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Feasibility Study for Alternative Technologies and Utilization for Managing Dairy and Poultry Manure

Submitted To

State of Connecticut
Department of Environmental Protection

Submitted By

Wright-Pierce

December 2005

FEASIBILITY STUDY
FOR ALTERNATIVE TECHNOLOGIES AND UTILIZATION
FOR MANAGING DAIRY AND POULTRY MANURE

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EXECUTIVE SUMMARY

OVERVIEW

The Connecticut Department of Environmental Protection (DEP) is developing a *General Permit for Concentrated Animal Feeding Operations* (CAFOs) in order to regulate manure management activities currently practiced on Connecticut Animal Feeding Operations (AFOs). The General Permit specifically regulates Connecticut AFOs with a larger number of animals, defined by the permit as CAFOs. In the Technical Report on the Impact of General Permit on Concentrated Animal Feeding Operations in Connecticut prepared for the Connecticut DEP and issued in March 2003, dairy and poultry manures were identified as contributing to a nutrient surplus in Connecticut. Land application is the most common agricultural manure management method for dairy and poultry manure. Due to the present loss of farmland in Connecticut, there is no longer sufficient land available under the control of the farms for agronomic application rates. The proposed DEP General Permit has provisions that will limit land application to agronomic rates and that could limit the amount of manure which is land applied on CAFO farms. In order to maintain current production rates, and thus manure production rates, development of feasible manure management alternatives are essential for the survival of the farms directly affected by the DEP General Permit.

To meet the proposed agronomic application rates for manure application, the surplus nutrients must be economically treated and moved off-farm for utilization in other market sectors. This report evaluates a variety of alternatives that would address the current State nutrient surplus. The ultimate goal of this project is to identify economically and technically feasible manure management methods for the dairy and poultry industry that would effectively manage surplus nutrients produced by CAFOs located throughout the State of Connecticut.

STATEWIDE AND COUNTY NUTRIENT DISTRIBUTION

Many different types of animals contribute to the over-all nutrient surplus in Connecticut. However, an analysis completed by the University of Connecticut indicates that dairy and poultry farms produce approximately 68% of the State's manure. This analysis is based on animal census data developed by the U.S. Department of Agriculture (USDA). Subsequent analysis of the data shows that the majority of the dairy and poultry populations are concentrated in four areas throughout the state. The percent of available land required for agronomic application of nutrients produced by the dairy industry, the dairy and poultry industry, and all animal sources, was compared on a county-by-county basis (see Table ES-1). This data assumes that land available for nutrient application is all grassland and corn fields listed in the crop census.

TABLE ES-1
PERCENTAGE OF AVAILABLE ACRES NEEDED FOR AGRONOMIC APPLICATION OF NUTRIENTS PRODUCED BY THE CONNECTICUT AGRICULTURAL INDUSTRY

	% Of Available Acres Needed For Agronomic Applications					
	DAIRY ONLY		DAIRY AND POULTRY		ALL MANURE	
AREA	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
State	58%	57%	101%	144%	149%	213%
Fairfield	14%	14%	15%	17%	75%	96%
Hartford	30%	29%	30%	30%	86%	114%
Litchfield	45%	45%	46%	45%	83%	99%
Middlesex	33%	33%	34%	35%	92%	117%
New Haven	37%	37%	40%	42%	94%	120%
New London	65%	63%	278%	500%	325%	567%
Tolland	82%	79%	83%	79%	138%	159%
Windham	82%	79%	82%	79%	133%	152%

A surplus of nutrients is theoretically indicated when greater than 100% of the available land is needed, however, a nutrient surplus can also occur at lower percentages. Not all of the grassland and corn fields are available for land application of manure due to proximity to sensitive water bodies or nearness to neighbors. In addition, some land already has a surplus of phosphorus which would prohibit further application of manure and could preclude further land application for many years.

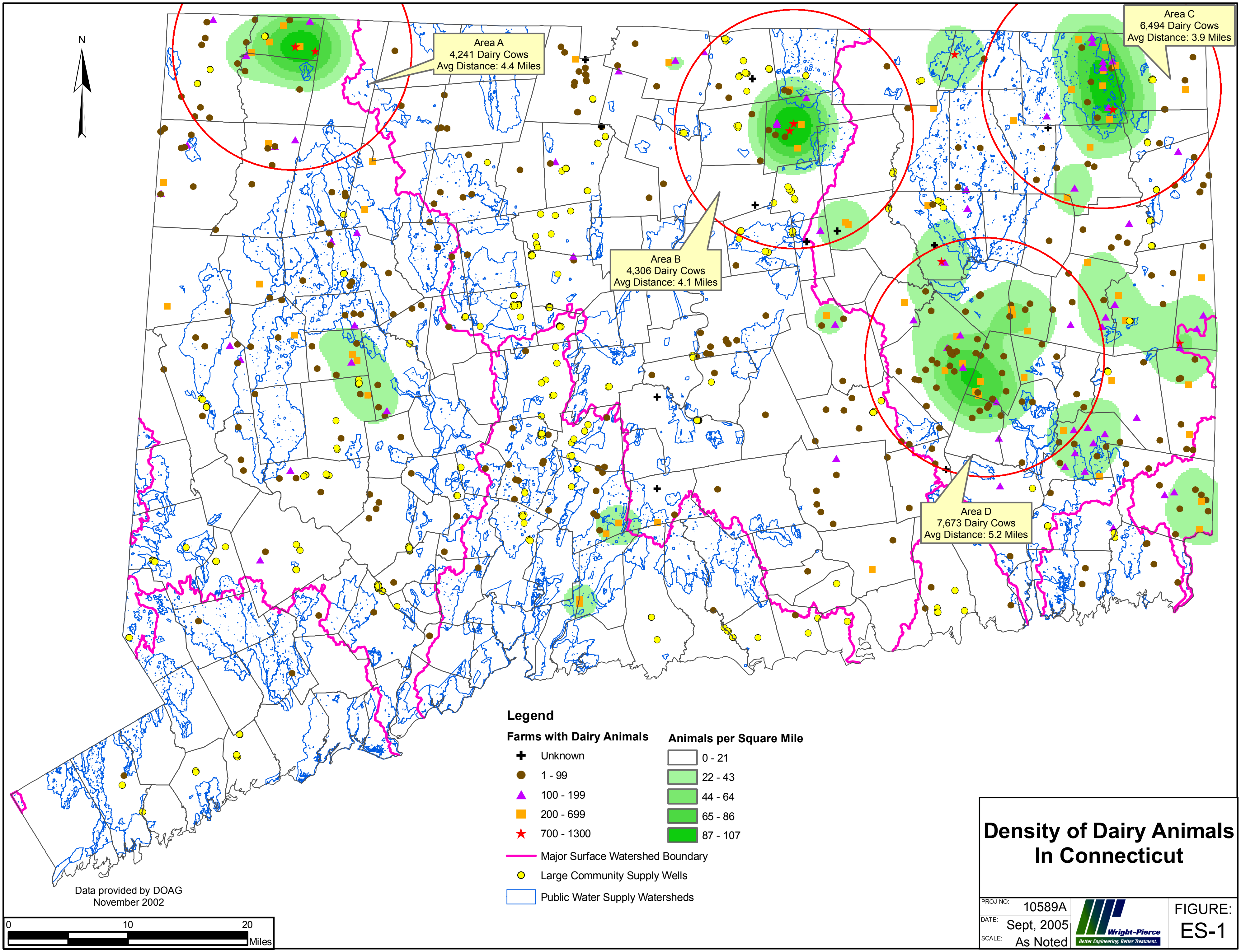
From Table ES-1, the counties where the dairy and poultry farms contribute significantly to the nutrient surplus are evident. Generally, dairy and poultry CAFOs, are currently using all available land for manure application in their surrounding areas. Table ES-1 indicates significant surpluses in New London, Tolland, Litchfield, and Windham Counties. Addressing the nutrient surplus in these areas is the focus of this study and the CAFO farms in these counties will likely be directly affected by the DEP CAFO General Permit.

In counties such as Fairfield County, Hartford County, Middlesex County and New Haven County, more than 60% of the manure produced is from non-poultry and non-dairy sources. In these counties other animal sources contribute significantly to the total amount of generated nutrients. However, none of these animal operations have sufficient numbers of animals to subject them to the requirements of the DEP General Permit.

FARM LOCATIONS AND BASIS OF DESIGN

This study focuses solely on the dairy and poultry CAFOs in the State of Connecticut. There is significant variability in the sizes and location of farms in Connecticut. Dairy farms are widely dispersed throughout the state. By mapping the dairy animal density in the State, four areas with high animal density were identified (See Figure ES-1). They are located in Litchfield, Tolland, Windham, and New London Counties. These regions of the State would be more suited for regional manure management solutions while the remaining areas are better suited for individual farm manure management solutions. Conversely, the majority of the CAFO poultry operations are located in New London County. Since the poultry facilities are already quite large, a separate regional facility was not considered.

For the regional dairy design basis, the animal density mapping was used to calculate the number of dairy cows within each of four areas of highest concentration. These numbers were further refined by assuming that one-third of the animals would be part of the replacement herd and that fifty percent of the remaining cows would be participating in a regional facility. This analysis resulted in a regional facility managing the manure from 2,500 animals. To account for the possibility that the regional facility would also process food wastes, an additional 500 animals



Density of Dairy Animals In Connecticut

PROJ NO: 10589A
DATE: Sept, 2005
SCALE: As Noted

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FIGURE: ES-1

were added to approximate the equivalent nutrient and solids loadings from food wastes for a total of 3,000 animals.

As the CAFO regulations potentially apply to all farms with greater than 200 head, the individual farm size was set at a 200 animal basis.

ALTERNATE NUTRIENT REDISTRIBUTION METHODS / PRODUCTS

In order to prevent the over-application of nutrients onto the grassland and corn fields traditionally used for dairy and poultry manure application, the nutrients will need to be converted into a form and/or product that can be exported off the farms. There is already an established market in Connecticut for both inorganic and organic based fertilizers. However, raw manure cannot compete with the products currently available. Raw dairy and poultry manure tends to contain a high amount of weed seeds, odor and pathogens. An acceptable product must be generated without the weed seeds, pathogens, and odor using cost effective technologies. The following products meet this criteria and can be generated by treating raw dairy and poultry manure:

- Anaerobic Digestion Effluent
- Compost
- Poop Pots
- Ash from Combusted Manure

Redistribution of dairy and poultry manures to other market sectors would significantly reduce the amount of nutrients contributing to the State nutrient surplus. A percentage of the manure produced will still need to be utilized as fertilizer in area crop land. Therefore, it is not necessary to move all manure to other sectors. Land application would still need to occur on area farmland, only in a smaller more manageable volumes to meet the agronomic application rate criteria**.**

ALTERNATIVE TECHNOLOGIES

A wide range of technologies were reviewed and screened for their technical feasibility and their ability to transfer nutrients to a form that facilitates moving nutrients off-farm. The screening of these technologies resulted in the development of a technology short-list for dairy and poultry manure management. These short-listed technologies include:

Dairy Farms

- Liquid/Solids Separation
- Anaerobic Digestion
- Chemical addition to precipitate phosphorus
- Composting
- Production of alternative products such as horticultural pots and paper.

Poultry Farms

- Composting
- Waste-to-Energy

For the most part, these technologies have been implemented in the United States and overseas at full-scale facilities for manure and/or residuals management, and are appropriate for either a local or regional manure management solution.

For the purposes of the study, the technology options listed above have been organized into nutrient management scenarios for individual farm and regional facilities. In order to easily compare the technologies under consideration, tables were developed listing each option and evaluation parameters. The individual dairy farm options, regional dairy manure facility options and poultry manure options are discussed below.

Individual Dairy Farm.

Three options were considered for the individual dairy farm:

- use of liquid/solid separation,
- composting whole manure, and
- liquid/solids separation followed by chemical precipitation of phosphorus.

Many of the parameters reviewed had the same impacts with each of the three options considered. Air Emissions Impacts are neutral, no renewable energy is produced, and greenhouse gases and criteria air pollutants are the same as existing manure management methods for all of the individual farm options considered. Table ES-2 summarizes the remaining review parameters for the dairy manure farm options.

TABLE ES-2

	Dairy Manure - Individual Farm Options		
Review Parameter	**Liquid/Solid Separation**	**Composting Whole Manure**	**Liquid/Solid Separation and Chemical Precipitation**
1. Technical Feasibility	High, Similar Facilities Exist	High, Similar Facilities Exist	Moderate. Not many Full size facilities
2. Economic Feasibility	$730 per cow per year Cap. Cost = $516,600	$880 per cow per year Cap. Cost = $979,000	$1,030 per cow per year Cap. Cost = $628,600
3. Nutrients moved to a new market or to a solids phase	19% of N 50% of P (31% of N is lost)	24% of N 100% of P (76% of N is lost)	29% of N 92% of P (46% of N is lost)
4. Water Pollution Impacts	Neutral	Reduction	Reduction
10. Funding Mechanisms	EQIP Funding	EQIP Funding	EQIP Funding

It should be noted that liquid/solids separation does not necessarily move any nutrients away from traditional land application. However, it does allow different application methods to be used and creates the potential of exporting solids to another market. It may also allow a greater percentage of the grasslands and corn fields to be used for land application by allowing the use of liquid injection application methods which generate less odor than surface application methods. By comparison, whole manure composting has the potential to move all of the nutrients away from traditional land application and chemical precipitation has the potential to move a majority of the nutrients off-farm as a phosphorus rich precipitate.

Regional Dairy Manure Facility Options

Three options were considered for the regional dairy manure facilities:

- composting dewatered manure (assuming dewatering occurs at the individual farm),
- anaerobic digestion of the whole manure followed by liquid/solid separation and composting of the solids, and
- anaerobic digestion of the whole manure followed by liquid/solid separation, chemical precipitation of phosphorus and composting of the manure solids and phosphorus precipitate.

