actual total dairy water usage rate at each dairy should be studied in detail before final system basis of design engineering assumptions are adopted.

2.7.2 Rainfall Runoff Management

Each of the four farms has locations where rainwater can directly enter to the collectable manure. A preliminary estimate of this exposed area at each farm was calculated from the farm site descriptions and presented in the November Waste Analysis Report. However, ultimately a rainwater diversion plan to fully measure and address rainwater inclusion at each of the participating farms is an important management consideration and is also a requirement for proper digester system function.

2.8 MANURE AND OUTSIDE WASTE CHARACTERISTICS

Manure quantities plus the estimated dairy process water are estimated to be about 6,435 cubic feet per day for the four-dairy combined herd of 2,005 MHE. The animal manure production estimate is based on a known correlation to the average milk production at each of the farms, which in turn is directly related to the dry matter intake provided in the feed rations. These values are presented in the farm site narrative descriptions. Estimates related to the food waste input were developed and discussed in the Preliminary Design Report. Table 3 illustrates anticipated source, quantities and characteristics.

Table 3. Summary of Waste Parameters

Animal Units	2,762	1000 lb units
Manure Production	3,587	ft3/d
Food waste Addition	451	ft3/d
Process Water	2,848	ft3/d
Total Waste Inflow	6,886	ft3/d
Food waste VS	5,827	lb/d
Manure VS	21,482	lb/d

2.8.1 Other Waste Streams

There is an opportunity to incorporate approximately 29,084 pounds per day of a 17% to 25% total solids highly digestible food waste into the digester. The Preliminary Design Element Report evaluates this opportunity in detail. This study has evaluated the digester system based on the assumption that these identified sources will be a constant input with a seasonality variable factored in for the School District contribution.

As was noted in both previous reports, there are numerous other possible food waste sources that could be discovered. Another possible digester feed stock to be explored comes from the Tulalip Tribe's annual fish harvest. Based on a preliminary review of data recently provided by the Tribe, there is an average of 1.5 million pounds of fish wastes available each year in October and November. It is estimated that this represents a potential production of about 3.5 million cubic feet of biogas. With this waste input to the digester, the gas output would increase by 35% (60,000 cubic feet per day) for approximately 60 days per year. This increase would generate an additional income of about $7,500 per year for the project. With some equipment modifications, the RCM system design has enough built in reserve capacity to allow the engines to be modulated up to accommodate some variable and seasonal waste addition.

If food waste is to be considered as a full time permanent addition to the digester, a written contract is recommended to secure the waste stream and ensure the quantity and quality of the input. Ultimately, the digester system will have to be designed accordingly. Any changes in quality and quantity of foodwaste would affect the analysis presented herein.

2.9 MANURE AND WASTE WATER COLLECTION

The Monroe Honor Farm Site and relative locations of the adjacent farms is sketched in Appendix 1. Manure collection at each farm will vary depending on waste removal techniques employed. Each farm will have a central manure collection tank designed to serve as the pump station to move wastewater and manure into the system pressure sewer. At the flushed dairies, it is assumed that a pretreatment process will be employed prior to the pump station to segregate the sand bedding and concentrate the manure solids. These design assumptions are based on a similar layout of an operating RCM system at a large flush dairy in Idaho.

For purposes of this design analysis, a series of multiple chambers is envisioned to provide a 1-hour gravity settling process. This sand separation process is expected to produce 4% solids with ½ the manure volatile solids recovered as described in the three year study at the University of Florida, Dairy Research Unit. An excerpt from the University's proceedings at the Water Environment Federation National Summit in 2003 describing this system is included in the appendix. This process and system, as well as other types of settling system assumptions were presented in the Preliminary Design Elements Report. It is assumed that all of the dairies will develop water conservation techniques to minimize excess fresh water from their parlor and milk house wash down process.

2.9.1 Manure Collection Description

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Current Manure Collection System and Schedule

Location	Manure Removal Technique	Manure Collection Interval
M2	Flush Lanes	End of Milking / 4x per day
M4	Scrape	End of Milking / 2x per day
M5	Scrape	End of Milking / 2x per day
M7	Flush lanes	End of Milking / 3x per day

2.9.2 Storage Pond Description

Each of the Monroe Dairies has existing waste storage ponds. Collectively, the four farms have nearly 17 million gallons of storage capacity. The Monroe Honor Farm has two existing waste storage ponds that provide an additional 36 million gallons of waste storage capacity to the project.

2.10 MANURE STORAGE AND TREATMENT

NRCS (Agricultural Waste Management Field Handbook, 1992) writes anaerobic lagoons "reduce animal waste odors if the lagoon is managed properly". Key to proper management is the initial design of the lagoon as a waste treatment vessel. A proper design adds the volume of the waste to be treated, to the minimum treatment volume needed for the climatic conditions in the county and the quantity of sludge, which accumulates in the bottom of the lagoon.

Anaerobic digesters treat waste prior to the waste being deposited in the storage pond. By digesting, the designer eliminates the minimum treatment volume from the calculation of lagoon size.

2.10.1 Existing Storage Pond Operation

The storage basins in the Monroe area are operated as hydraulic storage ponds not as treatment lagoons. When ponds are designed as a storage facility, no consideration is given to biological decomposition that occurs naturally in this type of a storage basin. At minimum volume, this type of storage system experiences a very high loading rate of biodegradable volatile solids. Excessive loading of these solids can create seasonal odors. Solids accumulation is another factor contributing to odor generation. If the pond is pumped down to a level that exposes solids accumulated on the bottom of the pond, potentially objectionable odors (from aerobic decomposition) will be generated. Anaerobic digestion of manure and the food wastes will reduce these solids and greatly reduce any odors from the waste storage ponds.

2.11 ENERGY USAGE

Electrical Use and Cost

Since there were no current Monroe Honor Farm power bills to evaluate, a conservative estimate of projected electrical use for the site was used to calculate costs. Table 4 represents an estimated summary of the calculated usage and costs. This is the utility information used in the assumptions to project energy and cost savings into the period of the “digester lifetime.” It is estimated that over the course of a year, very small seasonal cost variations will occur at the Monroe Honor Farm digester site.

Table 4. Estimated Electricity Use and Cost

		DEMAND			USAGE		TOTAL	$/ mo
	Basic	$/kW	kw/mo	$/mo	$/kWh	kwh/mo	$/mo	Demand & use total
JANUARY	$ 11.08	$ 2.73	259	$ 707.07	$ 0.046	21,870	$ 6,883	$ 7,590
FEBRUARY	$ 11.08	$ 2.73	261	$ 417.69	$ 0.046	21,870	$ 6,482	$ 6,900
MARCH	$ 11.08	$ 2.73	315	$ 409.50	$ 0.046	21,870	$ 8,725	$ 9,134
APRIL	$ 11.08	$ 2.73	258	$ 398.58	$ 0.046	21,870	$ 6,694	$ 7,093
MAY	$ 11.08	$ 2.73	247	$ 412.23	$ 0.044	21,870	$ 5,930	$ 6,343
JUNE	$ 11.08	$ 2.73	256	$ 382.20	$ 0.046	21,870	$ 6,686	$ 7,068
JULY	$ 11.08	$ 2.73	257	$ 395.85	$ 0.046	21,870	$ 6,343	$ 6,738
AUGUST	$ 11.08	$ 2.73	256	$ 382.20	$ 0.046	21,870	$ 6,655	$ 7,037
SEPTEMBER	$ 11.08	$ 2.73	258	$ 387.66	$ 0.046	21,870	$ 6,370	$ 6,757
OCTOBER	$ 11.08	$ 2.73	277	$ 425.88	$ 0.046	21,870	$ 6,590	$ 7,016
NOVEMBER	$ 11.08	$ 2.73	272	$ 475.02	$ 0.046	21,870	$ 7,394	$ 7,869
DECEMBER	$ 11.08	$ 2.73	270	$ 417.69	$ 0.046	21,870	$ 6,783	$ 7,200
TOTAL				$ 5,211.57		262,440.00	$ 81,534	$ 86,745
AVG $/kWh								$ 0.331

3.0 ANAEROBIC DIGESTER SYSTEM DESIGN

3.1 GENERAL PROJECT DESCRIPTION

Anaerobic digestion in a digester will reduce Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS) by 80-90%. Odor is virtually eliminated. The digester will have minimal effect on the nutrient content of the digested manure. Pathogen reduction is greater than 99% in a 20 day HRT mesophilic digester (100 degree F). Half or more of the organic nitrogen (Org-N) is mineralized to ammonia (NH_3-N). A small amount of the P and K will settle as sludge in most digesters. 30 - 40 % of P and K are retained in covered lagoon digesters. Digesters are very effective in killing weed seeds. Biogas from a stable digester can contain a range of 60% - 80% methane.

Manure consists of partially decomposed feed, waste feed and water. Manure alone or mixed with process water and flush water is generally too concentrated to be decomposed aerobically in a manure treatment or storage structure, because oxygen cannot diffuse into solution fast enough to support aerobic bacteria. Therefore, manure is broken down sequentially by groups of anaerobic bacteria. An anaerobic digester is a vessel sized to grow and maintain a population of methane bacteria that feed on organic wastes placed in the unit. The bacteria grow without oxygen, decompose the waste, and produce methane as a useable fuel byproduct. Methane bacteria are slow growing, environmentally sensitive bacteria. These bacteria require a pH greater than 6.5 and adequate time to convert organic acids into biogas. Methane production is reduced as water temperature decreases

A digester system is more successful if the operation of the manure collection integrates easily with existing farm operations. A digester design must be based upon the collectible fresh manure because volatile solids in the manure are decomposed to produce methane and the volatile solids content of manure decreases as manure ages. Therefore, the older the manure, the less methane can be produced and the less value there is to collecting it. Corral or pen pack manure that is collected infrequently is not suitable for digestion.

In the multi-farm and institutional regional collection system, manure and food wastes are sent to a collection/mix tank near the digester from which they can be fed to the digester on a regular schedule. The manure and food waste mixture is mechanically stirred, heated and anaerobically digested to produce biogas that is collected under the flexible cover. As the digester is fed, effluent is hydraulically displaced out of the discharge weir into an effluent tank. From there it is pumped through a screw press separator. Separated liquid flows or is pumped to the storage pond system. Gas is piped underground to a cogen building (containing the electrical generator and heat reclaim equipment) usually located as near to the electric service entrance as possible.

Biogas is combusted in a reciprocating engine for production of electricity and hot water. Insulated hot water pipes are routed underground between the co-gen building and the utility area to preheat water as it goes to hot water heaters for various on site uses. A hot water loop will also be conducted underground in the biogas pipe trench to provide digester heating.

New service wiring will connect the generator output to the electrical service. Appropriate safety relays will be part of the new system to meet interconnection requirements of the utility.

3.2 DESIGN AND COMPONENT DETAIL

3.2.1 Digester Description

Digester System at Monroe Honor Farm: Pressure Sewer with Complete Mix

Manure Collection and Concentration
Each of the dairy farms will have a collection/mix tank equipped with a pump to serve as the pressure sewer pump stations. It is envisioned that the M2 dairy will install or modify existing sand separation equipment on their flush water, followed by equipment to concentrate and capture coarse and fine manure solids. The combined solids content of the captured manure should be controlled at the 4% to 5% range. At this concentration, a pump station with a 3-4" HDPE plastic sewer line can transport this fluid to a central pump station site, located at the M5 Dairy immediately south of the M2 Dairy. The other scrape dairy (M4) will also have to pump a short distance to transport their collected manure to the central dairy collection tank. A pump station with a manure transport pump will be installed at the M5 scrape dairy. All three of these manure streams will then be mixed in a central pumping station to achieve a concentration of 6% to 7% solids. A similar, but separate flushed waste pretreatment process will have to be installed at the M7 flush dairy located south of the Honor Farm to be able to deliver their manure solids directly to the digester site.

Pressure Sewer
An appropriately sized pump will operate for about 4 hours per day and pump the mixture, at approximately 100 gallons per minute in a 3-4" HDPE plastic pipeline, into the Monroe Honor Farm Site collection/mix tank. The pressure sewer will have cleanout ports located at strategic points. The system will be plumbed with return lines installed in the same trench to pump digested effluent from the Honor Farm storage ponds back to the farm storage ponds for agronomic applications to their croplands and fields.

Digester
A mesophilic, complete mix digester will be considered at Monroe Honor Farm sized to accommodate the combined herd size of 2,005 mature Holstein equivalents (MHE) and the equivalent of 29,084 pounds per day of food wastes of about 18% to 20% total solids. The digester will be sized to provide a hydraulic retention time (HRT) of 24 days. The digester will maintain an operating temperature of 99 degrees Fahrenheit. The digester will be constructed at the Monroe Honor Farm site near the northeast corner of the existing waste storage pond and the electrical transformer. As noted earlier, the high water table at this site will be a factor for design considerations. Accordingly, the digester will be elevated, heavily insulated, and banked with soil.