All of these options are technically feasible and have the potential to move 50% or more of the nutrients to other markets. The option using chemical precipitation could potentially move up to 92% of the phosphorus to a different market. The composting only option is neutral to air emission impacts, reduces water pollution impacts and does not create any renewable energy. The two options with anaerobic digestion can produce renewable energy and should be able to meet Connecticut Class I Renewable Portfolio Standards but must apply for such a designation. Since the digester gas will be burned, there will be an increase in criteria air pollutants but they will fall within the State's emission limits. Anaerobic digestion will decrease the odor produced. These options will all reduce water pollution impacts. Table ES-3 summarizes the remaining review parameters for the regional options.

TABLE ES-3

	Dairy Manure - Regional Facility Options		
Review Parameter	**Composting with Liquid/Solid Separation at Farms**	**Anaerobic Digestion And Composting (or Poop Pots)**	**Anaerobic Digestion, Composting, and Chemical Precipitation**
1. Technical Feasibility	High, Similar Facilities Exist	High, except for Poop Pots which has not been demonstrated at full size facility	High
2. Economic Feasibility	$160 per cow per year	$685 per cow per year	$780 per cow per year
3. Nutrients moved to a new market	7% of N 50% of P (51% of N is lost)	7% of N 50% of P (60% of N is lost)	11% of N 93% of P (66% of N is lost)
10. Funding Mechanisms	EQIP Funding	EQIP Funding	EQIP Funding

Poultry Manure Options

Two options for poultry manure operations were considered: one, co-combustion of the manure with waste wood and two, composting of the whole manure. No distinction was made between individual farm and regional facilities for poultry manure since the individual farms are of the same size as a regional facility. Both options are technically feasible. Costs were not available for the co-combustion option so a comparison of costs was not done. The co-combustion option is being pursued privately at the time of this study.

Co-combustion of poultry manure generates ash, power, steam and heat. The ash is high in phosphorus and can be a saleable product. The power, steam and heat will be used at the farms for the egg processing facility. This renewable energy should be able to meet Connecticut Class I Renewable Portfolio Standards but an application must be filed to apply for such a designation. The co-combustion option will generate criteria air pollutants due to the combustion process. However, these can be controlled to meet air quality criteria. This option will reduce water pollution since all of the manure nutrients will be moved to another form.

Similarly, composting will have a positive impact on water pollution since compost is a slow release fertilizer and is less likely to leach into surface or groundwater than inorganic forms of fertilizer. Odor is generated in a composting process but can be controlled with appropriate odor control equipment. Table ES-4 summarizes the remaining review parameters for the poultry manure options.

IMPACTS ON NUTRIENT SURPLUS BY MANURE MANAGEMENT OPTIONS

The management of poultry manure in New London County has the single largest impact on the reduction of nutrients statewide. Managing poultry manure in New London county is estimated to reduce the statewide nitrogen load by an amount equal to 43% of the available area and the phosphorus load by an amount equal to 87% of available land. The next largest impact would come from implementing four regional dairy manure composting facilities

TABLE ES-4

	Poultry Manure Options	
Review Parameter	**Co-Combustion with Waste Wood**	**Composting Whole Manure**
1. Technical Feasibility	High	High, Similar Facilities Exist
2. Economic Feasibility	Unavailable	$91 per ton
3. Nutrients moved to new market	100% of N 100% of P	100% of N 100% of P
10. Funding Mechanisms	EQIP Funding USDA Rural Development	EQIP Funding USDA Rural Development

within the highest dairy density areas in the State. Implementing these facilities is estimated to further reduce nitrogen and phosphorus by approximately 14% and 15%, respectively.

The priority in terms of impact on the nutrient surplus would be to implement poultry manure options followed closely by implementing dairy manure options for the regional facilities. The poultry farm option currently moving towards development is the co-combustion option. This option is being developed privately, therefore the cost information in not publicly known. If all CAFO sized poultry farms choose to use whole manure composting, the overall capital cost would be roughly $17.5 million per million birds, or a total of $79 million for the 4.5 million birds at CAFO farms.

Since it is not possible to predict which CAFO dairy farms will choose to be involved in the regional facilities, the costs of implementation have been estimated for regional facilities and all CAFO dairy farms. There will be some overlap between these two categories but it should be noted that a large portion of CAFO animals are outside of the assumed regional facility areas. Assuming that all four regional facilities are built and operated, the overall capital cost will be four times $2.65 million or $10.6 million. If all CAFO sized dairy farms choose to use whole manure composting, the overall capital cost would be roughly $980,000 per two hundred cows. With 19,457 cows currently associated with CAFO farms, the total capital cost for all CAFO farms will be $95.4 million. It should be noted that these costs are in 2005 dollars and do not take into account future construction cost inflation, which is currently estimated at 5 to 6% per year.

RECOMMENDATIONS FOR IMPLEMENTATION

The goal of this study was to identify economically and technically feasible manure management methods for the dairy and poultry farms to manage manure from CAFOs in the State of Connecticut. While technically feasible options were identified, the capital and operating costs for all the options are high, considering the economics of dairy and poultry farms, and may preclude their implementation. Successful implementation of the CAFO General Rule must include maintaining viable local farms while addressing nutrient issues. Providing funding assistance will be critical to this end.

Based on the ability to impact the nutrient surplus in the State, the focus should be on implementing the poultry manure co-combustion option and regional dairy composting facilities. Towards this end, the following is recommended.

Political Advocacy

- This report should be used to educate legislators on the importance of adequate funding for the waste management needs of the CAFO farms in Connecticut. When the CAFO General Permit is issued, there needs to be sufficient funding support in place for the regulated community.
- Work to develop policies, incentives, and funding assistance which tie nutrient management solutions to the benefits of maintaining agricultural operations throughout the state. These benefits include potential for renewable energy production, open space maintained by farms, food security provided by having local (in-state) producers, reduced costs to the state and towns by maintaining farms (less housing development, therefore lower school costs etc), the economic contribution farms provide to local and state community (i.e. other businesses and jobs dependent on the existence of farms) and maintenance of strong local communities and cultural heritage (as farmers are tied to the land and communities).
- Farmers in Connecticut could use additional support in developing options that are well suited to their specific situation. This assistance would include funding for pilot tests of dewatering equipment or demonstration projects of small scale composting.
- Work to add anaerobic digestion of agricultural residuals and co-combustion of manure to the Connecticut Class I Renewable Portfolio Standard.
- State and Federal agencies should develop policies and incentives for nutrient export (inter-regional) to transfer manure and related by-products, such as compost, to alleviate issues of excess nutrient on one region and reliance on commercial inorganic fertilizers in other regions.

Project Development

There are several areas in which the DEP or other State Agencies or local organizations can work to move forward alternative manure management methods. These include the following:

- Work with the groups in the North Cannan area, the Woodstock area, the Ellington area and the New London area to develop and assess interest in a regional facility.
  - Involve all dairies in the area early in the process to foster interest and support.
  - Obtain "seed" funding to start the development process in each area.
  - Identify a local sponsor organization.
  - Proceed with site selection and preliminary design once the preliminary organization and initial development funding has been secured.

- Technologies to track and/or test that are not ready for full scale implementation
  - Dewatering Options
    - Pilot testing of screw press technology for dairy manure at interested farms. Manufacturer's guaranteed solids capture rate based on pilot testing data. Also, at least one manufacturer has stated that they will not sign contracts with individual farmers. Therefore, CT DEP or other entity will need to fund and spearhead any pilot testing program.
    - The Jannanco dewatering system shows promise but they have not yet published their results. If they are able to capture a high percentage of solids in a relatively high solids content cake, this will make composting facilities at individual farms smaller and more cost effective while still removing a large portion of the nutrients.
    - Development of high recovery dewatering - Tinedale in Wisconsin. Regional facilities may obtain higher nutrient removal by using a high recovery dewatering system. Such a system requires a review of higher technology options and a conceptual design caparison of the options.
  - Poop Pots or paper production show good potential as nutrient removal mechanisms. Testing should be done to determine the nutrients removed in the pots or paper and provide assistance in the scaling up of the current technology to a full scale production.
  - Phosphorus Precipitation - Conduct pilot testing to determine appropriate chemical dosing requirements. Get chemical supplier and equipment vendors to help determine proper alum dose on representative manure samples.

Facility Siting, Operations and Commodity Sales

- Site regional digester or co-combustion facilities near power/heat users who would be willing to purchase power directly from the regional facilities.

- Work with local planning and zoning boards and inland wetlands commissions to review plans for regional facilities.

- Farmers have expressed a need for assistance in marketing any products from manure such as compost. There are several methods to acquire this assistance:

    - Hire a compost broker. There are several organizations currently marketing compost for other compost producers in the New England area. Compost brokers have contacts with groups trying to purchase compost and are able to match the level of compost quality with the needs of compost users. They work in several ways: either charging a fee, or collecting a portion of the sales or both. Compost brokers will charge a fee to cover their marketing cost and to generate a small profit. Therefore, the money that the composter would receive from the sale of the compost would be reduced.
    - Develop Marketing assistance through CT Dept of Agriculture similar to the existing group which promotes CT grown products. This approach could be implemented to help farmers market their compost without having to pay as much for marketing. It would help the farmers keep a greater portion of the compost sales and thus make this method of manure management more feasible.

Funding Options

The next steps in regional facility development and individual farm solutions include development of feasibility studies for specific sites and situations, development of business plans and preliminary design of the chosen solution. To facilitate and assist in funding these tasks and the final design and construction phases the following is recommended.

- DEP should seek additional funding for Connecticut under Section 319 Non-Point Source Fund from the Clean Water Act.

- DEP should consider the possibility of modifying the Clean Water Fund program(s) to include agricultural waste management projects. The Department could consider the programs of other states, such as South Dakota, to explore how those programs have assisted farmers.

- Lobby USDA for Rural Development funds for Connecticut to conduct feasibility studies, develop business plans and preliminary designs for regional and individual farms solutions.

- DEP should seek Clean Water Fund increase for construction phases of manure management facilities for regional facilities and individual farms.

- NRCS in Connecticut should seek additional EQIP Funding for Connecticut to address farmers' needs with regional or individual farm modifications.

- CT DOAG should establish funding for the Environmental Assistance Program (EAP) consistent with farmers' needs to meet the proposed CAFO regulations. Funding for four regional composting facilities at a one facility per year rate and on the order of 10 individual farms per year for liquid/solid separation systems should be considered. The estimated funds needed would be $2.7 million for the regional facility and $5.2 million for 10 farms ($0.52 million per farm) for liquid/solid separation. The total fund requirements would be a total of $7.9 million per year.

- Explore using existing funding mechanisms, such as EAP or USDA Rural Development, to fund feasibility studies, business plans and preliminary designs of regional facilities and individual farms solutions.

- Farmers should seek EQIP and EAP Funding to address modifications such as storage facilities and liquid/solid separation needed on farms to meet proposed CAFO requirements or participation in regional facilities.

- Use the NRCS Conservation Innovation Grant as a source of funding for Alternative Technologies as site specific feasibility of these technologies is solidified.

- Groups interested in a regional manure facility should examine the applicability of EQIP funding for a regional project in which participant farmers would apply individually for support. They should also examine the applicability of the CT DOAG EAP funding for a regional manure management project.

- Groups interested in a regional manure facility should review the availability of federal funding under the USDA-NRCS *Renewable Energy and Energy Efficiency Program.* Farmers who are considering undertaking energy efficiency or methane digester projects can look to this fund for support. Further, they should examine this program in light of its potential to support a regional digester project.

SECTION 1
INTRODUCTION

1.1 INTRODUCTION

In 1999 the United States Environmental Protection Agency and the United States Department of Agriculture published a *Unified National Strategy for Animal Feeding Operations* (USEPA and USDA, 1999). The goal of the *Unified National Strategy* was to encourage the implementation of technically and economically feasible Comprehensive Nutrient Management Plans (CNMPs). In line with the goals established by the USEPA and USDA and with new Federal regulation that became effective April 14, 2003, the Connecticut Department of Environmental Protection (DEP) is developing a *General Permit for Concentrated Animal Feeding Operations* (CAFOs) in order to regulate manure management activates currently practiced on Connecticut AFOs. The General Permit specifically regulates Connecticut AFOs with a larger number of animals, defined by the permit as CAFOs.

The General Permit was developed in light of the State's effort to meet the federal regulations to minimize the environmental contamination by non-point sources. In an analysis of the US Department of Agricultural animal census completed by the University of Connecticut, AFOs located throughout Connecticut were identified as having a major contribution to the nutrient surplus in the State. Land application is the most common agricultural manure management method. Due to the loss of farmland in Connecticut, there is no longer sufficient land available under the control of the farmers for agronomic application rates. In order to avoid overloading farmland and other land used for land application, the surplus nutrients must be economically treated or exported off-farm for utilization. This report evaluates a variety of alternatives that would address the current State nutrient surplus. The ultimate goal of this project was to recommend manure management methods for the dairy and poultry operations that would effectively manage surplus nutrients produced by Concentrated Animal Feeding Operations (CAFOs) located though-out the State of Connecticut.

1.2 SCOPE OF SERVICES

This evaluation was completed under the direction of the DEP and the April 2002 established the CAFO Advisory Committee, made of representatives from:

- University of Connecticut;
- Natural Resources Conservation Service of USDA;
- Farm Service Agency of USDA;
- USEPA;
- Agricultural consultants;
- The dairy and poultry farming community;
- Connecticut Farm Bureau;
- DEP; and
- Connecticut Department of Agiculture.