3.2.2 Anticipated Design Values

Digester operation is dependent on controlling manure quality. Water use at all the participating dairies should be monitored and reduced as much as possible, without compromising the parlor, milk house clean up or gutter flows. Not more than 25% of design volatile solids may come from any non-manure source. Sufficient grit will settle in the digester to require cleaning in 8-15 years, depending on dirt contamination and water management. With settling of most of the grit occurring in the mix tanks at each of the dairies, cleanouts here may be required two or three times per year. It is assumed that the animal populations are as described in Section 2.6, Table 2. It is assumed all the manure from production animals in the free stall barns will be collectable for treatment. Table 5 summarizes digester design values for the identified waste delivery.

Table 5. Digester System Design Values

	Complete Mix	
Total Cow Number	2,005	MHE
Influent Volume	51,506	gal/d
Total Digester Volume	165,261	ft3
Number of Digesters	1	ea
Length	103	ft
Width	100	ft
Depth	16	ft
Cover Dimension	11,362	ft2
Engine-generators	320	kW

3.2.3 Anticipated System Outputs

NRCS estimates in the Agricultural Waste Handbook: one 1000 lb. mature dairy cow (dry or in production) excretes about 10 lb. VS per day. Monroe Honor Farm mature animals average approximately 1,400 lb. per animal. In addition to bedding and other wastes, mature Holsteins produce about 13 lb. of volatile solids per day that will be scrape-collected. Between 35% and 40% of the manure volatile solids reaching the digester will be converted to biogas (60% methane, water saturated). Table 6 shows the projected output for the various parameters.

Table 6. System Outputs

	Heated Systems	
Gas Production	163,351	ft3/d
CO2 Equivalent	16,448	Metric T/yr
Electricity Output	292	kWh avg
Heat Recovery	1,276,417	Max Btu/hr
	788,107	Min Btu/hr

A detailed monthly analysis of the digester system heat use and electrical output projections are shown in the following summary tables. The hot water savings values are not estimated because the overall site development and operational plans and therefore, the hot water needs, are unknown. The electrical summary table reflects a conservative estimate of the Honor Farm kWh usage requirement per month since no actual power bills were available for analysis. It would be advantageous to the overall system performance if an on-site use for the excess heat could be developed. Any excess biogas could be routed to a system to dry composting manure solids or other farm uses instead of a simply burning in a flare.

Table 7. Heat Use Summary

	Estimated Available Hot Water btu/hr	**Estimated Farm Needs btu/hr**	**Estimated Heat Balance btu/hr**	**Estimated Heating Water Savings $/mo**	**Estimated 50% of leftover Heat for drying $/mo**
January	547,586	-	547,586	$ -	$ 219
February	547,586	-	547,586	$ -	$ 198
March	681,209	-	681,209	$ -	$ 272
April	681,209	-	681,209	$ -	$ 264
May	788,107	-	788,107	$ -	$ 315
June	875,570	-	875,570	$ -	$ 339
July	875,570	-	875,570	$ -	$ 350
August	948,455	-	948,455	$ -	$ 379
September	948,455	-	948,455	$ -	$ 367
October	875,570	-	875,570	$ -	$ 350
November	788,107	-	788,107	$ -	$ 305
December	681,209	-	681,209	$ -	$ 272
Total				$ -	$ 3,632

Table 8. Electrical Output Summary

Month	days/mo	Biogas Ft3/day	Hourly Average Kwh	Potential Biogas kWh/mo	Est. of Farm required kWh/mo	Need v prod balance kWh/mo	Potential Electricity replacement $/mo	Electricity Surplus sale $/mo	Remaining Electricity Purchases
January	31	163,351	292	195,322	21,870	173,452	$ 893	$ 6,938	$ 354
February	28	163,351	292	176,420	21,870	154,550	$ 893	$ 6,182	$ 209
March	31	163,351	292	195,322	21,870	173,452	$ 893	$ 6,938	$ 205
April	30	163,351	292	189,021	21,870	167,151	$ 893	$ 6,686	$ 199
May	31	163,351	292	195,322	21,870	173,452	$ 893	$ 6,938	$ 206
June	30	163,351	292	189,021	21,870	167,151	$ 893	$ 6,686	$ 191
July	31	163,351	292	195,322	21,870	173,452	$ 893	$ 6,938	$ 198
August	31	163,351	292	195,322	21,870	173,452	$ 893	$ 6,938	$ 191
September	30	163,351	292	189,021	21,870	167,151	$ 893	$ 6,686	$ 194
October	31	163,351	292	195,322	21,870	173,452	$ 893	$ 6,938	$ 213
November	30	163,351	292	189,021	21,870	167,151	$ 893	$ 6,686	$ 238
December	31	163,351	292	195,322	21,870	173,452	$ 893	$ 6,938	$ 209
Totals		1,960,217		2,299,755		2,037,315		$ 81,493	$ 2,606
AVERAGE		163,351	292	191,646	21,870	169,776	$ 893	$ 6,791	$ 217

3.2.4 Hydraulic Flow

Pressure Sewer

Instead of relying on gravity flow, pressure sewers utilize the force supplied by pumps, which deliver the wastewater to the digester collection and mix tank from the four dairies. Since the pressure sewer will not rely on gravity, the systems network of piping can be laid in very shallow trenches that follow the contour of the land. Two pipelines will be laid in the same trench to provide waste delivery to the digester and effluent return to the dairy storage ponds.

The system will use a collection tank effluent pump at each dairy. The pressure sewer will utilize the collection tanks to settle out the grit; this allows for the use of piping that is extremely narrow in diameter. The effluent pump will deliver the wastewater to the sewer pipes and provide the necessary pressure to move it through the system to the digester site.

It is assumed that free stall barn alley manure will be collected by the collection system currently in use at the dairy. Manure from the main barns will be deposited directly into a collection tank and pumped to a mix tank at the central dairy M5. This combined manure from the three north dairies should be 6% to 7% total solids. The flush dairy south of the Honor Farm will pump separately and directly to the digester from its on-site collection tank.

A food waste collection chamber will be constructed with the mix tank at the digester to facilitate incremental introduction of the food waste into the mix tank for inclusion into the digester feed. The food waste chamber and the mix tank will be constructed to share a wall with the digester. A pump station in the pre-digester mix tank will be controlled semi automatically to feed the digester once a day. Digested effluent will be pumped to the solids separation system and the liquid will be deposited in the Honor Farm manure storage pond(s) or returned to the dairy's storage ponds.

3.2.5 Elevations

Lines between the inlet of the digester and the waste collection tank will have a vacuum break to prevent siphoning of the digester and will slope to the collection chamber. An effluent chamber will be constructed to share a wall with the digester. The complete mix digester will have an emergency spillway drain from the effluent collection chamber to the on site storage pond to handle the waste in times of system maintenance or screw press repair. Under normal operating conditions, effluent will be pumped to the screw press solids separator.

All buried pipes at the digester location will be a minimum of three feet below the finished grade. A site construction temporary benchmark (TBM) will be used for digestion system construction at the Honor Farm.

3.2.6 Finish Grading

The area of the proposed digester will be finished graded for surface waters to flow away from the digester, manure collection tank and solids collection pad. Additionally, the solids collection pad may require curbs to prevent wintertime surface water from flooding the solids storage area.

3.2.7 Digester System Component Sizing

Table 5 shows the system design values for the digester.

The 2,005-MHE complete mix digester will consist of:

- One concrete rectangular digester with insulation, a flexible impervious top, sized for 24 day manure retention and heated with engine waste heat
- One concrete rectangular concrete effluent storage tank, sized for two days retention covered with a wooden deck
- One concrete influent mix tank, sized for two days retention covered with a wooden deck
- One food waste collection tank, sized for two days retention covered with a wooden deck

3.2.8 Influent Mix Tank

A multi-chambered influent mix tank adjacent to the digester will be sized to accommodate at least two days of dairy manure with a food waste chamber also sized for two days of retention. It allows for some interruption of operations (as with a separator repair), settling of grit and mixing of the waste for more uniform digester feed. It will be fitted with a mixer and a pump.

3.2.9 Complete Mix Digester and Effluent Tanks

Table 5 showed preliminary digester size calculations of 103 x 100 x 16 feet for digester options at Monroe Honor Farm. The digester was priced as a rectangular cement vessel. A round vessel would be approximately the same price. A round metal digester vessel would cost more than the proposed cement structures. Top-of-wall elevation for the complete mix digester, pipe chase and effluent chamber will be the same. The top of the flexible gas collection cover will be about 5 feet higher than the digester walls. The top of the liquid in the digester will be higher than the maximum level of the adjacent storage ponds.

All plumbing will run underground. A covered pipe chase housing gas and water plumbing connections to the digester will be located near the feed end of the digester (to be determined when final operating plans are made). The effluent chamber will be covered with a treated wooden cover. The following photo shows a typical configuration for an RCM complete mix digester design. Additional information can be found by accessing www.rcmdigesters.com.

3.2.9.1 Digester Agitation

Waste agitation equipment will be required for the complete mix system to accommodate the introduction of the outside food waste material. Flygt mechanical mixers have been included in the cost estimate tables as needed.

3.2.9.2 Digester Heating

The complete mix digester is a heated digester design. Heat in the form of hot water is recovered from the engines. The hot water is piped to the digester manure heat exchanger where it elevates and maintains the digester temperature.

3.2.9.3 Effluent Structure

RCM included an effluent discharge structure for digester effluent to flow to the effluent collection sump on the complete mix design.

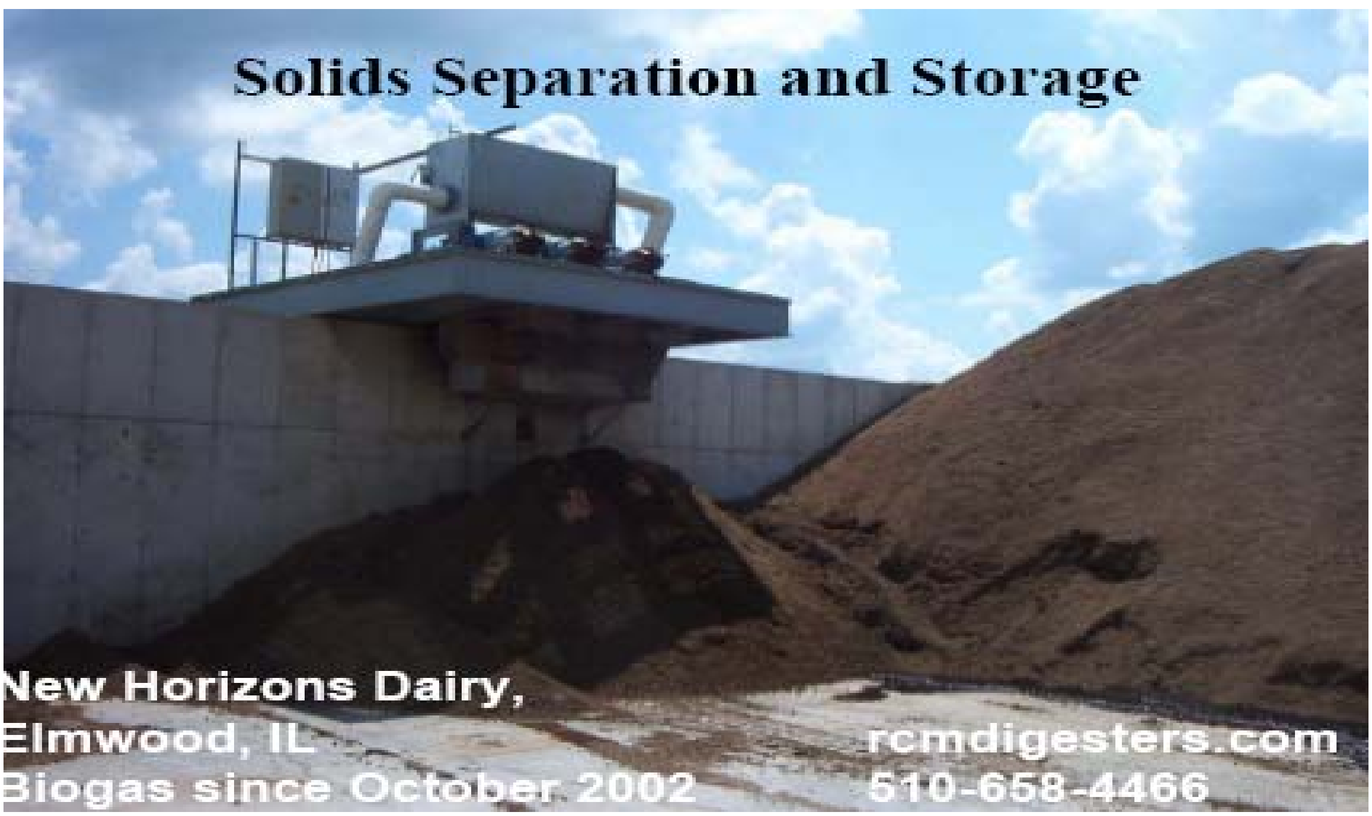
3.2.9.4 Gas Collection

Gas will be collected continually from under the inflated digester cover by gas pumps in the engine room. Gas is filtered, pressurized, and measured prior to introduction into the engines.

3.2.10 Solids Separation System

Fiber recovery is desirable. Digester effluent will be pumped from the effluent tank up to a screw press separator located in a solids collection building. The separator would be elevated to allow for gravity flow of digested liquid to the storage pond. Separated solids will fall onto a collection pad underneath the separator and will be transported to a fiber composting area in the existing freestall barn for drying. A second separator can be installed for redundancy and would cost an additional $60,000.

The solids could be offered back to the dairies for animal bedding, however, digested solids are a valuable byproduct that may merit product marketing as potting soil or soil amendment. A fiber soil amendment business may be developed as a part of the project business plan.



After fiber is separated, both the fiber and the liquid nutrient will be available for land application. Table 9 contains the estimate of liquid nutrient and fiber characteristics.

Table 9. Characteristics of Fiber and Liquid

	Fiber*	Liquid+
N	4.5-6.0	30-40
NH_4+	2-3	15-20
P_2O_5	2-3.5	10-15
K_2O	2-3.5	20-30
S	0.5-1.5	2-4
Mg	1-2	5-8
Ca	3-4.5	7-10
TS	20% - 30%	4.5%-5.5%
pH	7.8-8.5	7.5-8.2
Density	800-1000 lb./CY	8.5-8.6 lb./gal.
Consistency	"moist peat moss"	"chocolate milk"

*lb./CY +lb./1000 gallons

3.2.11 Gas Transmission and Handling

The collected biogas will be carried to the engine/generator in an 8” PVC buried pipe. A blower will pressurize the biogas before it is filtered, metered and sent to the engine/generator unit.

Gas Use Equipment in the Gas Use Building

- One gas pressurization unit - meter, gas blower and particulate filter. Biogas will be metered, pumped and filtered prior to use. A particulate filter is used whenever the biogas is used for engine fuel.
- One hot water circulating system with hot water storage

This analysis does not include any biogas cleanup. RCM experience has been that scrubbers are expensive to install and operate. Proper engine operation and maintenance with more frequent oil changes mitigates the lack of gas scrubbing. Proper operation will allow the engine to meet operational expectations.

Excess biogas during engine shutdown or from incidental overproduction will be released through a relief valve and burned in an emergency flare that will be located a minimum of one hundred feet from any structure. The gas line to the flare will be buried and properly sloped.

3.2.12 Biogas Utilization

Biogas can be used to fire a boiler or an engine-generator. The cost estimates are based on using an engine (appropriately modified for biogas) with a three-phase induction generator, a heat recovery equipment package and typical utility intertie package. Only proven equipment will be employed.

3.2.13 Engine Room

Cogeneration equipment must be located in an area to facilitate routine daily observation in the coarse of regular facility operations. Moreover, distance should be minimized between the heat recovery system and the heat uses. The engine-generator will be housed in a small building of 30 feet by 40 feet. The equipment in the engine room was selected and priced in modular units consisting of the engine package, the electrical control package, and a heat recovery package. These components are pre-fabricated and mounted on skids for ease of installation. The engine room for the Monroe facility is priced with two engine skids, two electrical control skids, and two heat recovery skids. Biogas piping from the digester would enter the building from underground and connect to the equipment inside.

3.2.14 Engine/Generator

The methane output of the 2,005-MHE-cow population could be variable depending on how much manure is collectable, the efficiency of pre-treatment practices, and the consistency of digester feed. The assumed 2,005-MHE herd along with the 451cubic feet per day food waste contribution will feed the digester daily to produce an average of 292 kWh by fueling two Caterpillar G3406TA engines with generators rated at 160 kW continuous duty.

The engine will include safety devices such as: low coolant level shutoff, high/low oil level shutoff, low oil pressure shutoff, and high oil and high water temperature shutoffs. The generators would be wired into the facility main electric panel. An automatically operated contactor at the generator and manual disconnects in the engine room and in the electric panel room will ensure safe high quality power. The engine generator will operate in parallel with the utility system at a constant level of output controlled by the biogas supply equipment. Parallel generation means that electricity generated by the biogas unit will be mixed with the utility supplied power. Shortfalls in electricity production are automatically fed by the utility and excesses flow off the dairy and into the utility system. A utility-approved electrical safety system will be required to insure disconnection of the generator from the utility system during power outages to avoid energizing power lines off the dairy. Typical interties of this type include solid-state commercial relays to monitor voltage, amperage and frequency.

3.2.15 Hot Water Storage and Utilization

Hot water will be available for use in various Honor Farm applications. It is typically stored in an insulated tank at 160° to 180° F. However, the complete mix digester temperature maintenance is paramount to assuring optimum digester performance. The complete mix digester must have first preference for hot water production.

3.3 SAFTEY

Prudent digester operation is safe. There are very few pieces of equipment or practices proposed with this digestion system that are not already on a typical dairy farm. Biogas, while comprising of 60% methane, does not contain the oxygen necessary for combustion. The inflated digester top has no oxygen within. As with all manure management practices, confined spaces must be ventilated for safe entry. As with all internal combustion engines, certain operating norms should be maintained. This application is little different from standby engines using natural gas or propane. Appropriate controls will regulate the system to match the voltage and frequency characteristics of the utility lines. A relay system approved by the utility will disconnect the system from the utility in the event that line conditions cannot be matched. Utilities may also require lockout boxes, special metering and other equipment for their approval of the interconnection. Local and federal regulations and standards should form the basis for operation.

4.0 COST AND BENEFITS ANALYSIS

4.1 ESTIMATED COSTS OF THE DIGESTION SYSTEM

Table 10 shows the estimated costs for construction of the digester options. A western Washington contractor with underground utility installation experience was interviewed to develop a budgetary cost estimate for use in modeling the system. The costs are reasonable estimates based on these recently discussed material costs, however costs vary regionally and seasonally. It is important to note that items such as dewatering would likely become an extra time and material cost if encountered. The model developed the system cost based on concrete estimated at $75.00/cu yd or $200.00/cu yd placed, for flat work and $300.00/ cu yd placed for walls. Skilled labor was estimated at an average of $40.00/hour. The installed pressure sewer lines were priced at $14.00 per foot including the return lines estimated at price of pipe only. Total system estimates includes costs associated with plumbing of manure lines to the digester, the collection/mix tanks and pumps, the digester and cover, effluent chamber, separator, cogeneration equipment, engine building, heat exchange, plumbing, wiring and professional assistance.

Table 10. System Capital Costs

			Complete Mix Rect. Tank
Remote Mix Tanks - 4			$ 96,550
Manure Pump, pipe, install - 6			$ 132,159
Manure transfer pipes			$ 458,304
Digester Excavation			$ 37,031
Digester			$ 411,565
Gas/hot water field piping			$ 19,100
Engine-generator building			$ 42,667
Gas pump, meter, filter skid			$ 56,276
Hot water Management skid			$ 34,190
Engine-generators			$ 320,000
Maintenance Boiler			$ -
Full production boiler			$ -
Hot water reuse			$ -
Separator in Building			$ 106,979
		Subtotal	**$ 1,714,820**
Contingencies			$ 171,482
Engineering/Site Assist			$ 171,482
Startup fuel and equipment			$ 8,500
	TOTAL COST		**$ 2,066,284**

4.2 ESTIMATED BENEFITS FROM THE DIGESTION SYSTEM

4.2.1 Benefit Assumptions

Certain assumptions had to be made for the analysis. Some are based on research from similar proposals; others are values known to be accurate for such projects. The new construction was budgeted as "contractor built" which can be 25% higher than costs if the farmer consortium does some of its own construction. Since there will be outside waste coming into the system, tipping fees could be generated, but are not included in this analysis. Thermal parasitic in the chart below is the requirement for digester heating.

Table 11. Assumptions Used Estimating System Benefits

System Thermal Parasitic	As needed	
System Power Parasitic	8%	
Operating efficiency	90%	
Boiler efficiencies	80%	
Electric Sale value	0.040	$/kWh
Thermal offset based on	$1.08	$/gal prop
Greenhouse Tax Credit	$1.50	/M. TN Methane Removed

Though gas production may be entirely converted, the electrical generating system is assumed be operating about 90% of the hours of the year due to downtime and maintenance. Gas produced during those periods cannot be economically stored and will be automatically flared.

4.2.2 Benefits

There was a substantial benefit assumed for sale of excess electrical energy in the amount of $81,493 per year. A conservative potential valuation of the fiber produced at $36,884 was factored in with the assumption that Monroe Honor Farm intends to develop a market for soil amendment sales.

Table 12. Potential System Benefits

Type of Digester		Heated/Mixed
Electricity purchase offset		$ 10,713
Sale of excess electricity		$ 81,493
Electric Capacity Savings		$ -
Hot Water Offset		$ -
Sale of Digested Solids		$ 36,884
Greenhouse Gas Tax Credits *		$ 24,672
TOTAL POTENTIAL BENEFIT		$ **153,761**
LESS SYSTEM O&M / kWh	$ 0.01	$ (21,720)
LESS LABOR	2 FTE at 40k	$ (80,000)
NET POTENTIAL BENEFIT		**$ 52,041**

*Greenhouse tax credit is calculated as $1.50 per metric ton of methane removed.

4.2.3 Non-monetary benefits

There are other project benefits. Table 13 summarizes non-monetary benefits expected from the installation of a digestion system.

Table 13. Non-Monetary Benefits of a Digestion System

1.	Odors from manure will be greatly reduced when biogas is produced in a controlled fashion, captured and burned.
2.	Pathogenic organisms in the digested manure will be greatly reduced.
3.	Recovery and combustion of methane reduces the uncontrolled release of methane, a highly reactive greenhouse gas, from manure management to the atmosphere.
4.	Weed seeds are essentially eliminated.

5.0 SIGNIFICANT ISSUES, POTENTIAL PITFALLS AND SOLUTIONS

5.1 COST ESTIMATING

5.1.1 Issue

RCM used "private contractor built" rather than public works type estimation techniques to arrive at costs for this analysis.

5.1.2 Significance

It is unknown how the Monroe Honor Farm will construct the digester. The method of construction and level of contractor involvement can significantly affect the costs.

5.1.3 Recommendation

Evaluate the least cost method for construction utilizing on farm labor or contractors who are capable of the construction needed. Develop a maximum system design capacity based on best estimates for waste generation expansion plans for the dairies and identified food waste imports. This will eliminate the need for costly upgrades and retrofitting before the effective operational life span of the system.

5.2 SYSTEM MANAGEMENT

5.2.1 Issue

The digester will need consistency in management and daily onsite operators.

5.2.2 Significance

Immediate attention to unexpected maintenance as well as daily observation and record keeping should be reliably provided. If not, equipment runtime may suffer. Off farm waste inputs will need to be routinely monitored to track quantity and makeup.

5.2.3 Recommendation

Find two full time operators who will be in position for several years. Maintain regular communication with off farm waste generator(s) and track any changes in waste quality or quantity. Keep accurate records for all digester system operations and observations.

5.3 SYSTEM DESIGNERS

5.3.1 Issue

The history of farm digesters in North America shows that about 75% of all past manure digestion systems have failed. Each location has unique design demands. Attempting to duplicate construction (aside from the legal implications) may result in installations insensitive to the realities of each individual site. Most often designs were inappropriate because they were proposed, designed and built by individuals or firms, though well intentioned, lacked experience.

5.3.2 Significance

Financial considerations may require the enticement of a bank or outside investor to build the facility. That investor must have absolute confidence the investment is sound. Success is expected with a dairy manure digester, if a good designer is chosen. Monroe Honor Farm wishes to increase farm profitability through a manure digestion system. Monroe Honor Farm must have a system that functions faultlessly from the beginning.