The purpose of this report is to recommend manure management methods that could be adopted by the farms identified as CAFOs by the General Permit. The proposed manure management method shall efficiently and economically treat or move nutrients off-farm for use, and address the State nutrient surplus. The final recommendations of this report addressed environmental regulatory issues associated with the proposed manure management alternative, cost analysis, and potential funding options. Organization of the report is as follows:

- Section ES provides a stand-alone Executive Summary.
- Following this Introduction (Section 1), Section 2 provides a summary of the agricultural nutrient surplus in Connecticut, drawing from a nutrient distribution spreadsheet created by Richard Meinert of the University of Connecticut.
- Section 3 presents a general discussion concerning characterization of the existing farm sizes and existing manure management practices.
- Section 4 discusses alternative products that could potentially be made using dairy and poultry manure and the marketing assistance needed to effectively move product.
- Section 5 presents a summary of the technologies identified during the brainstorming session with the CAFO Advisory Committee. Classes of technologies are identified regardless of feasibility. Infeasible technologies for redistributing nutrients in Connecticut are eliminated from further review in the discussion.
- Section 6 focuses on the feasibility of the short-listed alternatives identified during the Advisory Board brainstorming session. The discussion includes an evaluation of the technical & economic feasibility of each alternative. A separate analysis was completed for Dairy and Poultry Manure.

- Section 7 discusses the following factors for each of the short-listed technologies:

    - § Impact on water pollution;
    - § Ability to redistribute nitrogen and phosphorus;
    - § Impact on Air emissions/odor control;
    - § Ability to develop renewable energy;
    - § Greenhouse gas and Connecticut Climate Change Action Plan; and
    - § Applicability to the CT Class I Renewable Portfolio Standard.

- Section 8 considers the identification of existing funding mechanisms for implementation of the options considered. The discussion also includes recommendations for most applicable funding approach.
- Section 9 discusses current political, legal and administrative issues. Agricultural, environmental and power regulations are reviewed, and permits and rules applicable to the various short-listed technologies are identified.
- Section 10 Presents the *Technology Comparison* Table. This table includes the recommendations on each manure management alternative and a discussion of how to proceed with implementation.

SECTION 2
AGRICULTURAL NUTRIENT SURPLUS IN CONNECTICUT

2.1 NUTRIENT SOURCES

Connecticut is home to a wide range of agricultural operations involving animal husbandry. These operations range from small home operations with a horse or a few chickens to large dairy and poultry farms. The nutrient rich animal waste produced by the agricultural sector originates from a wide range of animal sources including: dairy cows, beef cattle, horses, goats, sheep, swine, llamas, alpacas, buffalos, chickens, ducks, quails, and turkeys. The animal waste from these operations contains a significant level of nutrients as phosphorus and nitrogen. Traditionally, these nutrients have been land applied onto grasslands and agricultural fields as a method of returning the nutrients to the soil for use in hay and crop production. However, on a statewide level, the level of nutrients currently generated by the various types of animals greatly exceeds that which can be agronomically used by the land available for land application.

The level of the Connecticut nutrient surplus can be seen by reviewing the farm and animal census data developed by the US Department of Agriculture animal census and cropland census. The University of Connecticut performed a statewide analysis of this data, estimating the amount of animal manure, including pounds of phosphorus and nitrogen, produced annually by animal agriculture. According to the manure analysis completed by the University of Connecticut, manure production on in-State AFOs was estimated to be approximately 1.3 million tons per year, with 7,600 tons of Nitrogen and 4,600 tons of Phosphorous. Further, for each county, they compared the pounds of nutrients produced annually, to the land available for land application. For this evaluation it was assumed that all agricultural manure was spread on nearby farmland, specifically grassland and corn fields. The amount of available corn and grassland for land application was based on the acreage reported in the cropland census. The amount of corn and grassland required for land application was based on the agronomic amount of nutrient that could be applied without over loading the soils. The calculations developed at the University of Connecticut are shown in full in Appendix B.

Comparing the criteria outlined in the DEP General Permit, and the number of animals on each farm recorded in the developed database, 43 dairy and poultry AFOs were defined as CAFOs by the General Permit. In order to address the nutrient management issues on the farms directly affected by the DEP General Permit, this evaluation will focus solely on the dairy and poultry CAFO's which account for 39% of the animal manure produced in Connecticut.

2.2 STATEWIDE AND COUNTY NUTRIENT DISTRIBUTION

The analysis completed by the University of Connecticut showed that the dairy and poultry industries produce approximately 68% of the Connecticut's manure. However, the majority of the dairy and poultry AFOs are concentrated in select areas throughout the state. Using the US Department of Agriculture animal census and the University of Connecticut analysis of this data, the percent of available land required for agronomic application of the nutrients produced by the dairy industry, the dairy and poultry industry, and all animal sources, was compared on a county-by-county basis. These values are summarizes in Table 2-1.

TABLE 2-1
PERCENTAGE OF AVAILABLE ACRES NEEDED FOR AGRONOMIC APPLICATION OF NUTRIENTS PRODUCED BY CONNECTICUT'S AGRICULTURAL INDUSTRY

	DAIRY ONLY		DAIRY AND POULTRY		ALL MANURE	
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State	58%	57%	101%	144%	149%	213%
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Tolland	82%	79%	83%	79%	138%	159%
Windham	82%	79%	82%	79%	133%	152%

The above data was presented to the CAFO Advisory Committee at the brainstorming meeting held on June 22, 2005. It was the general consensus of the participants in attendance that, in a practical sense, additional handling of nutrient by land application to fields has most likely become exhausted. Generally the larger AFOs, designated as CAFO farms, are currently using all available land in their surrounding areas. Trucking manure farther then they currently are, could become costly and was not seen to be a feasible option. The data presented in Table 2-1 was not used to locate areas that could be used for further nutrient loadings, but was used to determine the areas where the dairy and poultry operations contribute significantly to the nutrient surplus. Addressing the nutrient surplus in these areas is the focus of this evaluation and will be directly affected by the DEP General Permit.

2.3 CONNECTICUT NUTRIENT SURPLUS

On a state level, Table 2-1 identifies a surplus in nutrients produced by in-State agriculture, compared to the acres available for land application. As stated previously, the dairy and poultry industries generate approximately 68% of Connecticut's manure, however, an analysis of the count-by-county data indicates that the nutrients produced by the dairy and poultry industries are isolated to only a few counties. In counties such as Fairfield County, Hartford County, Middlesex County and New Haven County, more then 60% of the manure produced is from non-poultry and dairy sources. In these counties other animal sources contribute significantly to the total amount of generated nutrients. However, none of these animal operations have sufficient numbers of animals to subject them to the requirements of the DEP General Permit.

New London Country was shown to have the most significant nutrient surplus, mainly due to the poultry industry. The analysis completed by the University of Connecticut estimated that the County produces approximately 3.6 million lbs of excess nitrogen and 1.0 million lbs of excess phosphorus annually. Currently, due to the high amounts of nutrients produced in this area, the agricultural lands used for land application are at phosphorus saturation. Redistribution of the nutrients produced by the poultry industry into sectors other than land application would significantly reduce the risk of overloading nutrients to the area's farmland, relieving much of the county's nutrient surplus. The poultry industry is responsible for approximately 65.5% of the total nitrogen and 77% of the total phosphorus in New London County. The bulk of Connecticut's poultry industry is located in New London County.

The dairy industry produces approximately 40% of the Connecticut's manure. Although the dairy industry produces nearly half the Connecticut's manure, the majority of the nutrients generated by in-State dairy farms are located in only three counties; New London County, Tolland County and Windham County. In these three counties, dairy farms are close to using up all the theoretically available corn and grassland.

Overloading farmland with nutrients, specifically phosphorus, can potentially affect soil nutrient levels for a significant amount of time. It was noted during the CAFO Advisory Committee brainstorming meeting held on June 22, 2005, that the recovery of phosphorus concentrations in area soils may take decades. The phosphorus levels in grasslands may not be as big an issue, but corn land typically has a higher phosphorus level and could require an even longer recovery period.

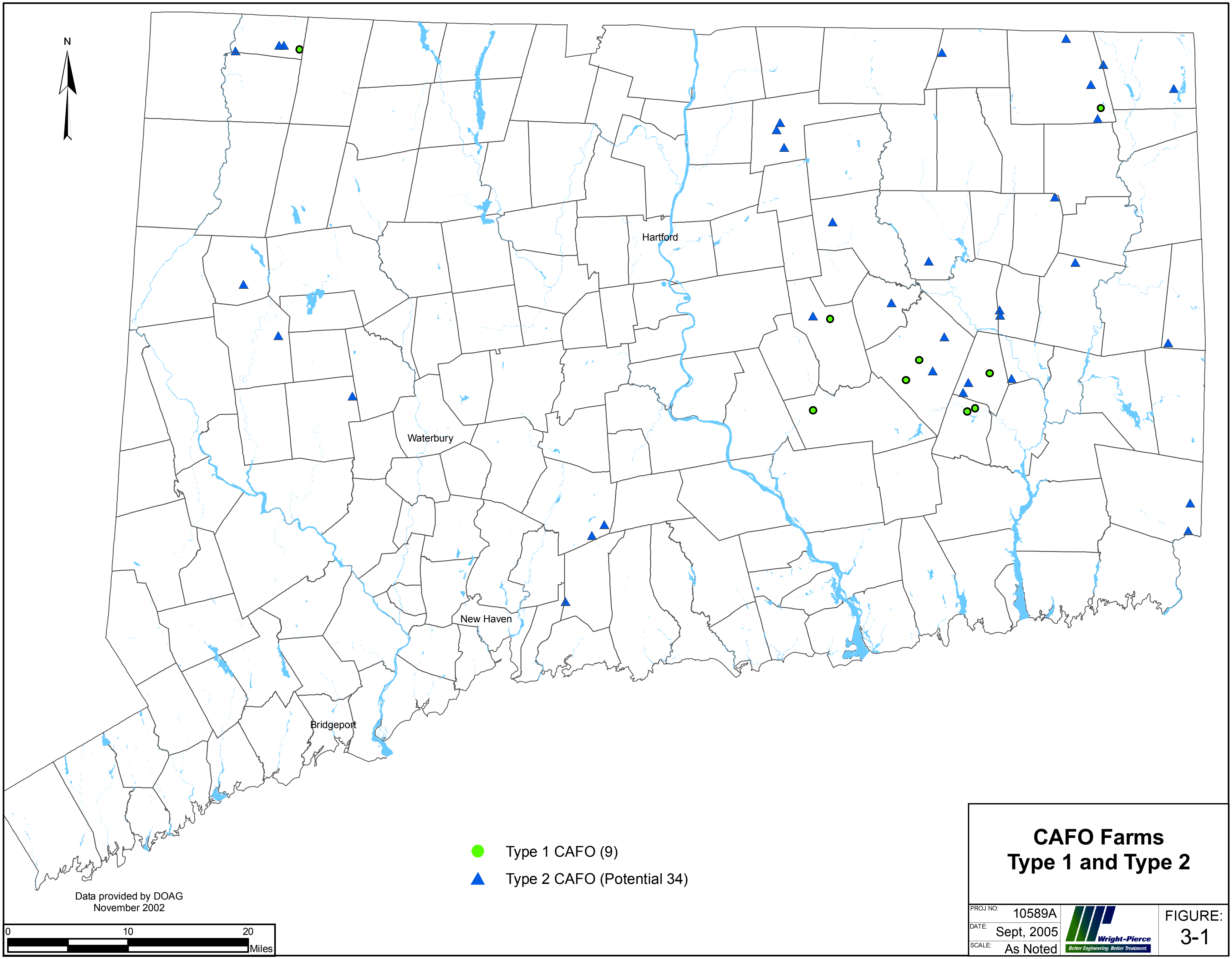
SECTION 3
FARM DATA

The farms discussed in this report were identified by the November 1, 2002, "*Connecticut farms database*" provided to Wright-Pierce by the Connecticut Department of Agriculture (DOA). This database is maintained and updated by the DOA for the purposes of inventory and communication with farmers in the state. The information presented in the DOA farm database is not viewed as a complete inventory of farms in the State of Connecticut. Rather, the database is used as a starting point for identifying AFOs and CAFOs. The database includes 546 farms, almost all of which are farms holding animals.

The alternatives considered in this evaluation focuses specifically on the farms that have been defined as "CAFO Farms" by the CAFO General Permit. Once issued and in force, the CAFO General Permit will serve as a statewide permit, authorizing wastewater and agricultural waste discharges at specific farms in Connecticut. The criteria used, and the individual farms potentially affected by the CAFO General Permit, are listed in Appendix A of this report.

3.1 CAFO AND AFO FARM LOCATIONS & SIZES

Using the data compiled in the November 1, 2002, "*Connecticut farms database*", the location and size of the listed farms were evaluated. The DOA database indicates that there are approximately 255 farms with dairy animals, and 68 farms with poultry animals, out of the total 546 farms listed. As shown in Appendix A, the CAFO General Permit identifies AFOs as CAFOs or potential CAFOs using specifically defined criteria and categorizes them by type. Using the criteria of the General Permit, CAFO farms in the DOA database were identified and categorized as either Type 1 or potential Type 2 CAFO farms. The 43 farms listed as Type 1 or potential Type 2 "CAFO Farms" in Appendix A are each labeled as being either poultry or dairy farms. Figure 3-1 illustrates the location of the 43 CAFOs in the state that have been identified as Type 1 and potential Type 2 CAFOs.