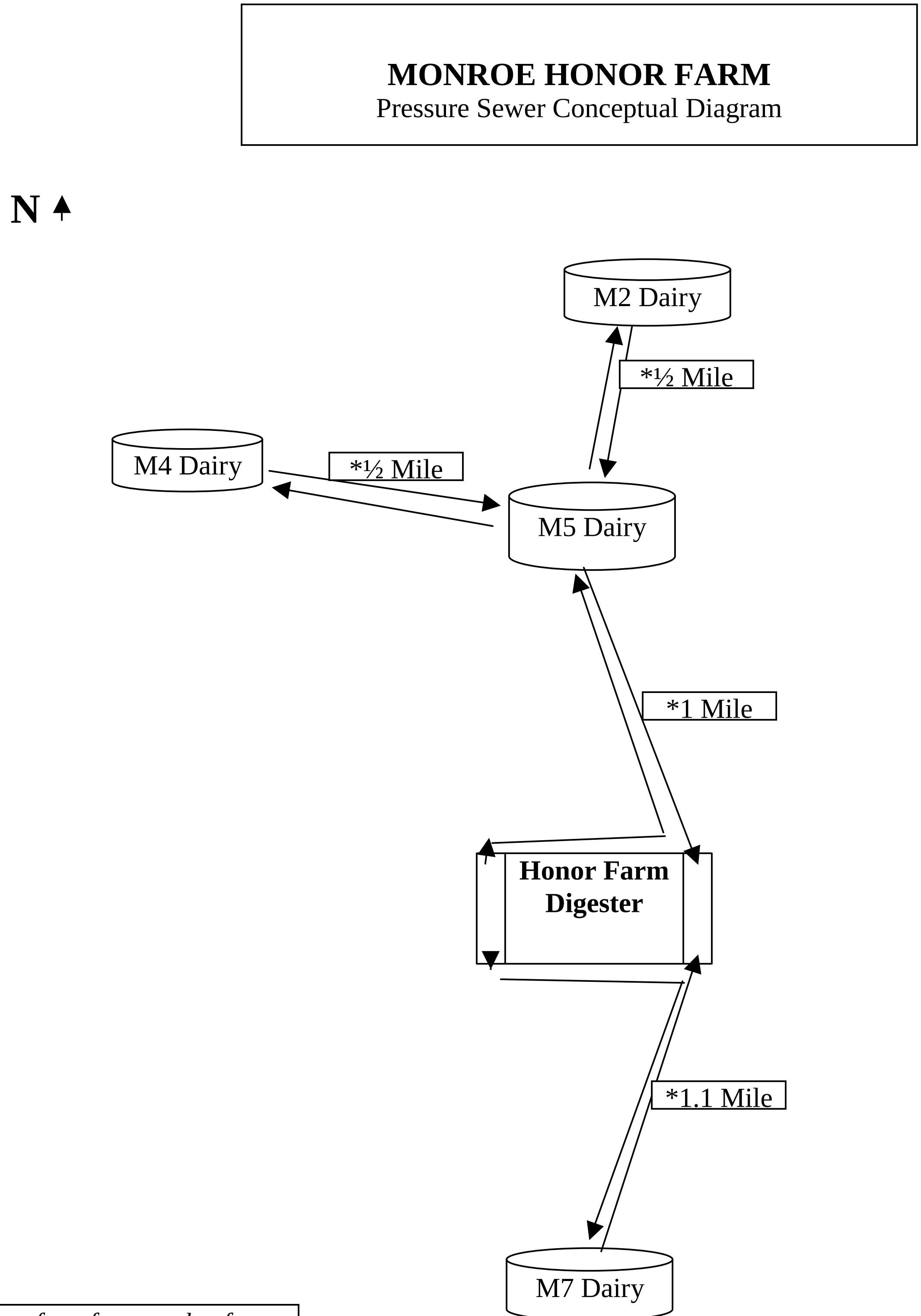
5.4.3 Recommendation

Request the services of a design firm with documented experience and liability insurance. The firm should have worked with similar manure, in a similar setting, and at a similar scale. The firm should be able to make output projections based on similar projects. The firm should be able to provide energy balances and mass balance for the proposed system. These balances will permit assessment of project technical feasibility.

APPENDIXES

1. Dairy Proximity Assumptions Sketch
2. System Design Assumptions Table
3. Excerpt from “Anaerobic Digestion of Flushed Dairy Manure”, University of Florida
4. Summary Mass Balance Chart
5. Conceptual System Layout Sketch

Appendix 1. Farm Proximity Assumptions



**Relative distances from farmstead to farmstead were calculated using the 2003 edition of The Thomas Guide Digital mapping software for Metro Puget Sound.*

Appendix 2. System Design Assumptions

SYSTEM CATEGORY	DESIGN ASSUMPTION
MANURE QUANTITY	Calculated from reported milk production and associated dry matter intake ratios
	Reported figures are fairly accurate based on Nov 2003 Report
MANURE COLLECTION	Rainwater inflow is managed and minimized
	Fresh water parlor wash is minimized
PRE-TREATMENT	Effective sand segregation with 1 hour gravity settling system
	Flushed manure solids recovery @1/2 VS
	Flush manure pre-treatment system yields 4% solids
FOOD WASTE IMPORTS	Consistent quality and quantity as reported in Jan 2004 Report
	Any process changes or contents are reported before feeding into the digester
MIX TANKS	5 Tanks with pumps: 1 at each farm, 1 at digester influent
	Digester vessel is mechanically stirred
	Daily operation of all mix tanks
PRESSURE SEWER	Up to 5% solids is readily pumped – Pumped 4 hours per day
	Pipeline to digester is 3 to 4 inch pipe
	System includes effluent return pipes back to the farms
OPERATION & MAINTENENCE	Operating efficiency @ 90% Cost @ 1 cent per kWh
	Labor: 2 FTE @ 8 hr shift/day, 7 days/week, 365 days/yr

Appendix 3. Excerpt from University of Florida Dairy Research Unit

Found In: *Proceedings – Anaerobic Digester Technology Applications in Animal Agriculture – A National Summit.*
Water Environment Federation, Alexandria, Virginia, 2003.

ANAEROBIC DIGESTION OF FLUSHED DAIRY MANURE

Ann C. Wilkie
Soil and Water Science Department
P.O. Box 110960
University of Florida
Gainesville, FL 32611-0960

(Excerpt from the Proceedings):

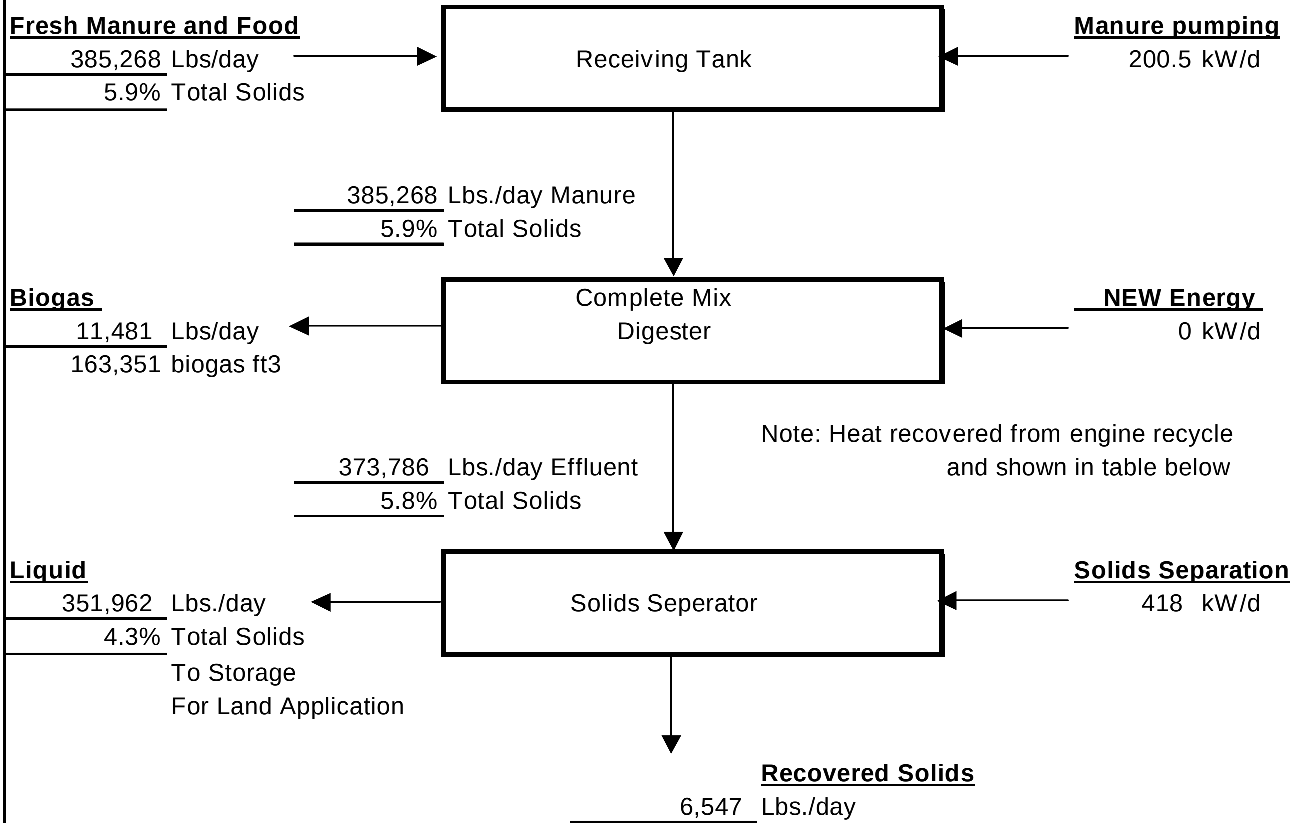
P4. "A demonstration-scale fixed-film digester has been built and is in operation at the University of Florida's Dairy Research Unit (DRU), located in Hague, Florida. The digester is an integral part of the overall waste management system at the 500-milking cow DRU and serves as a model for the dairy industry. The milking herd at the DRU is confined to freestall barns, which are hydraulically flushed to a wastewater collection channel. The cows are bedded on sand. Milking parlor wash-down water, combined with udder-wash water, also flows to the wastewater channel. In summer, misters are used in the freestall barns to keep the cows cool, contributing additional water to the waste stream. The wastewater initially flows down the collection channel to a sand trap, where some of the sand is recovered for reuse. After the sand trap, the wastewater flows to a mechanical separator, which removes large fibrous solids. The wastewater then flows across a settling basin and over a weir into a sump."

P4. "About half of the volatile solids in the flushed dairy manure is removed during pretreatment by mechanical separation and sedimentation."

Appendix 4. Summary Mass Balance Chart

Material and Energy Balance for Dairy Power Production

Monroe Dairy Digester,1 digester, 2 engines, 1 separator

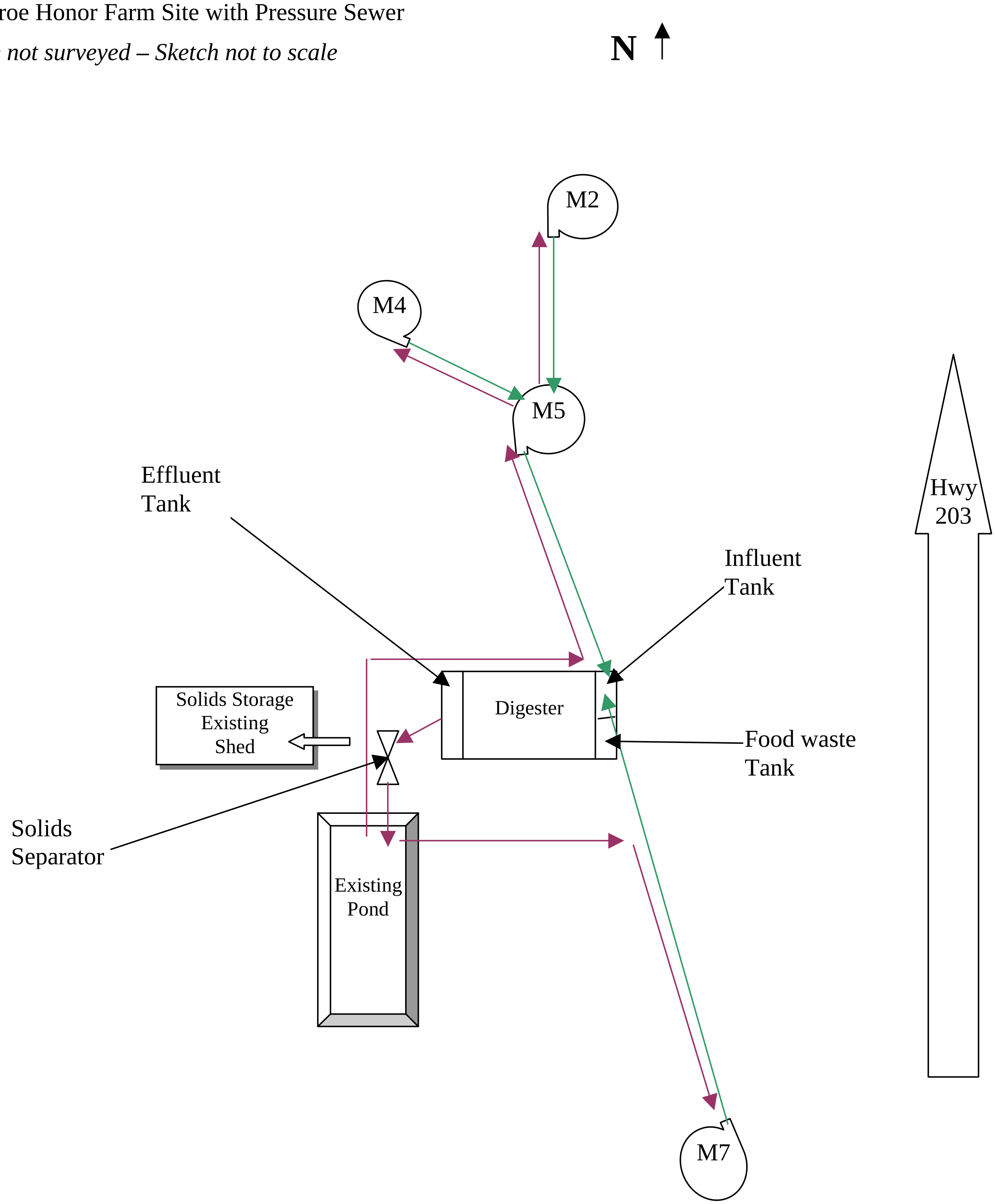


Mass Balance	**Lb/d**	**Lb/d**	**%**
Solids into digester	33,306		
Solids to Gas		11,481	34%
Solids Recovered		6,547	20%
Solids to Land		15,277	46%
totals	33,306	33,306	100%

Energy Balance	**BTU**	**BTU**	**%**
	Production	**Use**	
New Btu Produced	98,010,858		
kWh Produced		24,502,715	25%
Generation Parasitics		2,940,326	3%
Manure Pumping		855,383	1%
Separating		1,782,048	2%
Hot water for digester/farm		34,303,800	35%
System losses		33,626,586	34%
TOTAL	98,010,858	98,010,858	100%

Appendix 5. Conceptual System Layout Sketch
Monroe Honor Farm Site with Pressure Sewer

**Site not surveyed – Sketch not to scale*



ATTACHMENT 11

MEMORANDUM

DATE: March 3, 2004

TO: **Susan April**
The Clark Group

FROM: Marvin J. Hoekema, M.S.
Senior Consultant

RE: Quild Ceda Power Business Planning Considerations

After visiting by phone earlier this week, I thought it useful to assemble some business structure discussion parameters as you are entering this phase of discussions with the Quil Ceda Power stakeholders. While I am still attempting to fully understand the subtle dynamics of the plans and discussions to date, I am forming some observations on likely business structure options. The reason for this is there are several constraints already present with the structure, limiting some of the broader based options. This does not suggest that the options are limited, in a manner of speaking. However, there are some important structure considerations, which must be met as a result of the decisions already made. The constraints as I understand them are as follows:

- ✓ It is my understanding that the major source of federal grant funds ($500,000 suggested) will not be available until the completion of the project and at initiation of operation. While I am not discounting the fund availability (although you suggested that these are highly restricted funds), the timing risk becomes crucial, as this project will need some form of seed capital to initiate the project. Because this funding source is clearly not available to construct, another source of seed capital will need to be secured, even if in the form of bridge financing at a minimum.
- ✓ Land use restrictions associated with the Monroe Honor Farm site: After reviewing the draft resolution language, it is clear that this land is only for use as a bio-gas facility operated by the tribe. This leads to three sub-issues:
    - o If utilization does not commence within two years (which there is an outside chance that construction may not be initiate or completed in that timeframe), the title reverts back to the State of Washington. That brings up a timing issue that rates relatively high on the priority list.

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- It is unclear from the language if it is the Tribe or an entity partially or wholly owned by the tribe may operate the biogas facility on the deeded land. Some clarification of this is needed, as a likely business structure to consider may be a separate entities holding the land and operating the facilities.
- Because of the land use restrictions in the language and likely to carry forward onto the deed, the collateral value of this land is likely limited for any borrowing base. Usually mortgaged assets are held in a deed of trust because of their implied market value in the event of default and asset sale to recoup loaned funds. In this case if the biogas effort fails, the land will revert to the state for no due consideration since it is deeded at a zero value. The initial review suggests that this means the land has little collateral value. The intrinsic value to the project, however, is substantial, but likely not for use as collateral.

✓ Capital sourcing from developers: It appears that the major source of funding for this project is assumed from the technology developers. Initial reaction to this has been somewhat lukewarm to non-committal at least until a power purchase contract is secured for the plant capacity. Since this contract is not yet secure and the initial wholesale power rates are relatively low compared to what prospective developers are accustomed to realizing in other regions of the country, it appears that the initial interest level is fairly low, although not necessarily non-existent if a revenue source can be secured.

✓ Liability restrictions: All of the current stakeholders would like the venture to be funded 'debt-free' if possible. It is unclear how this is possible without the presence of seed capital and power contract to write a letter of credit on. Because the Quil Ceda Power corporation charter prevents the pledging of assets not transferred to this Tribal enterprise, a less-restrictive business structure with an equity base that can serve as collateral needs to be developed in order to realize this project.

✓ Capitalization hurdle: The initial baseline analysis suggested ~$2.0 mil capitalization hurdle to initiate the project. The baseline analysis did not suggest a capitalization model or start-up timeline to accomplish operations, so it is unclear if that is a finalized model. Clearly, a capital source and business structure to house the capital needs to be identified.

✓ Stakeholder roles: It appears that the tribe, dairy farm substrate providers, and system developers all have good-faith interests at stake for cooperation. Buy-in from all parties is also a critical business structure objective. That said, it is unclear how the parties will come together, given the land ownership constraints in the resolution language (deeded to the Tribe) and the fact that all parties are hesitant to contribute capital. That said, some level of buy-in (paid in capital, in-kind contributions, or investment) is needed to secure interests. On the surface, holding this at the zero level is likely not realistic.

The aforementioned constraints are not irresolvable hurdles. However, they do shape a likely business structure given their base inflexibility. A likely business structure to work within these constraints will probably need to embrace the following opportunities:

- ✓ Separation of the land-holding entity (presumed to be the Tribe or Quil Ceda Power corporation) from the operation/improvement entity. The operation entity will likely need to incur indebtedness whether at the developer level that secures the entity's assets as collateral or at the operation entity itself. Because the tribe cannot incur debt and the deeded site is of little collateral value, separating the land asset into a leasehold enterprise is probably the most effective way to prevent cross-collateralization issues.
- ✓ Designation of multiple classes of ownership to divide operational risks and liability. Depending on who the source is of the seed capital, splitting ownership will likely be needed to protect interests. For instance, the tribe cannot have their interests pledged into a debt relationship by Quil Ceda Power Corporation per charter restrictions. It is unlikely that the dairy farm substrate providers will want the operational entity business liability transferred to their respective business. Conversely, prospective developers will likely not want to take all of the risk for the project, without either a buy-out strategy and/or a healthy reward premium for their risks. This leads to the following possible class structures:
    - Assigning separate class ownership for each of the stakeholders with unique risk and reward agreements. The developer, in this case, is being asked to take all of the financial risks. That said, the rewards of the risk (e.g. profit sharing ownership interest) will likely need to stay with the developer in a separate class of ownership.
    - The Tribe (or Corporation) will have a separate class to limit its liability exposure per charter. It is possible that this interest can convert to risk/profit sharing ownership over time through a structured buy-out of the developer over time. If the seed capital from the grant monies is realized, this can be used to initiate this buy-out. Otherwise, a class interest will have to be assigned for the intrinsic value of the leasehold if the land cannot be collateralized.
    - The dairy farm substrate providers are likely to make some improvements to facilitate the handling and delivery of digester substrate on their respective properties. It is unclear who funds that expenditure and who owns these

improvements[1] when made on the site other than the digester proper. Ownership of these on-site improvements would likely have to remain with the dairy business. In exchange, the operating entity could finance the dairy ownership of the improvements by leasing right-of-way rights from the respective dairy providers. The dairy providers would then acquire an ownership interest in the operating entity for improvements, secured with a lease negotiated return form the operating entity. Class interest could be negotiated based on pro-rated substrate volume, distance, improvement requirements, or some combination thereof.

- ✓ Venture capital opportunities on active tax shields: Because this investment is almost entirely into highly depreciable equipment and improvements, the likelihood of setting up a depreciation pass-through entity which creates tax-shield benefits for selected private investors is rather high. A return and buy-out can be negotiated up front in the form of either guaranteed payments or profit sharing. Of course a private placement memorandum would need to be developed to qualify candidates. However, this is a possibility that needs to be considered for a seed capital source.
- ✓ Industrial revenue bonds: For waste and nutrient management, special industrial revenue bonds are available at reduced interest rates due to their tax-free municipal status on the bond market. While the organizational costs are not immaterial, the applicability to this project and usually extended principal terms (sometimes interest only up-front) makes them a potential fit for this project.
- ✓ Lease-back model from the developer: In situations of limited seed capital, perhaps a lease-back model for the digester technology is a good model, particularly in combination with venture capital and dairy substrate provider opportunities. This gives the developer a structured exit path, set returns on investment, and paper with which to write project development debt against. Conversely, if the lease is structured correctly, it is not recognized as a liability by GAAP and may satisfy the Quild Ceda Power Corporation charter constraints in absence of land collateral.

While there are additional considerations as the process moves forward and stakeholders position themselves within the project, the issues above appear to be the most critical in light of what I have discovered and been privy to in discussions to date. The above are subject to revision and further discussion as observations are corrected or new information is discovered. Please let me know if you have any questions or comments. I will be happy to discuss specific details or provide further observations and recommendations as appropriate.

---

[1] Likely to create cross collateralization issues with existing business relationships unless granted a leasehold from the digester.

TO: RAY CLARK, CLARK GROUP

FROM: KAREN J. ATKINSON

RE: POTENTIAL BUSINESS STRUCTURES FOR SNOHOMISH BIOGAS PARTNERSHIP

DATE: APRIL 28, 2004

This memo outlines potential business structures for the Snohomish Biogas Partnership's proposed biogas facility. These business structures can be analyzed by considering the various objectives identified by the Snohomish Biogas Partnership. These objectives can include: flexible management by both the Tribe and farmers; ownership interest by both the Tribe and farmers; limiting owner exposure to business liabilities; enable equity and/or debt financing; maximize use of tax credits or incentives; and minimize state and federal taxes on business profits. This memo provides a generalized description of the complex legal and tax rules regarding the possible business structures available to choose from and is not intended to be a comprehensive legal analysis of the possible ramifications of each structure.

The Snohomish Biogas Partnership is considering the creation of a business entity to develop, own and operate an anaerobic digester system to biologically treat dairy farm manure and other institutional wastes, and to generate electric power. The goals of the Snohomish Biogas Partnership are to improve water quality and salmon habitat and reduce environmental risks associated with manure management. The project site is located off the Tulalip reservation on the Monroe Honor Farm, in Monroe, Washington. The Snohomish Biogas Partnership also has a broader vision for use of the site including a native nursery and interpretative center. Ideally the business structure should be flexible enough to encompass these future ventures by the Snohomish Biogas Partnership.

Because the project proposed by the Snohomish Biogas Partnership will be located off the Tulalip reservation on fee lands, many benefits that might be available based on a tribe's governmental status or trust land status will not likely be applicable and are therefore not analyzed in this memo. For purposes of this memo, I assume all applicable state business taxes would apply to the development because it will be sited on fee lands located outside the exterior boundaries of the Tulalip Reservation.

Tribal Energy Partnerships

The following are examples of how Indian tribes have structured energy partnerships primarily for on-reservation projects.