CAFO Farms
Type 1 and Type 2

FIGURE: 3-1

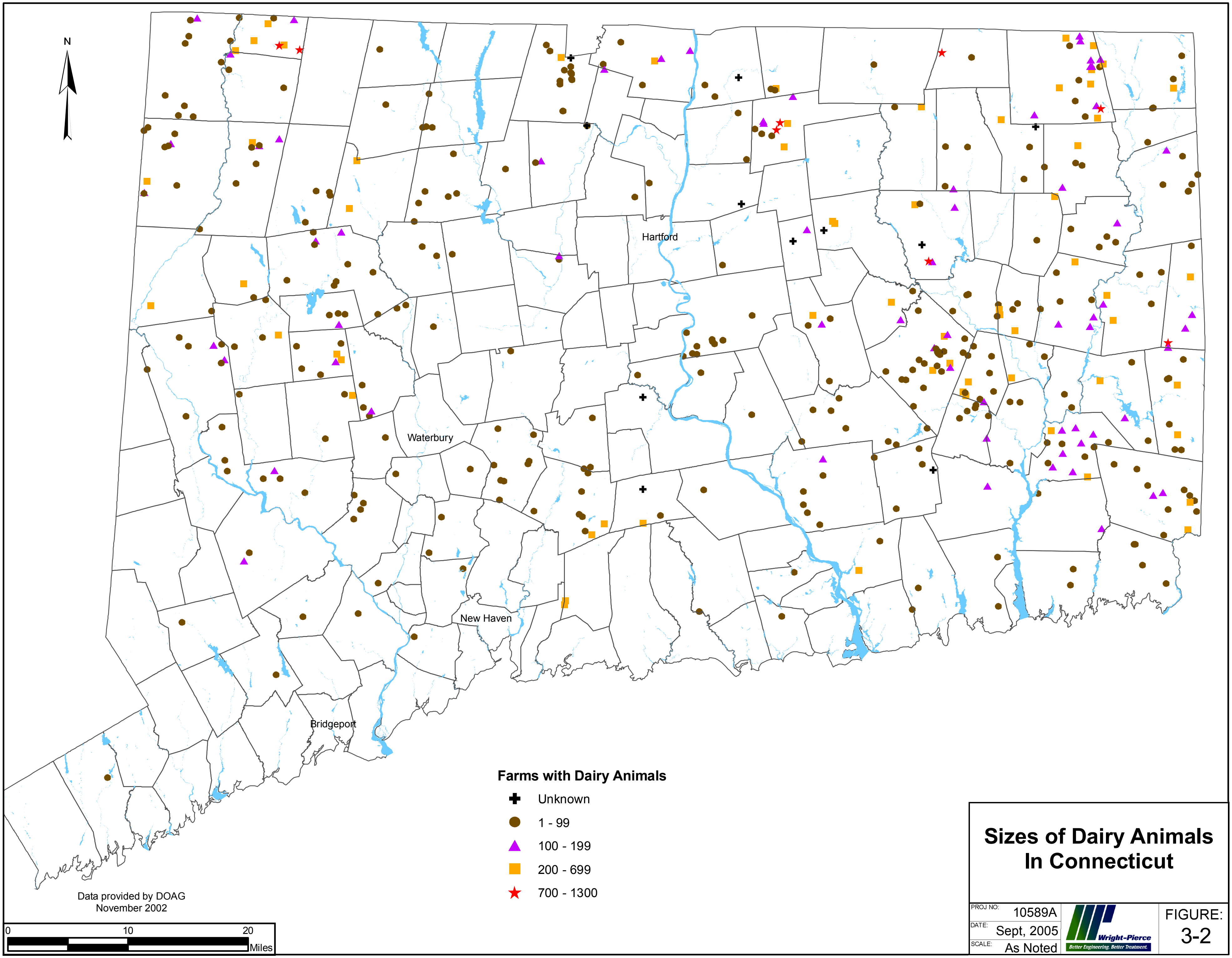
The poultry farms in the State of Connecticut are mainly made up of chicken layers. In addition to layer chickens, the DOA data includes farms that raise ducks, pheasant, turkeys and other game birds as poultry farms. According to the November 1, 2002, DOA data, there are approximately 5,000,000 birds raised in-State, 98% of these are layer chickens.

The DOA database also indicates that 94% of the layer chickens are handled by two major poultry farms. Approximately 3,450,000 birds at three different farms are located within a 4-mile radius of each other, and approximately 1,020,000 birds at four different farms are located within a 10-mile radius of each other.

The majority of the documented dairy farms in the State of Connecticut are of the smaller type. Approximately 211 of the total 255 dairy farms listed in the DOA database have less than 300 dairy animals on-farm. Only 3.5% of the listed dairy farms, only nine of the total 255 farms, have more than 700 dairy animals. Unlike the poultry industry, the larger dairy farms are located through out the state and are not found in one central location. Figure 3-2 illustrates the farms with dairy animals on them, shown by size classes and location. A significant amount of the State's dairy farms are located in the northwestern and eastern portions of the state.

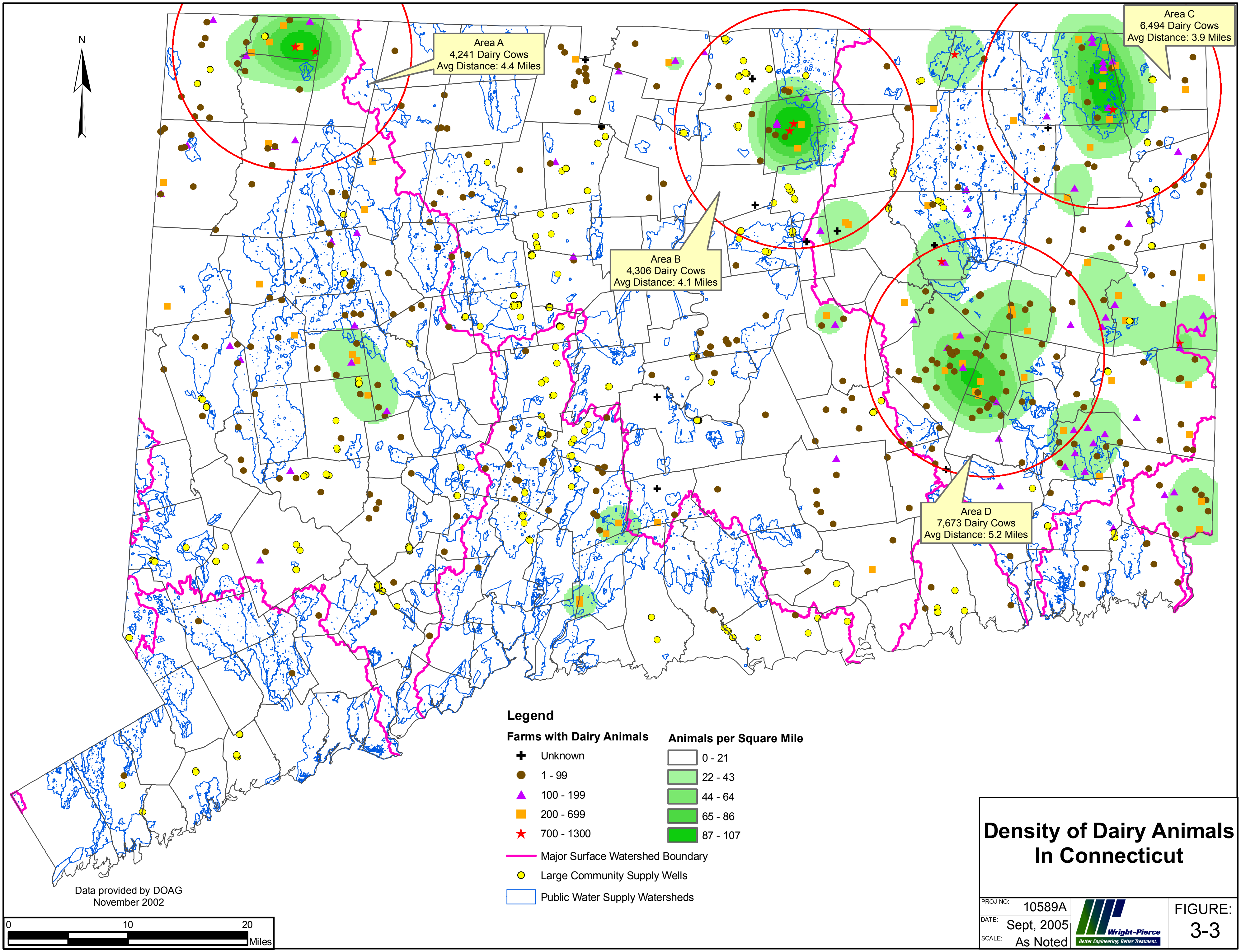
3.2 ANIMAL DENSITY MAPPING AND BASIS

In order to identify the best potential locations for regional manure handing facilities, a map depicting the density of dairy cows across the state was developed (Figure 3-3). The areas with high animal densities (high concentrations of dairy animals) occur in the counties of Litchfield, Tolland, Windham, and New London. These counties are shown to have a relatively high animal density, up to 87-107 animals per square mile. The areas identified as high density areas would be the best locations for potential regional manure management solutions, as the transport distances would be shorter. The areas that are shown to have a relatively low animal density are areas more suitable for local farm solution. Both regional and individual farm solutions are discussed in later sections of this report.



Sizes of Dairy Animals In Connecticut

PROJ NO: 10589A		FIGURE:
DATE: Sept, 2005	Wright-Pierce Better Engineering. Better Treatment.	3-2
SCALE: As Noted		



Density of Dairy Animals In Connecticut

PROJ NO: 10589A
DATE: Sept, 2005
SCALE: As Noted

Wright-Pierce
Better Engineering. Better Treatment.

FIGURE: 3-3

3.3 MANURE HANDLING, BEDDING TYPES

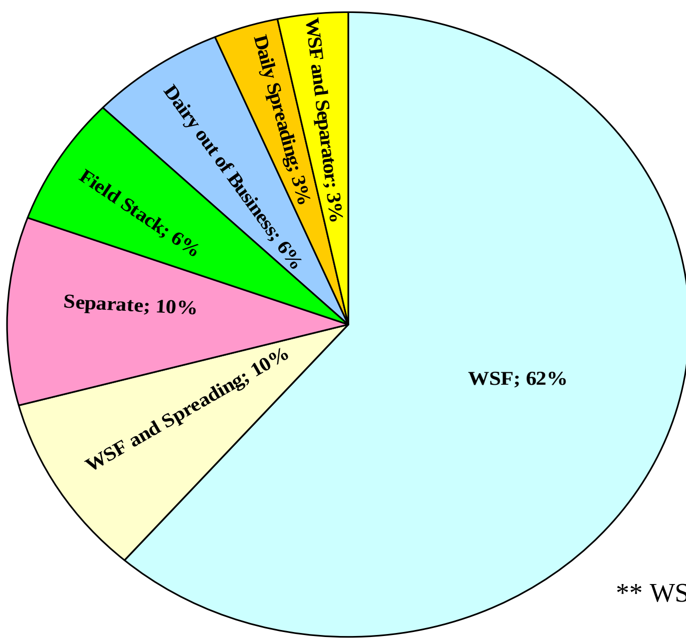
Current manure management and bedding practices were identified in order to develop a feasible manure management solution for the identified CAFOs. The U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS) provided this information based on their work with many Connecticut farmers addressing nutrient management issues.

This data was used to characterize existing practices and bedding for the 43 farms listed as Type 1 and potential Type 2 CAFOs.

Of the 43 Type 1 and potential Type 2 CAFOs, bedding and manure handling information for 31 farms was available. Refer to Appendix A, Table A-4, for a list of the manure management methods and bedding materials used at each Type 1 and potential Type 2 CAFO. The farms that did not have either manure handling or bedding data readily available are indicated as "unknown" in Table A-4. These farms have not worked closely with NRCS in the past; hence NRCS could not say for certain which methods are currently being used. Figures 3-4 and 3-5 summarize the available data from the 31 farms.

FIGURE 3-4

EXISTING MANURE MANAGEMENT METHODS USED AT CONNECTICUT TYPE 1 AND TYPE 2 CAFO FARMS

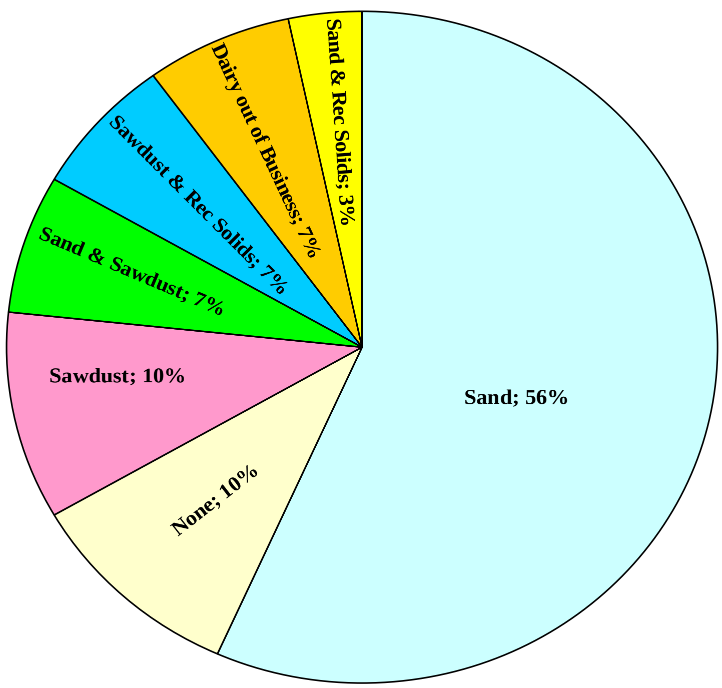


** WSF - Waste Storage Facility

The NRCS data shows that approximately 62% of the known Type 1 and potential Type 2 CAFOs currently store raw manure in on-site waste storage facilities (See Figure 3-4). Manure is stored until it is eventually either moved off-site or used as fertilizer on-farm. Ten percent of the farms with known methods use waste storage and daily spreading of raw manure on nearby fields and another 10% use solids/liquid separation. Both waste storage facilities with liquid/solid separation and daily spreading are the manure management strategy for 3% of the farms.