Rosebud Sioux Wind Turbine—Tribal Utility Model

- Rosebud Sioux Tribe installed 750kW wind turbine on tribally-owned trust land
- The Rosebud Sioux Tribe is the owner of the project through the Rosebud Tribal Utility Commission (RTUC)
- RTUC hired Disgen to design and construct
- NEG Micon will operate and maintain
- Tribe financed project with DOE grant and RUS loan
- Project power used to generate electricity for tribal casino and excess sold to Ellsworth Air Force Base
- Green tags sold to Native Energy

Wanapa Energy Center—Section 17 Model

- Umatilla Wanapa Energy Center
- Confederated Tribes of the Umatilla Indian Reservation (CTUIR) developing a 1200 megawatt natural gas power plant
- Plant to be located on off-reservation trust land owned by the CTUIR
- Business partners include: Diamond Generating Corporation, City of Hermiston, Eugene Water and Electric Board and the Port of Umatilla
- Tribe is the owner of project through a tribal economic development corporation chartered under federal law (Section 17 Corporation)
- Diamond Generating Corporation will fund the project and develop it using non-recourse financing and using federal tax incentives for economic development on tribal lands
- CTUIR may consider issuing tax-exempt bonds if it substantially reduces to costs to the partnership

Tri-Cities Landfill—Lease Arrangement

- Tri-Cities Landfill Generating Facility
- Partnership b/t Salt River Pima-Maricopa Indian Community and the Salt River Project
- Generates 4 MW of methane gas
- Located on tribal trust land, SRP leases land from the tribe for generating plant, SRP purchases the landfill gas for an energy facility
- Developer installed and operates the LF collection system and receives tax benefits

Business Structures

The first inquiry is how to structure the business relationship (Snohomish Biogas Partnership) between the Tulalip Tribe and Snohomish farmers. A second inquiry is how the Snohomish Biogas Partnership can structure its relationship with a developer. This memo focuses primarily on the first inquiry.

The types of entities available include 1) sole proprietorship; 2) a joint venture in unincorporated form; 3) a general partnership; 4) a limited liability partnership, 5) a limited partnership; 6) a corporation; 7) a limited liability corporation; 8) a Section 17 federal corporation; 9) a tribally-chartered corporation; 10) cooperative; and 11) tribal utility.

The key attributes that are usually considered when comparing the types of entities are: who manages the entity; how is it formed; what are the ownership types; are there classes of ownership interest; federal tax treatment; and limitation of the owner's liability for the obligations of the entity.

The following is a brief description of the attributes of the most relevant business structures for consideration by the Snohomish Biogas Partnership for development of the Monroe Honor Farm site.

1. Section 17 Corporation

    - A federally chartered corporation formed under Section 17 of the Indian Reorganization Act, 25 U.S.C. 477, is the most common form of tribal economic development corporation
    - Corporate charter issued by the Secretary of the Interior
    - Power to buy and sell real and personal property
    - Wholly tribally-owned
    - Non-taxable entity for purposes of Federal corporate income taxes for both on reservation and off reservation activities
    - Can pledge assets of the corporation
    - Sue and be sued clause may waive sovereign immunity of the corporation
    - Segregates tribal governmental assets and liabilities from the assets and liabilities of the corporation
    - Secretary of Interior Section 81 approval of contracts for a term of more than 7 years generally not required

    Comments:

- Farmers would not have ownership interest
- But farmers could form separate business entity that would be a partner to the project through a joint venture agreement, production agreement or operating agreement
- The Tulalip Tribe would be assuming most of the development and operating risks

2. Tribally Chartered Enterprise

- Instrumentality of tribal government chartered under Tulalip Incorporation Ordinance
- Example: Quil Ceda Power is incorporated as a governmental enterprise which functions as an arm of the tribal government
- Shares the same privileges and immunities of the tribal government
- May not be subject to federal corporate income taxes regardless of the location of activities if incorporated as an arm of the tribal government
- Can generally pledge assets of the corporation

Comments:

- The Tulalip Tribe could amend its tribal ordinance to include the farmers in the management and ownership of the corporation
- Farmers could form separate business entity that could partner as a through joint venture management, production agreement, or management agreement
- If the corporation can not pledge the assets of the corporation then the ability to obtain debt financing would be severely limited
- The Tulalip Tribe would assume most of the development and operating risk

3. Unincorporated Joint Venture

  - A tribal Section 17 corporation or tribally-chartered enterprise may enter into management, operating, production, service agreements
  - Tribal business can retain all ownership of a business activity and contract with other parties for management, professional and technical services
  - Contractual agreement specifies role and responsibilities of each party to the agreement
  - Other party is typically an independent contractor
  - Tribal federal tax status could be maintained for the tribal ownership share of the venture

4. Lease Arrangement

- Tulalip Tribe can lease the Monroe Farm site to 1) an enterprise created for both the tribe and the farmers to develop the biogas facility and related activities; or 2) a developer for the use and development of a biogas plant
- The Tulalip Tribe would retain ownership of the underlying land in fee status and enterprise would be able to use the property for specified purposes which could include all other uses such as the native nursery and interpretative center
- The leasee can mortgage the leasehold interest (improvements to the land) if security is required to finance the biogas project
- Need to check the Tulalip Tribe's constitution & by-laws and relevant federal statutes to see if the tribe has the authority to mortgage a leasehold interest on tribally-owned fee land
- If leased to a developer, a lease-back arrangement can be structured to turn ownership over to the tribe/farmer enterprise after a specified period – generally after the payback period.

5). <u>Tribal Utility</u>

- Put land into trust status
- Typically tribal government instrumentality formed under tribal law
- May be able to provide service to on-reservation loads and facilities
- Would not be subject to federal corporate income taxes and state excise taxes
- Access to low cost BPA power as preference customer
- May qualify for federal accelerated depreciation and wage credit if the purpose of the infrastructure property (biogas facility) located off the reservation is to connect with qualified infrastructure property on the reservation
- May qualify for exemption from Washington state utility taxes (RCW 54.28.020 and 82.16) if service is delivered to a tribe or tribal members in Indian country

Comments:

- Controversy over land into trust
- Regulatory issues associated with off reservation location
- Negotiation with state and county over regulatory and tax issues would likely be necessary
- Ownership of distribution system may be necessary requirement for BPA preference service
- Farmers likely could not share in ownership or distribution of profits

6. <u>Limited Liability Corporation</u>

- Formed under Washington State law
- Governed by agreement among members (Tulalip Tribe and farmers)
- All members can be involved in management of the operation
- Flexibility with respect to number of members needed for consent, voting, allocation of profit/loss and distributions
- Type of owners is unrestricted, can include affiliated membership such as a LLC, tribe, and tribal enterprise, and multiple classes of ownership
- Tax attributes passed down from entity to owners in proportion to their ownership interest (pass-through tax treatment)
- Can be treated as partnership for federal income tax purposes (no entity level tax)
- Tulalip Tribe's federal tax status can be preserved for its share of the LLC taxable profits
- Many LLC's that are treated as partnerships for federal tax purposes maintain operating agreements that provide for limited liability and a centralized management structure
- Ownership interest of members may be transferable with consent of other members
- As a state-chartered entity, the LLC would likely be subject to state regulation, taxation and court jurisdiction (including state employment laws)

Comments:

- Provides an attractive alternative for a tribe's participation in a business located off the reservation on non-trust lands
- Well suited for small, closely held businesses that want to maintain control over management as well as limited liability protection for investors
- Preserves some of the tribe's non-taxable federal status for federal corporate income taxes while providing for limited liability
- Parties can determine ownership interests by agreement
- Corporate formalities need to be maintained in order to preserve limited liability

Example of LLC used for off-reservation development -- Four Fires LLC:

- Four Fires, LLC is an investment partnership of four tribes: the Oneida Tribe of Indians of Wisconsin, the Forest County Potawatomi Community of Wisconsin, the San Manuel Band of Mission Indians and the Viejas Band of Kumeyaay Indians
- Incorporated under Delaware law
- Four Fires LLC functions as an investment coalition, with plans to develop construction, hospitality, and other business development ventures, with each tribe as an equal investor

- The first venture of Four Fires LLC is the development of a $43 million, 13-story, 233 suite Residence Inn by Marriot in Washington D.C. The inn is called the Marriot Residence Inn Capitol. Four Fires LLC owns a 59% equity share in the project. A hotel management company will run the company
- The four tribes combined resources to minimize risk and take advantage of prime investment opportunities and to maximize its resources both on and off the reservation

This memo describes the general attributes of the possible business structures available for consideration by the Snohomish Biogas Partnership. Further research will need to be completed to further refine this analysis and further explore Washington state corporation requirements, and the federal and state tax treatment and tax consequences of possible options.

TRIBAL STRATEGIES, INC

MEMORANDUM

TO: RAY CLARK, CLARK GROUP

FROM: KAREN J. ATKINSON

SUBJECT: STATE TAX ISSUES

DATE: MARCH 29, 2004

Pursuant to your instructions, I am providing a preliminary analysis of the state and local tax issues related to a biogas development located on an off reservation tract of land for the purpose of evaluating possible options for structuring the biogas development and for evaluating possible business models for the biogas partnership. As the project proceeds, a more in-depth analysis of these issues will need to be completed.

As a general rule, under federal law a state may not tax Indians or Indian tribes in Indian country. In some circumstances this prohibition extends to a state's authority to impose a tax on a nonmember doing business with an Indian or with an Indian tribe in Indian country. The issue of state authority to tax Indian tribes is a fact specific inquiry but generally, federal courts have found that tribes are immune from taxes when the taxes are imposed directly on them. Many states have attempted to work around this immunity by imposing a tax on nonmembers doing business with tribes, however, federal courts have generally not upheld these taxes if the economic impact or incidence of the tax is on the tribe.

The state of Washington has codified many of these federal tribal tax principles and as a matter of state law has provided tax exemptions on the sales of goods and services to Indians and Indian tribes taking place in Indian country. WAC 458-20-192. This exclusion from Washington taxes includes business and occupation taxes, public utility, and retail sales and use taxes. Under the Washington statute and guidance issued by the Department of Revenue, this exclusion applies to transactions taking place in "Indian country" which is broadly defined as all lands within an Indian reservation, including fee lands, and trust lands located outside of an Indian reservation.

As a matter of federal law, because the Honor Farm is in fee status and located off the reservation, most state taxes will apply unless it can be shown that the federal government intended to preempt the state taxes. This is usually demonstrated through some comprehensive federal statutory or regulatory scheme that covers the activities being taxed thereby showing a strong federal interest in the activities or by showing that the tribe itself has a significant interest in the transaction that outweighs the interest of the state.

There is a federal statute that governs the acquisition, management, and disposal of lands by the Tulalip Tribe. 25 U.S.C. 403a-2. In certain circumstances under this authority, land acquired by the Tribe in fee status on the reservation is considered to be subject to "restrictions against alienation" and therefore not taxable by the State or county. According to the Tulalip's tribal attorney, Mike Taylor, the Tribe and Snohomish County have worked out an agreement whereby the county has agreed not to assess property taxes on fee lands acquired by the Tribe within the reservation. Mike Taylor suggested that his office would need to do a comprehensive analysis of this federal statutory authority to determine if it could be extended to the off reservation acquisition of the Monroe Honor Farm by the Tribe.

It may be possible to approach the county on this issue to explore whether an agreement could be made between the Tulalip and the county whereby the county agrees that once the Monroe Honor Farm is transferred to the tribe, the county would consider it to be "subject to restrictions against alienation" and therefore not subject to county property taxes. Since the land is owned by the state it is probably not currently subject to county property taxes, so if an agreement were reached with the county or if the land were put into trust, there would be no property tax revenue losses to the county because it currently is not receiving those revenues. It is common for tribes and counties to negotiate intergovernmental agreements to address tax issues and impacts related to tribal off reservation economic development and to allocate responsibilities for governmental services and to allocate tax burdens.

For purposes of the options and scenarios you are developing, I would suggest that you include one option that shows the biogas development not subject to ad valorem property taxes with the assumption that an agreement could be reached with the county or that the land might be put into trust. Under this scenario, you could also make the assumption that all of the other state and local business taxes would also not apply if the business structure were Quil Ceda Power (tribal governmental corporation) or a Section 17 corporation. In the meantime, the Tulalip Tribe could further research this issue and perhaps begin a dialogue with the county. You could later adjust your analysis under this option depending on the results of the Tribe's research and agreement with county. Also, note that if the property were put into trust or deemed to be subject to restraints against alienation all other laws and regulations regarding leasing and use of tribal trust lands would probably be triggered and Bureau of Indian Affairs regulations and other regulations that apply to federal lands may need to be complied with (ie. NEPA).

At this stage in the analysis, you would also want to develop another option, which would apply the relevant state and local taxes to the Monroe Honor Farm property and to the business activities of the biogas development. This option would reflect the general rule that absent federal preemption, Indians conducting business outside of Indian country are generally subject to state taxes. Under this option, the following state taxes identified by

Marvin Hoekema will likely apply even if Quil Ceda Power is the sole owner of both the land and operating entity for the biogas development:

- Ad valorem property tax
- Business and Occupation tax
- Public utility taxes – however Washington does provide an exemption from these taxes (RCW 54.28.020 and 82.16 RCW) to businesses that deliver a public utility service to a tribe or tribal members in Indian country.
- County impact fees

Under Washington law, a state chartered corporation comprised solely of Indians (at least half of the owners enrolled members of the tribe) or partnership is not subject to tax on business conducted in Indian country but is subject to these taxes outside of Indian country. Retail sales tax is not imposed on sales to Indian tribes if the personal property is delivered to a tribe in Indian country. Retail sales taxes for services (construction and engineering), performed both in Indian country and off Indian country can be apportioned and those performed in Indian country can be excluded from the tax. Use taxes are not imposed on personal property when acquired by a Tribe in Indian country for at least partial use in Indian country.