FIGURE 3-5

EXISTING BEDDING MATERIAL USED AT CONNECTICUT TYPE 1 AND TYPE 2 CAFO FARMS



* Data for 31 Farms

As shown in Figure 3-5 the majority of the farmers in Connecticut prefer sand bedding to other alternatives for cow comfort and hygiene reasons. Approximately 56% of the farms, where the bedding is known, currently use sand as their sole bedding material. An additional 10% of the farms use a combination of sand and sawdust, or sand and recovered solids. Although sand bedding is preferred by farmers, it is not a good material for manure management technologies. The abrasiveness of the material tends to damage mechanical equipment, and increase the volume required for waste storage facilities and the capacity of treatment equipment due to solids loading. Sand bedding will limit the number of manure management alternatives that could be potentially recommended. Therefore, appropriate methods will need to be implemented to remove the sand from the manure, as required.

3.4 BASIS OF DESIGN

As can be seen from the design data above, significant variability exists in the farm data that a common basis for evaluation needed to be developed. In the case of dairy, it is clear from the animal density mapping that some regions of the state would be more suited for regional manure management solutions and other areas for individual farm manure management solutions. Conversely, the largest concentration of poultry is in one area of the state thus making regional management the appropriate approach.

For the dairy regional design basis, the animal density mapping was used to calculate the number of dairy cows within each of four areas of highest concentration. These numbers were further refined by assuming that one-third of the animals would be part of the replacement herd, and that fifty percent of the cows would be participating in a regional facility. This analysis resulted in a theoretical regional facility managing the manure from 2,500 animals. To account for the possibility that the regional facility would also process food wastes, an additional 500 animals were added to approximate the equivalent nutrient and solids loadings from food wastes for a total of 3,000 animals. For the individual farm design basis, the relative sizes of CAFO farms outside of the regional facility candidate areas were analyzed. As CAFO regulation will potentially apply to all farms with greater than 200 head, the individual farm size was set at a 200 animal basis.

As stated, the majority of poultry manure within the state is generated by poultry farms in New London County. The proximity of the farms and concentration of birds makes this situation ideal for a regional manure management solution. For the purposes of this study, it is assumed that any poultry manure management solution would be implemented within this area of high concentration.

SECTION 4
OPPORTUNITIES FOR REDISTRIBUTION OF NUTRIENTS

Most of the dairy and poultry manure produced in Connecticut is land applied. As indicated in Section 2, there is a surplus of nutrients in the State when compared to the traditional land (grassland and corn fields) available for land application. The proposed DEP General Permit has provisions which will limit land application to agronomic rates and which could limit the amount of manure which is land applied on CAFO farms. In order to maintain current production rates (and thus manure production rates), development of feasible alternative manure management methods are essential for the survival of the farms directly affected by the DEP General Permit.

In order to reduce the amount of nutrients being applied to area farmland, nutrient redistribution is essential. The nutrient rich manure produced by dairy and poultry farms is a valuable resource that can also be utilized outside the agricultural industry. By moving nutrients off dairy and poultry farms, the current nutrient surplus could be reduced or eliminated. This section discusses the uses of nutrients throughout the state and alternatives for nutrient distribution.

4.1 NUTRIENT USE

Currently, many large and small scale growing operations throughout the State, such as fruit farms, vegetable farms, greenhouse businesses, and residential gardeners purchase fertilizer from commercial distributors. Both inorganic and organic fertilizers are used with inorganic fertilizers being the bulk of the fertilizers purchased. However, the majority of the manure based organic fertilizer sold to in-State growers is generated from manure produced on out-of-state farms. A study completed by the US Department of Agriculture (USDA), New England Agricultural Statistics (National Agricultural Statistics Service (NASS)), revealed that approximately 9.5 million pounds of out-of-state organic fertilizer was sold in Connecticut in 2004 (USDA, NASS, 2004). While the data does not break organic fertilizers into smaller categories such as compost, bloodmeal, etc, a significant amount of the total is likely to be compost from manures or other organic materials.

Alternate manure management methods in Connecticut could be utilized to create a marketable product that could potentially move nutrients off-farm to other industries such as the large scale growing operations and topsoil manufacturers. By tapping into the in-State fertilizer market, and potentially the out-of-state markets, the redistribution of the excess nutrients generated by the dairy and poultry industries would significantly reduce the current nutrient surplus without affecting current production.

4.2 ALTERNATE NUTRIENT REDISTRIBUTION METHODS / PRODUCTS

In order to market animal manures as a commercial fertilizer, additional manure management processes need to be adopted. Raw manure cannot compete with the current products available. Raw dairy and poultry manure tends to contain a high amount of weed seeds, odor and pathogens. A quality product must be generated which kills the weed seeds and pathogens and reduces odor using cost effective technologies. The following manure management practices can be adopted in order to treat raw dairy and poultry manure and create value-added products:

- Anaerobic Digestion: The anaerobic digestion process reduces odor and kills pathogens and weed seeds. The finished effluent can be moved off-farm and applied to vegetable farms and other nearby agricultural lands. It is not economical to transport this material over long distances due to its high moisture content and wet weight.

- Composting: The composting process stabilizes raw or digested manure. The heat generated during the composting process kills off weed seeds and pathogens, and also creates a drier product. The product is more easily transported and, depending on the quality, can be widely marketed in-State and/or out-of-State. Composted animal manure can be safely used in the following applications:

  Large scale growers, such as green houses, fruit farms, vegetable farms
  Residential users
  Landscapers
  Turf growers
  Topsoil manufactures
  Athletic fields

- Poop Pots: The Poop Pot product demonstrates the ability to move agricultural nutrients into a different sector. Poop pots are made from digested and composted dairy manure. The pots could be sold to hold plants, large and small, for sale in a green house or other commercial garden centers. The pots can be planted directly with the plant and will act as a source of fertilizer as it biodegrades. This is an experimental technology, which has not been used outside of Connecticut.

- Ash from Combusted Manure: Using manure as a fuel in an incinerator or waste-to-energy power plant will leave a nutrient rich ash as a by-product. This by-product is free of weed seeds and pathogens and is highly marketable to the plant growing industries. The reduced volume of the material makes it easily transported and can be marketed in-State and/or out-of-State. Ash from combusted animal manure can be safely used in the following applications:

  Large scale growers, such as green houses, fruit farms, vegetable farms
  Residential users
  Landscapers
  Turf growers
  Topsoil manufactures
  Athletic fields

Redistribution of dairy and poultry manures to other agricultural sectors would significantly reduce the amount of nutrients contributing to the State nutrient surplus. A percentage of the manure produced will still need to be utilized as fertilizer on area crop land. Therefore it is not necessary to move all nutrients to other sectors. Land application would still need to occur on area farmland, only in a smaller more manageable scale.

SECTION 5
MANURE MANAGEMENT TECHNOLOGIES

There are many management methods and technologies available to treat manures. Each technology has a particular niche both in terms of feasibility and end goal. This section identifies and gives brief descriptions of technologies available for manure management. Classes of technologies have been identified regardless of feasibility for nutrient redistribution and applicability to the situations in Connecticut. The discussions will include emerging technologies but will not focus on undemonstrated technologies. Clearly infeasible technologies for redistributing nutrients in Connecticut are eliminated from further review in the discussion and the short list of technologies for more detailed review is summarized at the end of this section.

5.1 DAIRY MANURE OPTIONS

5.1.1 Direct Land Application

Dairy manure in Connecticut is currently primarily land applied. Because of the excess of nutrients which exists in the State, farmers have worked with the landowners in their areas to maximize the use of appropriate land. Additional work towards generating agreements to allow land to be used for manure land application is not likely to generate significant new options.

One method to increase the amount of land available for land application is to use methods such as injection of manure liquids which has fewer odor impacts than surface spreading of whole manure. The impediment to using this method for some farmers is the cost of the injection equipment and the solids/liquid separation equipment. Sharing the injection equipment among several farms is one way to decrease the cost of such equipment to each farmer. This option requires communication and coordination among the participating farms.

Since land application has been used extensively in the state, this option will not be discussed further in this report. However, regardless of the manure management alternatives discussed or adapted in the future, land application will remain an integral part of any manure management solution.

5.1.2 Anaerobic Digestion

There are a variety of anaerobic digester types available ranging in degree of initial capital expenditure and operational complexity and cost. In terms of manure digesters, the most common conventional established and proven designs include the following:

- Covered Lagoon Digesters;
- Complete Mix Digesters, and;
- Plug-flow digesters.

The U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS) interim practice standard guidance addresses all three digester designs. In general, anaerobic digestion of manure and biogas generation occurs between 39°F and 155°F to produce methane. However, the rate of methane production is directly related to temperature. Optimum biogas production occurs between 95°F and 105°F. Both complete mix and plug-flow digesters use supplemental heat, typically waste heat from the process, to heat the digester and maintain temperatures in the optimum range.

Covered lagoons are the least complex of these systems and generally have lower operating and capital costs. Lagoons are typically used for systems with low suspended solids levels (< 2% solids). Additionally, covered lagoons do not use supplemental heat because the relatively low amount of waste heat generated and large liquid volumes involved make heating impractical. Since lagoons operate at ambient temperatures, they are designed with long residence times with slower biological treatment rates. Covered lagoons are typically used in warmer climates. Indeed, NRCS guidelines do not recommend using covered lagoon systems farther north than southern New Jersey. Therefore, this configuration is not applicable to Connecticut.

Complete mix and plug-flow digesters have similar levels of complexity and cost. The choice between complete mix or plug-flow digestion is mostly dependent on the solids content of the manure collected. Plug-flow digesters are suited for manure with higher total percent solids contents between 11 to 14%, while complete mix digesters are suited for manure with lower percent solids concentration of between 3 to 10%. Undiluted dairy manure has a percent solids concentration of approximately 14%. Dairies using a flush system for cleaning the barns will have lower solids content more appropriate for a complete mix system. However, the volume of manure and flush water requiring handling is larger than at a farm using dry handling methods.

Anaerobic digesters are well established as a treatment method for dairy manure. The advantages to anaerobic digestion include reduction odors and pathogens, the elimination of weed seeds from the effluent and the generation of digester gas. The digester gas can be used to generate renewable power or heat. However, anaerobic digestion does not convert nutrients into a product which can be transferred to another sector for distribution. It does reduce odor and eliminate weed seeds which can allow application on land not available to application of undigested manure. This land would include grassland and corn fields located close to neighbors' sensitive to odor and other crop land with weed seed concerns.

Anaerobic digestion will be considered for the regional treatment facility options. It will not be considered for the individual farm as it is not typically economical for smaller dairies.

5.1.3 Aerobic Digestion

Aerobic digestion is widely used for treatment of municipal wastewater and could be used for treatment of manure wastes. It would involve aerating the manure to allow an activated mass of microorganisms to biologically breakdown and stabilize the waste. Aerobic Digestion is not typically done with dairy manure wastes. It would be an energy intensive and expensive option due to the aeration system and would generate a sludge which would in turn need to be handled. This option will not be considered further.

5.1.4 Lime Stabilization

Lime stabilization is widely used to manage sludges from wastewater treatment systems. In the lime stabilization process, lime is added to the solids until the pH is greater than 12 standard pH units. The high pH kills the microorganisms in the solids preventing the solids from putrefying or creating odors. This method of stabilization will not necessarily kill the weed seeds and once land applied, the pH will be reduced and the seeds will be viable. Because of the weed seed issue, this option does not generate a product which can be used in another sector or on different agricultural land than its current use. Lime Stabilization will not be considered further.

5.1.5 Composting

Composting is the biological degradation of organic materials to a stable product. Composting manure stabilizes the organic material in the manure and reduces the volume of the waste material making it less expensive to transport off-site. During the composting process, weed seeds and pathogens are destroyed, leaving a virtually odorless material which can be safely used as plant fertilizer. The market for compost in the New England area is large and encompasses many different market sectors including from residential users, topsoil manufacturers, landscapers, and others.

There are a variety of composting systems which would be applicable for dairy manure and choice of the most appropriate system depends somewhat on the site considerations. Even the best operated composting facility will generate odors so it is recommended to have a site located away from sensitive neighbors. The easiest and lowest capital cost method is to use a windrow system located outside. However, this type of system does not allow for the collection of air for odor control. Other systems include the following:

- Bag Composting Systems: These systems are similar to windrow system. In bag composting systems the composting process occurs inside of large tubular bags. The material is aerated with fans and the tubes help contain odor from the process.
- Bin Composting Systems: Bin composting systems are generally located in a building. These systems use a bin turner to aerate the composting material and move the material down the bin. In addition, the material can be aerated from below using fans. The

advantage to bin systems is that they generally require a smaller footprint and can increase the rate of composting. In addition, since the process is enclosed in a building, the odorous air can be collected and treated to reduce odor emissions from the facility.

- Tunnel composting systems: Tunnel systems are also located in a building and are high rate composting systems. In this type of system, the feed material is loaded into an enclosed tunnel. The tunnel has an aeration flow where fans direct air through the compost. At the end of the tunnel composting cycle, the compost is removed from the tunnel for curing to a final product. The advantages of tunnel composting systems are that they provide the best control of the conditions during composting, minimizes the footprint of the facility and also minimizes the amount of air requiring odor control. However, tunnel composting systems do not have a mechanism to breakup hot spots in the material and therefore may not be as appropriate for manures as a bin system.

Composting can be done cost effectively at a wide range of capacities. Therefore, composting will be further evaluated for both the local farm option and for regional facility options.