This preliminary analysis can be refined as you proceed with the project and adjustments to the options can be made as further legal research is done or options with the county are explored. The various options may also assist the Tulalip Tribe in determining what level of effort they want to commit to in addressing or pursing the different project structures and business models.

Attachment 13

January 21, 2004

TO: Tulalip Tribes via Susan April (The Clark Group)

FR: Scott Sklar, The Stella Group, Ltd.

RE: Review of Expression of Interest (EOI) Submissions

I have received fifteen submissions (project design and builders, vendors, and services) and per the solicitation criteria, weight is given to the extent of previous expertise in anaerobic digestion particularly from cattle manure, number of years in business, projects fully operational using proposed systems, and quality of installations and references. Finally, as requested, I give my candid review or conclusion as well as caveats.

As many of you know, I ran the National Biomass Industries Association (NBIA), the national industry association of the biomass-to-electric industry for 15 years in Washington, D.C., previous to NBIA served for three years with the National Center for Appropriate Technology which I served, in part, as Acting R&D Director overseeing technical assistance for renewable energy projects in agricultural settings, and after NBIA I head my own multitechnology firm which facilitates on-site clean energy generation projects which includes all the renewable and advanced technology applications. I have not worked for or against any company that submitted proposals and have no relationships as a client or partner with any of the companies reviewed. I have visited some farms where the installations are noted, and I have identified them in my minireviews.

Only four companies, in my opinion, can deliver the product requested. The four have “real world” experience with anaerobic digestion and dairies. They are involved in design and project management and have solid successes. They are Andgar Corp (really GHD) outlined as number one, below; Entec, outlined as number eight, below, RCM Digesters, Inc., outlined as number fifteen, below and possibly Environmental Power Corporation, number nine below (if their investor relationships can bring resources to this project) then also deserve consideration.

Other (“maybe”) companies have experience in only one country, I felt their assuredness for a solid US delivery is unproven, so I was more cautious.

Some other companies offer equipment, analysis, or adjunct services or products that might be applicable – after a lead company is selected.

Finally, some companies just did not have the core competence to offer services or gave such poor a submissions, it was unlikely they have the detail and capability to successfully pull off a project of this size and scope.

I did not make elaborate reviews, because this exercise is to scope down to the few companies that need to go into the final round. They need to be asked specific questions uniformly before a final contender company is selected. I am happy to guide those questions and review their responses in detail. I am happy to go into more detail on all the company submissions, if required. I reviewed their letters, submitted marketing materials and their web sites.

Please note that I am available to answer any questions or participate in any meetings or conference calls as required.

Submission #1
Company: Andgar Corporation
State: Ferndale, Washington
Expertise in Regional Anaerobic Digestion Projects:
Andgar Corporation is proposing to install and construct the system in alliance with GHD, Inc. of Chilton, Wisconsin will do the design and engineering. This team has solid experience in designing and installing dairy manure and water management projects and electric energy generation using waste heat from water. Coproducts include fertilizer, bedding and waste heat used for process and heating dairy flooring.

Basic process is is raw manure will be collected and heat to 100 degrees F (also using waste heat from the electrical generator system) and the goal is to facilitate the growth of acid forming bacteria. Second stage is a 20 day process at the same temperature in a gravity flow effluent pit. The third stage uses reciprocating engines to combust the emitted methane from the first two stages to produce electricity and hot water (from heat in the engine jacket and the exhaust). The hot water's heat is transferred to the pits as well as to the dairy for in-floor heating (if necessary) and to dry out fiber for bedding replacement. Finally, the dairy's storage lagoon is gravity fed and the remaining manure, less the solids, can be used via liquid irrigation nozzles for fertilizer if appropriate and far enough from watersheds. The concrete vessels have a life of 30 – 50 years. Engines are off-the-shelf warranted by the manufacturer.

Years in the Business: 26 years Steve Dvorak (GHD) registered PE#16461
Summary of All Fully Operational Projects Using Proposed Technology and Services:
Herrema Dairy, Fair Oaks, IN 2700 cows and 600 kW Generation
Gordondale Farms, Nelsonville, WI 695 cows 135 kW Generation

Double “S” Dairy, Markesan, WI 750 cows 140 kW Generation
Wholesome Dairy, Hilbert, WI 3300 cows 500 kW Generation

Quality of References (maximum-3)
Another eight are coming on line this year. I have seen the Fair Oaks and Nelsonville installations on other business. Very impressive.

Comments by Reviewer: Andgar Corp biogas experience is unclear while GHD has long and solid experience, Andgar as construction manager and installer is located in the State of Washington, which is a plus. GHD and its founder are proven in the field with many quality installations. The farms I visited and subsequently called were highly complimentary. I would see no “down side” to this choice of a competent and proven team. (YES, with validation of Angar qualifications)

Submission #2
Company: BioScan
State: Denmark
Expertise in Regional Anaerobic Digestion Projects:
Bioscan is a merger of an engineering firm and an environmental laboratory.

Years in the Business: 15 years
Summary of All Fully Operational Projects Using Proposed Technology and Services:
This company has three projects that are biomass related under their belt. Two of the projects were a 1990 German facility with 360 tons of cow manure and a 1996 Danish project of a 300 ton livestock manure facility. In 2000, they extended the output of the German facility to 550 tons per day.

The process includes production of lactic acid for food preservatives or biodegradable polymers, methane and liquid CO2 and energy generation.

Quality of References (maximum-3)
Bioscan has two pig manure slurry demonstrations which are both in Denmark, a 25-40 tones per day and a 41-45 tones per day and another 65 tons per day for pigs in Hashimoto, Japan. They also have a 70 tones per day of pig and cattle slurry in Holland and

other organic wastes in Germany (4 tons per day of kitchen waste and 20 tons of gray water per day) and another German facility of 68 tons per day of brewery wastes and other organics. (MAYBE, PROBABLY A LONG SHOT)

Comments by Reviewer:
This is a sophisticated company but with very limited experience outside of Europe and Japan, and limited experience with dairies and cow manures. There is no question their technology works, but it will be costly because of lack of US partners, knowledge of explicit US waste practices and US markets for unique coproducts they produce (liquid CO_2 and lactic acid. (PROBABLY NOT)

Submission #3
Company: BSI Environmental, Inc.
State: Florida
Expertise in Regional Anaerobic Digestion Projects: Primarily focused on environmental waste projects but teamed with Kreig and Fischer Ingenieure GmbH of Germany that has installed over 20 biogas projects only in Germany, and the California-based Tetra tech, Inc. which is an engineering and resource management firm established in 1966.

Years in the Business: Each partner has over 10 years
Summary of All Fully Operational Projects Using Proposed Technology and Services:

Quality of References (maximum-3): Three references are all in California with the Inland Empire Utility and Regional Composting Authority.

Comments by Reviewer: The biogas expertise is in Germany and only Germany, and the engineering company has done compost management and power projects. In regard to anaerobic digestion, this team is non-global, limited dairy and anaerobic digestion experience of the USA partners. They could pull it off probably, but their experience is limited for this particular project. (MAYBE, AT BEST)

Submission #4
Company: Daritech, Inc.
State: Lynden, Washington
Expertise in Regional Anaerobic Digestion Projects: Founded to provide equipment, service and support to Western dairies.

Years in the Business: 14 years
Summary of All Fully Operational Projects Using Proposed Technology and Services:
Daritech is not bidding on the whole project. They have offered to help on pretreatment of manures (scrape and flush approaches) and effluent solids separation.

Quality of References (maximum-3): Four Washington dairies are listed and they have done a good job.

Comments by Reviewer: The company is a service provider after the selection of a prime company. If the selected company and dairies believe they needed a proven in-state company relating to pretreatment and effluent solid separation, Daritech has solid experience. (MAYBE AS PART OF A PROJECT)

Submission #5
Company: Eco Tec of Northwest America, Inc.
State: Sandpoint, Idaho
Expertise in Regional Anaerobic Digestion Projects: At least four of the ten sample projects related to manures, others to MSW and industrial waste water. Appear to have little major projects in the Northwest.

Years in the Business: 1995
Summary of All Fully Operational Projects Using Proposed Technology and Services: Digester and municipal solid waste is their main thrust emanating from the Carl Bro Group (founder) a Danish engineer.

Quality of References (maximum-3) The company didn't offer references (until we request permission to access on a case-by-case basis. The listed facilities are all overseas – four in Denmark and one in Sweden, two in Japan, two in Africa in Tanzania and Zimbabwe, and one in Indonesia. Most are design and supervision projects.

Comments by Reviewer: It appears the Company has a good history of projects overseas but little in North America and no references to manure projects in this hemisphere. Unless teamed with an installation company, but concrete relationships are mentioned, there may be better options. (MAYBE)

Submission #6
Company: EcoTechnologySolutions
State: Leesburg, Virginia
Expertise in Regional Anaerobic Digestion Projects: Emerging business in eastern US and teamed with engineering firm and German technology manufacturer.

Years in the Business: October 2003
Summary of All Fully Operational Projects Using Proposed Technology and Services: Company formed last year to help farms deal with EPA CAFO requirements and uses the GBU (German company) digester technology. They are also teamed with Stearns and Wheeler environmental engineering company founded in 1950. S&W also did two recent engineering studies for a manure digester for a 3800 cow digester in Washington County, New York and a 700 cow anaerobic digester in Adams New York and is likely to be built in 2004.

Quality of References (maximum-3) Company gives two New York dairy references, one with 3,000 cows and 50 tons per day with 2 MW of heat and electric power

Comments by Reviewer: New company with emerging strength in New York. No solid list of installed projects which we can determine success. (MODERATE CHOICE)

Submission #7
Company: EcoTope
State: Seattle, Washington

Expertise in Regional Anaerobic Digestion Projects: Based on Ecotope's founder David Smith's experience with a research biodigester project in 1975 at the Monroe dairy which was operated for several years. They have done utility and farm projects in the Northwest including the Calgon Farm digester study in Polk County, Oregon. They are teamed with 2020 Engineering of

Years in the Business: Not clear of varied partners
Summary of All Fully Operational Projects Using Proposed Technology and Services:

Quality of References (maximum-3) 202 Engineering has applied some engineering design to Blok's Evergreen Dairy and they have engineered wastewater and compost systems using ECS, which designs automated compost controls and vessels.

Comments by Reviewer: The team has some valuable experience but not many commercial projects involving dairies and manures. ECS and other design assistance might be applicable to the project – but only after a lead company is selected to design a complete and operable system. This team does not have the necessary experience for the proposed project. (MAYBE, SOME PART)

Submission #8
Company: Entec
State: Austria
Expertise in Regional Anaerobic Digestion Projects: Entech has more than 20 years experience and has participated in more than 100 full scale biomass plants worldwide.

Years in the Business: 20 years
Summary of All Fully Operational Projects Using Proposed Technology and Services: design, construction contractor and operations guidance. They have solid component suppliers including

Quality of References (maximum-3) Great references which include full information and contacts including two German Pig Manure plants of 625 kW and 90,000 cubic meters of manure and 330 kW and 45,000 sq meter cow manure operation. Another two cow manure operations in Germany of 803 KW and 370 kW respectively and a 1 MW cow dairy manure project (India's largest), and a host of others.

Comments by Reviewer: The company is a proven performer in cow, pig and chicken manures and can operate globally. They have a North Carolina engineering representative who has links with several proven energy construction companies. Entec has also said they will approach their investor relationships for this project if they are selected (an important consideration). Worth serious consideration and further interviews. (YES)

Submission #9
Company: Environmental Power Corporation
State: Portsmouth, New Hampshire
Expertise in Regional Anaerobic Digestion Projects:

Years in the Business: 20 years
Summary of All Fully Operational Projects Using Proposed Technology and Services: Holding company with $50 million in annual revenues, holdings are Microgy Cogeneration Systems which is the exclusive North American licensee to European anaerobic digestion technology and combined heat and power.

Quality of References (maximum-3) The company is working with a Wisconsin dairy cooperative on a 1.5 MW facility and a Lodi, California regional digester for 1,500 cows with approximately 5 MWs of electric generation. They can and have worked with Daritech and Organix, who also proposed. They have provided 14 codigester projects in Denmark only with a combined output of 2.67 MWs.