5.1.6 Liquid-Solids Separation

Liquid-Solids Separation is a method currently being used as a manure handling practice on many dairy farms. A variety of methods are currently being developed and utilized in order to effectively dewater dairy manure. The goal of the dewatering process is to isolate nutrients in the solid form and separate a nutrient deficient liquid from a solid material. Solid and liquid phases produced during the liquid-solids separation process must still be disposed. Currently, there is no economical method of treating manure so that the treated liquids can be disposed in a watercourse. However, by separating out a nutrient rich solid, the liquid can be spread on fields at higher application rates due to the lower nutrient content. The left over solids can be more easily transported off-site and applied to land elsewhere or treated further to develop a saleable fertilizer. Three different liquid-solids separation methods are discussed below.

- Gravity Separation: The Gravity method of the liquid-solid separation process is typically more economical on smaller farms, approximately 200-300 head. Manure is stored in a lagoon or in vertical tanks to allow the solids in the manure to settle. Typically, the majority of the readily settable solids will settle within the first 30 minutes or less, although additional settling will occur over a longer storage period.

The storage facility will reduce fresh dairy manure liquids to a solids content of approximately 3% to 4%. The gravity settling process has been shown to produce an average solids reduction in the liquid of 55%. The solids settled out of the stored manure tend to contain approximately 28% of the total phosphorus and 26% of the organic nitrogen.

Routine maintenance of the storage facility, including solids removal, will greatly affect the efficiency of the gravity settling process. The main issue with the gravity separation process is the odor generation. A lagoon should be located a substantial distance from property lines and residential areas. Precautions are also needed in order to prevent runoff from and leaking of the storage facility. As stated above, the gravity separation process does not address the need to export nutrients. It only produces a material that is more readily handled.

- Mechanical Separation: The Mechanical method of liquid-solid separation involves the use of mechanical equipment to dewater liquid manure. Testing and current operations have shown that manure can be effectively dewatered by machinery such as a belt filter press, a centrifuge or a screw press. Each of these methods can stand alone as an effective dewatering process, although they are more commonly used in combination with polymer or chemical coagulants.

Screw presses can dewater raw manure that is scraped, typically containing 5% to 10% solids, and flushed manure, typically containing 2% solids. The nutrient removal efficiency of screw presses is based on the percent solids of the input manure. Manure with a 9% solids content can result in a solid with 27% of the phosphorus and 22% of the nitrogen entering the screw press.

An Aero-Mod Belt Filter Press (BFP) is currently being tested on a farm in Wisconsin. The equipment can dewater raw manure that is scraped, typically containing 5% to 8% solids, and flushed manure, typically containing 2% solids. The nutrient removal efficiency of the BFP is based on the percent solids of the input manure. Manure with a 5% to 8% solids content can result in a dewatered solid with solids content of approximately 25% to 30%. The nutrient removal rate is still being evaluated and will be available in the future. The main advantage of the BFP is its ability to handle manure mixed with sand bedding. A screw press will tend to wear faster if sand gets into the moving parts, and require more frequent maintenance.

Jannanco, LLC has recently completed pilot testing on Active Filtration equipment. The trials were partially funded by the New York State Energy Research and Development Authority (NYSERDA). Active Filtration is an industrial-scale filtration method used extensively in Europe. The process equipment includes dewatering membranes with durable air bladders that are inflated and deflated to manipulate manure solids through the filter. The system was tested using digested and undigested manure, digested and undigested manure from a screw press, and final effluent from a clarifier. The clarified effluent for each of the tested streams consistently had suspended solids content of 0.2%, which represented a phosphate reduction of 100% and organic nitrogen reduction of 90%. These values were obtained at a chemical loading rate at or below conventional technologies used in the Midwest. Early reports have indicated that up to 95% solids capture is possible but the data has not been published yet. It is unclear what levels of solids content of the solid phase is achievable. Full results of this report will be available in a report from NYESRA and Jannanco, LLC later this year. (Jannanco, LLC, 2005) This is a technology worth following but has no full-scale applications to date.

- <u>Combination of Separation Methods</u>: A combination of the gravity and mechanical separation process has been used to produce a nutrient rich solid, to accelerate the dewatering process and to maximize nutrient remove from liquid manure.

The Tinedale Farm in Wisconsin has developed a dewatering process that includes a gravity thickener, a screw press and a polymer addition system. The Tinedale Farm houses approximately 2,500 animals and produces around 50,000 gallons of manure daily. Fresh manure enters the gravity thickener at approximately 8%-10% solids. Digested manure enters the system at approximately 5% solids. The combined system, utilizing the gravity thicker and screw press, has consistently captured 60% to 70% of the solids from raw and digested manure. In terms of nutrients, the filtrate from the screw press was found to have 30% to 40% of the phosphorus of the influent. The addition of polymer helped precipitate more nutrients to a solid form and has shown a nutrient removal rate of approximately 98%. The equipment at the Tinedale Farm has a higher capital cost and operation of the thickening process needs to be monitored and requires routine maintenance. The Tinedale Farm received a grant from the state of Wisconsin to offset the cost of the selected process equipment.

5.1.7 Chemical Precipitation of Phosphorus

The chemical precipitation of phosphorus includes the addition of chemicals, such as iron compounds, alum, and lime, to treat liquid dairy manure for nutrient separation. Nutrient separation with the addition of chemicals is dependent on three main steps: 1) coagulation, 2) flocculation, and 3) separation of aggregated floc.

A study at Michigan State University was completed evaluating the percent reduction of nutrients with the addition of chemical additives. Additives were used to precipitate mainly phosphorus in liquid dairy manure with a solids content of 2.85%. Alum, lime, and ferric chloride were used in this study. The results showed a phosphorus reduction range of 30% to 82% after 60 minutes of settling and a reduction of 57% to 100% after 24 hours of settling. Of the three chemicals used in this study, alum was shown to have the best reduction results.

Due to its ability to remove phosphorus from the liquid manure stream, chemical precipitation of phosphorus will be considered further.

5.1.8 Conversion to Energy - Cofiring

Cofiring of dairy manure is not typically done due to the amount of water associated with dairy manures. Significant additional fuel would therefore be necessary to burn dairy manure. This option is not considered further.

5.2 POULTRY MANURE

5.2.1 Land Application

As with dairy manure, land application is currently the primary method of handling poultry manure. Because of the excess of nutrients which exists in the State, farmers have worked with the landowners in their areas to maximize the use of appropriate land. Additional work towards generating agreements to allow land to be used for manure land application is not likely to generate significant new options. Since land application has been used to the extent possible in the state, this option will not be considered further.

5.2.2 Composting Poultry Manure

Composting poultry manure is a manure management practice that has been readily adopted overseas in Europe and Australia. Composting poultry manure has not been a widely used manure management practice in the States although it has been used at several farms including the Daylay Farm in Ohio. Composting poultry manure stabilizes the organic material in the manure and reduces the overall volume of the waste material making it easier to transport off-site. During the composting process, weed seeds and pathogens are destroyed, leaving a virtually odorless material which can be safely used as plant fertilizer.

Currently, composting poultry manure in the State of Connecticut has been thought to be uneconomical by area poultry farmers. The state requires all poultry composting to be completed in an enclosed structure. Large poultry farm operations in Connecticut, such as operations with as many as 4.8 million birds, would need to build a new structure that could house a composting operation. If the poultry manure produced at these farms were to be composted, a large scale process with multiple composting houses would be needed.

As poultry manure composting has been successfully implemented at a full-scale system, it will be considered further in Section 6.

5.2.3 Conversion to Energy - Gasification

Clearview Renewable Power, LLC is currently developing a proposed facility to burn poultry manure and waste wood for the generation of electrical energy. The conceptual design developed by Clearview Renewable Power, LLC, is a 20MW Net-to-the-Grid biomass gasification cogeneration facility. The facility is proposed to be located near the KofKoff Egg Farms. The facility would utilize poultry manure (produced by the farm) and wood waste as fuel to generate electricity using cogeneration gasification biomass energy technology. The facility is estimated to have an average daily biomass capacity that would be able to handle 340 tons of poultry manure a day, essentially 100 percent of the poultry manure produced at The KofKoff Farms. The facility could potentially process all manure produced by the KofKoff Farms and substantially reduce nutrient loadings in the state. This process is discussed in more detail in Section 6.

5.2.4 Drying/Pelletizing

Drying and pelletizing of poultry manure has been done as an alternative to composting. The pelletizing process has been found to be less labor intensive than composting and produces a product which is easier to package and market. Also, composted manure tends to have a higher moisture content and is more expensive to transport than pelletized manure.

Perdue Farms, Inc, located in Delaware, has a successful pelletizing operation and has reportedly processed more than 60,000 tons of poultry manure since it went into operation in 2001.

The pelletizing process on the Perdue Farms starts with a large volume storage facility. The large volume storage facility takes in poultry manure from each of the Perdue Farms and other local poultry farms located in the immediate vicinity of the pelletizing plant. The large volume storage facility is emptied every two years. Manure from the building is removed and deep stacked in piles for a relatively short period of time. The stacked material is then screened and deep stacked a second time, after which, the manure is broken down by a smashing machine. From the smashing machine, the manure moves to a heating chamber which is 10 ft in diameter and 40 ft long. The chamber's drum rotates, spinning the waste through a 650^{o}F heat stream, dehydrating and pasteurizing it. Afterwards, the material can be as hot as 180^{o}F, killing any remaining bacteria and fungus. The product is then ground through a hammer mill and mixed with raw steam. Water for the steam is recovered from earlier processes. Any extra liquid is put through additional scrubbers to burn off nutrients and then sold to private agricultural companies for land application.

In order for this process to operate properly, the manure must enter the deep stacks at a moisture content of approximately 25% to 30%. The poultry farms in the State of Connecticut do not have the facilities to achieve the needed moisture content. The largest poultry farm in the State, uses two separate methods to store manure on-site. These methods are described below.

- In all of the growing houses and two of the layer houses, a belt system is used. A series of belts run beneath the cages in these facilities and collect the poultry manure. The conveyor belt discharges all manure into dump trailers which transports the manure to a central pad. Manure is stored on the pad until taken off-site for disposal. Approximately 15% (51 tons per day) of all manure is handled by this process. The moisture content in the dump trailers is approximately 30% to 40%.

- The remaining layers are housed in two-story buildings. Within these buildings the chickens are housed on the second floor. Manure in these buildings drop to the first floor which acts as a storage pit. This manure is periodically transported to a central pit until taken off-site for disposal. The moisture content in the storage pit is approximately 60% to 75%.

If this poultry farm was to adopt the pelletization method of manure management, the farm would have to reconfigure the current manure storage facilities in order to produce manure with an initial moisture content of 25% to 30%. In addition to the cost included in reconfiguring the initial manure handling processes, it was estimated that the initial capital cost for the pelletizing equipment would be approximately $3-$5 million, not including equipment needed in order to meet environmental regulations concerning air and dust emissions. The Purdue Farm has spent approximately $3.5 million on environmental upgrades to eliminate air emissions and odor problems. The actual pelletizing process O&M costs are estimated be approximately $25-$35 a ton. The pellets are shipped country/worldwide and sold at a price of $50-$55 a ton. Due to the start-up cost and reconfiguration cost, the dry/pelletizing process is not recommended as a feasible manure management method in the State of Connecticut.

SECTION 6
SHORT-LISTED TECHNOLOGY ALTERNATIVES

The technologies identified in Section 5 were reduced to a short-list of technically feasible technologies during the Advisory Board brainstorming session on June 22, 2005. Short-listed technologies from the brainstorming session for dairy and poultry farms include:

Dairy Farms

- Liquid/Solids Separation
- Anaerobic Digestion
- Chemical addition to precipitate phosphorus
- Composting
- Production of alternative products such as horticultural pots and paper.

Poultry Farms

- Composting
- Waste-to-Energy

For the most part, these technologies have been implemented full-scale for either manure or residuals management applications, and are deemed to be the appropriate for either a local or regional manure management solution for moving nutrients out of the agricultural sector. This section presents more detailed technical descriptions for each short-listed technology as well as analyses of the estimated nutrient redistribution and economics of each. For the purpose of this report, dairy and poultry manure management alternatives are discussed separately.

6.1 DAIRY MANURE OPTIONS

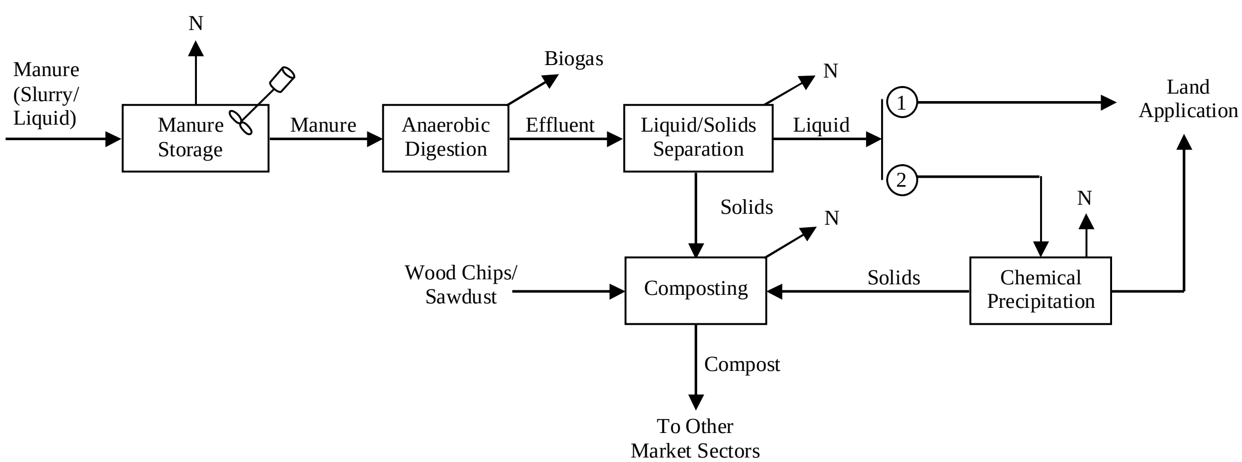
The animal density mapping developed from the CAFO farm database reveals several high density concentrations of dairy animals in four distinct areas of the State (See Section 3). Short manure haul distances make these areas suitable candidates for regionalized manure management solutions. Conversely, the lower animal densities in the remaining areas of the State would favor a local farm-based manure management solution.

In the technical analysis of dairy manure management options, each short-listed technology has been considered as both a local and regional manure management solution with the exception of anaerobic digestion. Anaerobic digestion was not considered as a local solution since for the 200-head local farm-size anaerobic digestion would not be economically reasonable. For a local solution, the technology is able to be implemented on a single farm. Technologies considered for regional solutions have either been implemented in this capacity at existing facilities, or have been implemented on single farms but show potential for a regional facility.

The short listed options for dairy manure can be used individually or in combinations. Figure 6-1 presents a schematic which combines all of the short listed technologies as they could be used at a single facility. Different options can be removed by deleting an option from the schematic but the basic flow of the remaining options will remain the same. For instance, anaerobic digestion can be removed, in which case manure from storage would go directly to liquid/solid separation before composting or chemical precipitation. Or a farm may choose to use liquid/solids separation followed by composting. The technical feasibility of each of the options is discussed individually below, however the nutrient distribution and economics of the options is presented in an integrated discussion.

FIGURE 6-1

DAIRY MANURE MANAGEMENT TECHNOLOGY SCHEMATIC



6.1.1 Dairy Options Technical Evaluation

6.1.1.1 Liquid/Solids Separation

In general, nutrients in the manure are primarily associated with the solids. Separating the liquid and solid portions of the manure helps concentrate the nutrients in the solids thereby reducing the volume of material that needs to be managed. As a result, the liquid portion can be applied at a higher rate to the land. In addition, application systems are simplified since liquid-type application systems only are required (i.e., irrigation or subsurface injection systems). Liquid/solids separation therefore becomes critical in developing a cost effective manure management solution.

Liquid and solids separation may be achieved by either using gravity or mechanical means. Of these two methods, mechanical separation is a more effective method for redistributing nutrients in high rate and high volume applications, such as a regional processing facility. Therefore, mechanical separation technologies only are considered further in this study.

Currently, a small fraction of the farms in Connecticut use mechanical separation as part of their manure management plans. The limited use of this technology on farms may be due either to economics, lack of awareness or perception of the technologies. However, the farmers that use liquid/solids separation are usually pleased with the results and continue to utilize the technologies.

Testing and current operations have shown manure can be effectively dewatered by machinery such as belt filter presses, centrifuges or screw presses. Each method can be used without any chemical addition, however, solids capture and phosphorus removal can be improved markedly by the addition of polymers and metal salts. For the purposes of this study, it has been assumed that screw presses will be utilized for liquid/solids separation due to their lower maintenance requirements compared to belt filter presses and centrifuges and their established performance in manure applications. In some applications, such as processing manure mixed with sand bedding, belt filter presses may be more appropriate.

Solids capture for the screw press is assumed to be 55% in mass balances developed for this study. However, solids capture rates can vary between 25 and 55% depending on the solids content of the feed manure. Typically, higher solids content in the feed will translate into higher solids capture rates. For low solids content, manure feeds, sludge thickening or conditioning may be required to obtain the solids capture assumed above. Most screw press manufacturers will not guarantee a solids capture rate without performing pilot testing first.

Based on operational experience at Freund Farm, the maximum solids content of the dewatered manure is assumed to be 27% by weight. Nitrogen and phosphorus removal is assumed to be 20% and 50% by weight, respectively. These assumptions are based on published values.

The typical arrangement for the screw press dewatering system would consist of a concrete storage pit, tank or lagoon for the raw manure, a pump or auger for transferring the manure to the separator, screw press system, and solids and liquid effluent storage. For manure containing sand bedding, the raw manure would be pumped through a cyclone-sand separation system prior to flowing by gravity to the screw press system. Polymer, if used, would be added to the influent feed prior to a flocculation tank upstream of the press. Dewatered solids would be stockpiled for further processing, such as composting.

Liquid effluent would be stored in a tank or a pond for eventual land application. Metal salts can be added to the liquid effluent stream from the press for additional phosphorus removal. Chemical precipitation methods are discussed in more detail below.

6.1.1.2 Anaerobic Digestion

Anaerobic digestion reduces the amount of volatile solids in the manure feed, but removes few nutrients except for some nitrogen consumed in the process. The primary benefit of anaerobic digestion is that the digested effluent has reduced odors and pathogens and is free of weed seeds and other undesirable organics, thereby significantly increasing the acceptability of the digested material for land application. This allows the liquid digester effluent to be land applied on land that may not otherwise be available for untreated manure. Liquid/solids separation equipment can be used to remove digested solids from the liquid effluent stream from the digester for further processing by composting or other means.

Capital costs for anaerobic digesters are fairly high. The economics are more favorable when considering the technology for a regional facility and the upfront capital expenditure can be recovered by charging tipping fees, producing saleable products and processing larger volumes of manure. Additionally, energy generated by the process, whether as excess electricity or heat, can be sold to offset operational costs. For this study, anaerobic digestion is being considered for regional manure management solutions only. Past digester studies performed by Wright-Pierce have shown that locating a regional facility near a host that can purchase the excess energy directly, rather than selling to the grid, provides the most economic benefit.

Considering that the manure sources available for any proposed digester are predominantly dairy manure and that reduced manure volumes, and therefore reduced transportation costs are preferred, a plug-flow digester was chosen for this study. During any future facility design, the choice of using a plug-flow or complete mix system should be further reviewed, as should more advanced digester designs (i.e., thermophilic designs), which may produce a greater volume of biogas.

An anaerobic digester system would consist of covered manure feed storage tanks, digester tank(s), heat exchangers, biogas handling equipment, generator set, transfer pumps, and a covered effluent storage tank(s). Buildings would include an enclosed manure receiving building, and process/administration building for housing ancillary equipment such as pumps, heat exchangers and boiler system.

Collected manure would be stored in storage tanks located adjacent to a receiving building. The tanks would be sized for approximately three (3) days of storage to provide enough manure to operate through a long weekend without deliveries. The three day storage requirement corresponds to a combined feed tank volume of approximately 180,000 gallons.

Manure would be pumped from the manure feed tanks through two heat exchangers and into one of three plug-flow digesters. The first heat exchanger would recover heat from the digester effluent, and the second would raise the temperature to 100°F. Per NRCS design standards, each plug-flow digester will be sized for an 18 day residence time, resulting in a combined tank volume of 1.2 million gallons. Manual valves would be used to direct manure to each of the tanks.

Plug-flow digesters are essentially long troughs with an air-tight expandable cover. A new plug of manure would be added daily at one end, pushing the material already in the digester slowly through the system. Halfway through the system, a portion of the solids is removed, reheated and returned to the digester to maintain the digester temperature. Methane would be collected off the tanks and stored in a biogas storage tank to be eventually burned by either a boiler or engine generator set. A biogas blower will be required to ensure the proper feed gas pressure to the equipment.

Digested manure will flow by gravity to one of two below ground effluent storage tanks. The tanks will be sized to provide five (5) days of storage. Digested manure will be stored in these tanks until it is removed for further processing.

In addition to the manure receiving building, an administrative, control and operations building will be required for offices and housing of mechanical equipment such as pumps and heat exchangers.

As mentioned previously in Section 5, plug-flow digesters require supplemental heat to maintain the process at the optimum temperature for methane production, typically 100°F. Heat can be supplied by burning a portion of the generated biogas with either a biogas-fired boiler, or an engine generator set. Water heated from the boiler or engine will be recirculated through a closed loop system containing two heat exchangers. One heat exchanger heats the manure fed to the digester, while the other re-heats manure drawn from each digester and recirculated back into the tanks.

The choice of heating system will ultimately depend on the most economically attractive market for the biogas (e.g., electricity generation or the sale of biogas as a natural gas equivalent). To generate electricity, an internal combustion engine generator set will be required. System components will consist of an internal combustion engine, induction or synchronous generator, control system, and optional heat recovery system. In addition to providing electricity, the engine will generate excess heat that can be used to heat the digester. Engine generator sets burning digester gas produce approximately 0.0053 kW of electricity per Btu/min of biogas and 0.42 Btu waste heat per Btu of biogas burned.

If an engine generator set is not used, a biogas-fired boiler will be required to provide the supplemental heat to the digesters. Typically, natural gas boilers modified for biogas are used in this type of application.

6.1.1.3 Chemical Precipitation of Phosphorus

Chemical precipitants have been used for many years for the removal of phosphorus in municipal applications. Recently, there has been increased interest in using metal salts, most notably aluminum sulfate, ferric chloride, and lime to remove phosphorus for nutrient management. It should be noted that phosphorus removal using chemical precipitation is well established in full scale municipal applications. However, it appears to have only been demonstrated in bench scale testing for dairy manure. It is recommended that pilot testing be performed on dairy manure before considering implementing this technology for full scale applications.

Chemical precipitation requires a liquid stream and may be used either in a single farm or regional application. In order to reduce chemical costs, it is recommended that chemical precipitation only be considered in conjunction with a liquid/solids separation process. As outlined above, a significant portion of the phosphorus will be removed with the solids thereby reducing the required chemical dosage for the liquid effluent stream.

Bench scale studies have shown the highest reduction of phosphorus occurs with aluminum sulfate (i.e., alum). For this reason, alum is being considered as the chemical of choice for this study. From these studies, the reported phosphorus reduction using alum is as high as 100%. However, in full scale municipal applications a point of diminishing return occurs where the chemical dosage and cost begin to greatly exceed the marginal incremental reduction in phosphorus. Typically, this point occurs at approximately an 85 to 90% reduction. This study assumes that chemical precipitation with manure will behave in a similar fashion and an 85% phosphorus reduction for alum is used.

The chemical reaction between phosphorus and alum is complex. Generally, aluminum in the alum solution will react with orthophosphates in the manure to form an insoluble precipitate, which must be settled out of the liquid stream. In practice, the quantities of alum required are higher than one would predict for phosphorus alone due to competing chemical reactions. The end result is that more alum will be used and more chemical solids generated than expected. As a general rule, the ratio of aluminum dosed to phosphorus removed is 2.2 to 1 on a per pound basis. However, chemical suppliers indicate that alum consumption may be even higher in practice. Federal guidelines also recommend that the amount of sludge calculated using this ratio be further increased by an additional 35% to account for variations in solids generation observed in full scale applications.

Whether being used on a single farm or at a regional facility, a phosphorus chemical precipitation system will consist of these basic components:

- A chemical storage tank and metering pump(s),
- Flocculating tank with a mixer and settling tank, or
- A flocculating clarifier.

The volume of chemical storage required is ultimately dependent on the chemical dosage. However, considerations must also be made for standard bulk chemical delivery volumes and chemical shelf-life. For this study, the estimated required chemical storage volumes are 2,000 gallons and 12,000 gallons for the local and regional scenarios, respectively. These volumes correspond to approximately one month and 2 weeks of storage based on the anticipated alum usage.

For a single farm, it is assumed that a flocculating mix tank would be used followed by a settling tank or lagoon. The flocculating tank would be sized to provide a hydraulic detention time of about 30 seconds. In the case of a regional facility, a flocculating lamella clarifier would be used due to higher continuous flows required for processing.

One aspect of concern regarding the use of alum is the potential toxicity of the aluminum precipitates and their reuse or disposal. EPA Biosolids Rule promulgates regulations concerning metals contaminant concentrations in municipal sludges (i.e., biosolids). These regulations, however, do not cover the beneficial reuse of non-municipal sludges or aluminum containing sludges or solids. Currently, the State of Maine is the most progressive in developing and implementing standards for beneficial reuse. Based on Maine Department of Environmental Protection beneficial reuse standards, the regulatory screening level for aluminum is 97,500 mg/kg of dry solids. For this study, the projected aluminum concentrations in the solids are approximately 11,300 mg/kg and 9,600 mg/kg of dry solids when using chemical precipitation on individual farms and at a regional facility, respectively. For the regional facility, it is assumed that aluminum solids are being mixed with the composted material. In both instances, aluminum concentrations are below the Maine screening levels.

6.1.1.4 Composting

Composting is perhaps the most effective technology for transferring nutrients out of the agricultural sector in that there are no by-products remaining from the process that are not a marketable product. Nitrogen contained in the composted manure will either be consumed in the decomposition of organic materials, or remain in the finished composted product. The majority of the phosphorus contained in composted manure is anticipated to remain in the finished product.

Composting may be used as the primary nutrient management technology, or in conjunction with other processes. In general, composting process requires a feedstock with forty percent solids content by weight. Most raw material feedstocks do not have this level of solids. Therefore, bulking agents, such as saw dust or wood chips, and other amendments are added. The ratio of the amount of carbon to nitrogen (C:N) in the material being composted is also critical. The addition of bulking agents and amendments helps to adjust the C:N ratio for feedstocks with less than optimum carbon or nitrogen contents. Typically, optimum composting occurs when the C:N ratio is between 20:1 to 40:1. Raw dairy manure typically has a C:N ratio of between 10:1 to 15:1. Addition of a carbon source such as wood chips or sawdust will increase the carbon to nitrogen ratio. The typical solids content for the finished compost will be approximately sixty percent solids by weight.