Comments by Reviewer: The company appears to have a focus on combining food waste and manures, and has some solid partners in the US, some who applied to our EOI. They have no finalized US experience and they have experience in only one country (Denmark). They have competence but they are very limited geographically but has also said they will approach their investor relationships for this project if they are selected (an important consideration). (YES, particularly if they can bring resources to the project)

Submission #10
Company: Environmental Resource Recovery Group, LLC
State: Nortonville, Kansas
Expertise in Regional Anaerobic Digestion Projects: The company has dome feasibility studies on dairy, piggeries and poultry operations. They are solid professionals with over 20 years experience in the field.

Years in the Business: Over 20 years
Summary of All Fully Operational Projects Using Proposed Technology and Services: Primarily analysis and design and some operation design and construction management.

Quality of References (maximum-3) Pilot plant in West Virginia, 320 cow dairy in Cooperston, NY, 6500 head Cushman dairy in Connecticut, a 600 head dairy in Illinois and two swine projects in Illinois and Taiwan.

Comments by Reviewer: This is a solid environmental and waste management team. While they have experience in energy it is not clear who they use from their professional roster. This is a solid team of analysts but the materials they provided are unclear as to their construction oversight managers or corporate alliances would be. My view is that this would be a great due diligence firm on the final plans from the chosen company of the project. This group would be a great firm to provide concurring analysis and support for the power, emissions, and treatment side of the project. (YES, ON SERVICES – POSSIBLY)

Submission #11
Company: Industrial Resources, Inc.
State: Skagit County, Washington
Expertise in Regional Anaerobic Digestion Projects: IRI sells itself on its web site as a food processing and forest products systems company. In it's one page letter, it also states they have municipal and chemical waste experience.

Years in the Business: 34 years
Summary of All Fully Operational Projects Using Proposed Technology and Services: None really elaborated upon.

Quality of References (maximum-3) Their Shell Oil and Trident Seafood references are sound but not one has stated experience in manure and anaerobic digester systems.

Comments by Reviewer: The company is obviously a great contract process system design and installation firm but with limited anaerobic digestion and dairy experience. (NO)

Submission #12
Company: Martin Machinery
State: Latham, Missouri
Expertise in Regional Anaerobic Digestion Projects: An equipment provider for engines and switching gear in biomass projects including most of the reciprocating engines and diesels from major manufacturers.

Years in the Business: 28 years
Summary of All Fully Operational Projects Using Proposed Technology and Services:

Quality of References (maximum-3) They have provided equipment for Pennsylvania, Oregon and Illinois dairies at 100 kW, 260 kW and 320 kW respectively.

Comments by Reviewer: No question, whoever is selected to design and construct this project may wish to use their equipment, (YES, POSSIBLY AS AN EQUIPMENT SUPPLIER)

Submission #13
Company: Organix
State: Walla Walla, Washington
Expertise in Regional Anaerobic Digestion Projects:

Years in the Business: Since 2001, 3 years
Summary of All Fully Operational Projects Using Proposed Technology and Services: The company manages wastes and Organix, has 6 ongoing customers and 70 wholesale clients, generally focused in Oregon.

Quality of References (maximum-3) They have a strategic partnership with Energy Northwest and one compost site, three compost distributors and Oregon State offices of Agriculture and Environmental Quality.

Comments by Reviewer: The firm is a promising firm on organic waste management, primarily compost in Oregon. They have no manure and dairy experience in real projects. (NO)

Submission #14
Company: Prometheus Energy Company
State: Bellevue, Washington
Expertise in Regional Anaerobic Digestion Projects: The company is in a joint venture with Chemithron Constructors, Inc. (Everett, Washington) is “raw” gas projects and LNG. Raw gas includes anaerobic digesters, remote well, and natural gas, where they do purification, liquefaction, and dispensing.

Years in the Business: 10 years in research, last few years in project development
Summary of All Fully Operational Projects Using Proposed Technology and Services: basically three landfill gas projects with the third underway. The first two in California and British Columbia are operational liquefying their output.

Quality of References (maximum-3) Less then three biogas operational. I did not site verify or check references at this time.

Comments by Reviewer: This firm has had no experience with dairy manures and anaerobic digestion to any extent. Their process, though, may become very applicable to a biogas project if there is a proven, demonstrable market, in selling their biogas as a liquefied gas product. This market potential should be addressed closer to time of production since market rates are quite variable. (POSSIBLE SERVICE PROVIDER AFTER PROJECT LEAD IS SELECTED).

Submission #15
Company: RCM Digesters, Inc.
State: Berkeley, California
Expertise in Regional Anaerobic Digestion Projects: Designs and builds anaerobic digester systems and supplies specialty equipment.

Years in the Business: 1982
Summary of All Fully Operational Projects Using Proposed Technology and Services: Their earliest project is a 407 cows built in 1982 in Chile and their newest in 2003 is a 4,000 cow centralized digester system in Tillamook, Oregon. They have multiple waste digesters in Clymer, New York and a pig and cheese co-digester in Gypsy Hill, Pennsylvania built 16 years ago.They utilize internal combustion engines and are a global company.

Quality of References (maximum-3): RCM gave a 10 site plug flow reference for dairies from California, Connecticut, Illinois, Minnesota, New York, Oregon, and Wisconsin. I have seen some of their installations. This is an impressive and proven company.

Comments by Reviewer: This is a proven company with solid dairy experience. They offer a blend of technology and four different systems including mixed organic waste. (YES)

Please feel free to contact me about any of my assessments and reviews. Thank you.

Scott Sklar
President
The Stella Group, Ltd.
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The Stella Group, Ltd. is a strategic marketing and policy firm advancing the utilization of clean, distributed energy applications such as advanced batteries and controls, energy efficiency, fuel cells, heat engines, microhydropower, minigeneration (natural gas), modular biomass, photovoltaics, small wind and solar thermal (air-conditioning, water and industrial process heat, and power generation); with blended financing and customer facilitation

[Copy of Letter Sent to 50 Anaerobic Digestion Vendors and Service Providers in U.S. and Europe. 15 Responded with Submissions of Expression of Interest]

December 15, 2003

To Whom It May Concern:

The purpose of this letter is to introduce you to the concept of a regional anaerobic digester biogas project to be sited near Monroe, Snohomish County, Washington (USA) and to formally request your Expression of Interest (EOI) in our project.

On April 3, 2003, the Tulalip Tribes, Lower Skykomish River Habitat Conservation Group, Northwest Chinook Recovery, and Washington State Dairy Federation signed a cooperative agreement to form the Snohomish Basin Biogas Partnership (SBBP). The partners have a common interest in protecting water quality and salmon habitat, providing jobs to support agriculture in Snohomish County, and developing county-based renewable energy. To meet these goals, SBBP partners are participating in a DOE-funded study to assess the feasibility of a regional anaerobic digester biogas facility to be sited in Snohomish County.

A field survey has been completed to locate and assess available organic waste sources. This baseline document (November 2003, Biomass Assessment Report) can be downloaded from the following: http://www.quilcedapower.com/Documents.htm

At this point in the Feasibility Study, the partners have selected The Monroe Honor Farm property, located south of the town of Monroe WA, as the best site for a regional digester. The anticipated waste stream will include a mixture of both flushed and scraped dairy manure, as well as good quality food waste resources. There are as many as 5,155 lactating cows currently under consideration in the Monroe site area.

The facility design will need to include provisions for on-farm pre-treatment techniques to concentrate dilute flush dairy manure, and a strategy to incorporate diverse waste streams. The system must include commercially available (i.e., proven) biogas utilization equipment and control systems for the co-generation facility, and provide effective solids separation for digester effluent and composting technologies to support a marketable fiber product.

Within your EOI submittal, please provide the following:

- A company resume that clearly defines your area of expertise as it pertains to a regional anaerobic digester project;

- A statement of the number of years of experience specifically in agricultural settings with animal manure anaerobic digestion systems;

- A list of all projects that are fully operational utilizing your technology; and

- A list of at least 3 references we may contact.

Please limit your EOI response to not more than 5 pages and submit this information electronically to Biogas@clarkgroupllc.com or via Fax to 202-544-8330, Attention: Biogas.

Supplemental hardcopy material (e.g., corporate brochures, case studies, etc.) may be sent to: Biogas, c/o The Clark Group, 501 Capitol Court, NE, Suite 300, Washington, DC 20002.

Once your EOI information has been received, it will be evaluated for further consideration by our project panel. If you have any questions, please contact either myself at 360-794-8927, or Susan April of The Clark Group at 202-544-8200.

Please reply by 5:00 p.m., EDT, Wednesday, December 31, 2003.

We look forward to your responses.

Thank you.

Sincerely,

Dave Somers

Project Coordinator

The Tulalip Tribes

Attachment 14

QUIL CEDA POWER CORPORATION
A SMALL BUSINESS ENTERPRISE OF THE TULALIP INDIAN TRIBE
NOTIFICATION OF RURAL DEVELOPMENT'S
FINDING OF NO SIGNIFICANT ENVIRONMENTAL IMPACT AND DETERMINATION OF NO PRACTICABLE ALTERNATIVE TO POTENTIAL IMPACTS TO IMPORTANT LAND RESOURCES
(Floodplains)

The U. S. Department of Agriculture, Rural Development has received an application from the Quil Ceda Power Corporation, a small business enterprise of the Tulalip Indian Tribe, to construct an Anaerobic Manure Digester.

The specific elements of this proposed action are to collect liquid manure produced from an aggregate of 4,000 Dairy cows through existing collection systems from three to six neighboring dairies and process the manure through an anaerobic digestion process that creates methane gas, manure solids, and liquid. The methane gas will be collected and burned in a power generation facility to produce a sustained yield of .5 to 1.0 Megawatts of electrical energy that will be sold to the Public Utility District Number 1, of Snohomish County. Solids will be extracted from the manure, dried and returned to the originating source for use as bedding material or used in other commercial activities of the Tulalip Tribe. Liquids will be applied to the land as in the current distribution methods. The resulting liquids will have reduced odor, and have reduced nutrient content.

Rural Development has assessed the potential environmental impacts of this proposed action and determined that the location of the improvements will lie within the above designated classifications. All or a portion of the proposed site may include areas designated as floodplains. Short term minimal impacts could occur during construction of the Anaerobic Digester. It has been determined that there are no practicable alternatives to the potential impact to floodplains.

The following mitigation measures will be required:

1. Flood Insurance will be required and maintained for the life of the project.

2. New construction or modification to any existing structure must be approved in writing by the Seattle Corps of Engineers prior to construction activity. Rural Development must concur in all plans prior to the start of construction. Where practical, all new construction shall be placed either above the flood plain or protected by a dike or other barrier to prevent discharge of manure wastes into a live stream or water supply.

3. An Air Quality Permit must be obtained from the Puget Sound Clean Air Authority and a Notice of Construction permit obtained.

4. A Dairy Nutrient Management Plan is required to be submitted for approval by USDA, Washington State Department of Agriculture, and Washington State Department of Ecology.

5. The project is subject to the Coastal Zone Management Program and requires a Consistency Certification from the Department of Ecology prior to release of any Federal funds.

6. An Unanticipated Discovery Plan (UDP) must be "in place" before Notice to Proceed is issued. If earth disturbing activities during project construction uncover cultural materials (i.e. structural remains, historic artifacts, or prehistoric artifacts), all work shall cease and the Washington State Archaeologist at the Office of Archaeology and Historic Preservation (OAHP) , and rural Development (RD) State Environmental Coordinator (SEC) shall be notified immediately.

   If earth disturbing activities during any area of the project uncover human remains, all work shall cease immediately in accordance with the Native American Graves Protection and Repatriation Act of 1990 (NAGRPA) and state statutes RCW 27.44. The area around the discovery site shall be secured and the County Coroner and the State Archaeologist at OAHP shall be notified immediately. The State Archeologist shall notify the Tribe and the SEC at RD without delay.

7. Construction activities will be scheduled to reduce traffic and noise impacts in commercial and residential areas.

8. Best management practices shall be implemented for dust control during construction.

Rural Development has assessed the potential environmental impacts of this proposed action and has determined that it will not significantly affect the quality of the human environment. Therefore, Rural Development will not prepare an environmental impact statement for this proposed action.

Any written comments regarding this determination should be provided within 15 days of this publication to Chris Cassidy, Rural Business Cooperative Service Program Director. Rural Development will make no further decisions regarding this proposed action during this 15 day period. Requests to review the Rural Development environmental assessment upon which this determination is based or to receive a copy of it should be directed to Chris Cassidy at 1606 Perry Street, Suite E, Yakima, WA 98902-5769 or John Brugger at 1908 North Dale Lane, Spokane, WA 99212.

A general location map of the proposed action and impact area is attached.