There are many types and configurations of composting systems, however, they can be grouped into several basic categories including windrow systems, agitated bin systems, and aerated static pile systems. All of these composting systems have basic features in common:

- A mixing area where the manure is combined with the woodchips/leaves or other amendment;
- A composting area where the mixed feed decomposes into a compost product;
- An odor control system to treat the exhaust from the system if needed;
- A curing area to allow the compost to cure to a finished product;
- A storage area to stockpile finished compost produced during the off-season (e.g. during the winter when demand for compost is low); and
- A screening area where the product is screened to remove large size pieces such as partially decomposed woodchips. (These woodchips can be recycled back into the basic feed mix.)

Many of these features are the same for the various composting systems. The curing, storage, and screening systems are assumed to be the same for purposes of comparing the systems. These activities will take place outdoors on a paved surface. The mixing area and mixing equipment will be substantially the same for each system and will be located inside the composting building. The odor control system will depend on the size and site location of the composting system. For the individual farm we have assumed that the composting system can be located such that odor control will not be necessary. For a regional facility the odor control system could be a biofilter or a packed-bed scrubber followed by a biofilter. Each of the composting system types is discussed briefly below.

Windrow Systems

A windrow system consists of large piles of the mixed feed which are aerated using a windrow turner. This type of system does not compost as quickly as systems which are aerated continuously and therefore requires a longer time in composting piles. Many windrow turners are available from turners towed by a tractor to self propelled turners. The size of the windrow turners determine the windrows that can be built. In general, windrow turners have large turning radii and require significant space to turn around at each end of the windrow. Because of this, windrow systems are frequently not enclosed in a building but used at more remote sites where composting can occur outdoors.

Agitated Bin

An agitated bin system consists of bins with concrete walls and aerated floors in which the compost is loaded. The bin walls support a compost turner that travels down the length of the bin, turning the compost and moving it down the length of the bin. With this system the feed is loaded into one end of the bin and it is moved down the length of the bin by the compost turner until it is finally moved out of the bin on the discharge end. From here it is removed for curing, screening and storage. While there are many manufactures of compost turners for agitated bins, these turners are primarily designed for larger facilities. Most turners move the compost 7 to 15 feet per pass. Assuming 15 turns (five days per week for three weeks), each bin would be 105 to 225 feet long.

Aerated Static Pile

Aerated static piles involve mixing the compost and forming piles which are actively aerated. These piles are not disturbed during the active composting period. There are several versions of aerated static piles, most of which use some sort of sidewall to maximize the amount of compost per floor area. Fans provide the active aeration in either an upflow or downflow configuration via some form of aeration system at the floor. The common types of aerated static pile systems: bag composting, tunnel systems, bin systems and containerized systems. The bag composting system is similar to the bag silage system except that aeration has been added. The bags can lie directly on the ground and help contain the odor. The latter three systems can be enclosed in a building and allow capture of odorous air for odor control. However, static pile systems may not be well suited for manure based composting systems. Static piles are not mixed and do not benefit from the agitation of other systems in breaking up clumps or hot spots in the compost pile. Therefore static piles may produce a more inconsistent product with portions that have not been fully composted. These systems could be used as the first phase of composting followed by an agitated phase such as windrows.

For both the individual farm and the regional facility we have used a windrow system model, assuming that the site location will be sufficiently remote that odor control will not be necessary. If odor control is necessary, then a high-rate agitated bin system or a modified static pile system followed by a windrow system should be considered.

The proposed manure composting system will consist of the mixing area, the composting area, the curing area, and the storage area. These areas are all discussed below. All of these areas are located outside and the windrows, composting and curing areas will be paved. Stormwater collection and treatment will be provided to mitigate impacts to water quality. Garage and office spaces are also proposed for the regional facility but are assumed to exist for the individual farm area. The manure will first be mixed with wood chips, sawdust, recycled compost or other organic material to both increase the carbon content and the solids level of the mix. After the mixer, windrows will be formed and turned as necessary by windrow turner pulled by a tractor or front end loader. The material will be composted for 30 days, placed in curing windrows for 60 days and stored for up to 150 days. Compost sales are very seasonal, so adequate storage facilities are important to be able to sell compost at higher prices. Between curing and final storage the material will be screened. The overs (woodchips which have not fully degraded) will be recycled to mix with the incoming manure.

The windrows will be turned based on the temperature and oxygen levels in the windrow, likely two or three times a week. Particularly during the summer season, water will need to be added to the windrows. Several methods of water addition are possible including the following:

- Spraying the piles with hose reel systems or sprinkler systems.

- Forming a trough in the top of the windrow and using a water truck to fill it will water.
- Use of drip irrigation lines on the windrows.
- Addition of water while turning the pile.

It may be possible to use the thickened phosphorus precipitate as a water addition to the windrows, however, for the purposes of this review it was assumed that this precipitate would be added to the feed mix. The quality of water added does not need to be of drinking water quality but should be free of pathogens to avoid reintroducing pathogens to the compost after the composting process has destroyed them.

6.1.1.5 Production of Alternative Products

Innovative alternative products are being developed to market manure solids by other means than traditional methods (i.e., composted manure). The Freund Farm in East Canaan, Connecticut is currently developing a technology to produce horticultural pots, or 'poop pots', out of digested, composted manure. This technology was not developed for nutrient management, but shows significant potential for moving nutrients to the horticultural market. For the purposes of this study, the technology for the production of alternative products is being modeled after the Freund 'poop pot' process.

In the process, raw dairy manure is digested, composted and the composted material formed into pots. The composting step is not essential for the physical production of the pots. However, it is essential for reducing odors. Pots made without composted material will release odors when wetted.

The process is sensitive to minor variations in the manure content and requires adjustments for the equipment to process the manure effectively. Therefore, the process appears to be more suited for a regional application where larger volumes of manure can be homogenized and processed. The type of bedding used appears to have an affect on the production of pots. Currently, sawdust is seen to cause a problem with production. Bedding with higher fiber content, such as cotton, silage, or straw may be beneficial in forming the pots.

As stated earlier, this technology was not originally developed for nutrient management, but is moving towards full-scale implementation. The technology is feasible and costs have not been developed as part of this study as this technology is being privately developed. At this time, the ultimate distribution of nutrients in the pots is not known. Before being considered further as a nutrient management technology for this study, it is recommended that the nutrient distribution in the finished products be investigated further.

6.1.2 Nutrient Mass Balance and Distribution

For the purposes of the study, the demonstrated, full-scale short-listed technology options have been organized to develop six scenarios options to manage nutrients on a farm and regional basis. These scenarios include:

Individual Farms

- Liquid/Solid Separation
- Liquid/Solid Separation and Chemical Precipitation
- Composting Whole Manure

Regional Facility

- Liquid/Solids Separation at Farms and Regional Composting
- Anaerobic Digestion, Liquid/Solids Separation and Composting (or Poop Pots)
- Anaerobic Digestion, Liquid/Solids Separation, Composting and Chemical Precipitation

For each of the scenarios, a nutrient mass balance was developed for the assumed nutrient loadings discussed in Section 3. In summary, the farm scenarios assume manure management for 200 mature head of dairy cows, and the regional scenarios assume manure management for 3000 mature head of dairy cows. The mass balances use published nutrient distribution data for the various technologies. The results of the mass balance are presented in Table 6-1.

TABLE 6-1
TECHNOLOGY NUTRIENT DISTRIBUTION

Short-Listed Technology Scenario	Distribution of Nutrients (% of Total)					
	Agricultural Sector		To Other Markets		Lost [1]	
	N	P	N	P	N	P
Farm						
Liquid/Solids Separation (Other Markets = dewatered solids)	42	50	19	50	39	0
Liquid/Solids Separation With Chemical precipitation (Other Markets = dewatered solids)	25	8	29	92	46	0
Composting whole manure	0	0	24	100	76	0
Regional Facility						
Regional Composting with Liquid/ Solids Separation at Farms	42	50	7	50	51	0
Anaerobic Digestion and Composting	33	50	7	50	60	0
Anaerobic Digestion ,Composting & Chemical Precipitation	23	7	11	93	66	0

Notes:
(1) Lost to atmosphere or in digestion or composting process.

It should be noted that the two farm scenarios that utilize liquid/solids separation do not move nutrients out of the agricultural sector unless the dewatered solids can be moved into another market sector. Furthermore, phosphorus reductions are based on data from bench scale tests and not full scale applications. In addition, for the regional facility options using anaerobic digestion, the nutrients staying in the agricultural sector will need to be trucked back to area farms and fields for application. With these considerations, the calculated nutrient distributions for farm composting and regional composting scenarios were used to develop an estimate of total statewide nutrient reductions for various implementations schemes. These estimates can be found in Section 10.

6.1.3 Economic Analysis for Dairy Alternatives

Economic analyses were performed for the six scenarios described in Section 6.1.2. Costs have been prepared for the each scenario and are presented in Appendix C. These planning-level costs were developed using standard cost estimating procedures consistent with industry standards utilizing concept layouts, unit cost information, and planning-level cost curves, as necessary. Total project capital costs include an allowance of 42% of the estimated construction costs to account for construction contingency, design and construction engineering, permitting, as well as financing, administrative and legal expenses. The project cost information presented herein is in current dollars and is based on an ENR Index 7478 from August 2005. The capital cost for each scenario, both total and annualized, are shown in Table 6-2.

These estimates have been developed primarily for comparing alternative solutions and are generally reliable for determining the relative costs of various options. Many factors arise during final design and project implementation (e.g. foundation conditions, owner selected features and amenities, code issues, etc.) that can not be definitively identified and estimated at this time. These factors are typically covered by the 42% allowance described above; however, this allowance may not be adequate for all circumstances.

These estimates also include a 35% of equipment cost allowance for installation as well as a cost allowance for electrical systems from 18% to 20% of the total equipment cost. For options where electrical costs are anticipated to not factor significantly into the total project cost, such as on-farm composting, minimal electrical costs are assumed. These allowances may be different for installations at existing farms or situations where an outside contractor is not used for installation or electrical service modifications are not needed.

Annual operating and maintenance costs have also been developed for each scenario and include such items as transportation labor, power, fuel, chemicals and laboratory costs. Indirect operating expenses such as overhead, utilities, taxes, insurance and administration costs are included in the operating expenses as a percentage of the scenario project cost. A sinking fund cost line item is also included for equipment replacement. It is assumed in the estimate that all equipment/buildings will have an effective operating life of 15 years, with the exception of the liquid/solid separation at the individual farms where a 10 year operating life was used. It should be noted that over the past several years, equipment and construction costs have increased significantly greater than average inflation and these costs are anticipated to continue to rise. This increase in costs is due to many factors including not only increased fuel costs, but also increased materials costs due to world-wide demand for building materials, especially steel.

Capital costs included buildings for equipment, offices and maintenance areas for the regional facility options but assumed this was already available at the individual farms. For all options including composting, it was assumed that the active composting and curing areas would need to be paved and that suitable subgrade material would need to be imported. Stormwater collection and treatment systems are also assumed to be required.

To offset operating costs, income sources have been evaluated for each scenario and are included in the economic analysis. Income sources include such items as tipping fees for food waste accepted at a regional facility, the sale of renewable energy to private entities or to utilities, or compost sales. For the scenarios with anaerobic digestion, it is assumed that any power generated from biogas would be sold as green energy to the grid, garnering approximately 8¢/kWh based on current rates. The wholesale market price of compost varies with the primary factors influencing revenue being annual volume of compost produced, storage capacity of the facility and product quality. Good quality finished manure compost can sell wholesale for $5 to $10 per cubic yard loaded at the facility. Delivered wholesale pricing can be $12 to $16 per cubic yard. In general, small producers of exceptional compost that can sell to a local market, typically less than 20 miles distant, and can receive certification as "organic" can get a premium price (e.g., $25 to $35 per cubic yard). Producers that have limited storage, produce an average quality of product or need to rely on larger shipping area will not receive high selling prices.

For the purposes of this study, it is assumed that the compost would be sold for an average price of $20 per cubic yard.

The estimated annual operating expenses and income for each scenario are shown in Table 6-2. Total annualized capital costs are included for two financing scenarios, 6% and 2%. The total cost per cow for each financing scenario is also included.

As can be seen in Table 6-2, the most cost effective scenarios on a cost per cow per year basis are the scenarios for liquid/solids separation on individual farms, $730 per cow per year and regional composting with liquid/solids separation at the farms, $160 per cow per year.

Liquid/solids separation at the farms does not move nutrients out of the agricultural sector unless the solids are processed further. As mentioned previously, on-farm composting is the only on-farm alternative suitable for moving nutrients to other market sectors. The cost for on-farm composting is estimated to be $880 per cow per year.

Regional composting with liquid solids separation is estimated to cost $160 per cow per year with 6% financing. However, it should be noted that the capital and net operating cost for the regional composting with liquid/solids separation does not include the capital or operational costs for implementing liquid/solids separation at the individual farms. In the development of the regional facility, farms interested in participating in the regional facility will need to be identified and their current manure management practices assessed. It is at this time that costs for providing liquid/solids separation at farms should be determined.

Costs for both the local farm and the regional composting options assume use of a windrow system operated outside. This system can be enclosed by use of a bag composting system where the compost is fed into long bags with an aeration system. The bag contains the odor during the initial stage of composting and is considered an enclosed system. The bag composting system would add approximately $6/ton of source materials to each option. On a per cow basis this incremental cost is approximately $300 per cow for the farm using whole manure, $70 per cow for the regional facility using dewatered manure, $45 per cow for the regional facility using

TABLE 6-2
SUMMARY OF DAIRY ECONOMIC ANALYSES

Scenario	Capital Cost			Operating Costs/Income			Total Cost per Cow per year (1)	
	Total	Annualized 6% Interest	Annualized 2% Interest	O&M	Income	Net Cost	6%	2%
Local Farm: Liquid/Solids Separation	$516,600	$70,200	$57,500	$75,400	$0	$75,400	$730	$665
Local Farm: Liquid/Solids Separation With Chemical Precipitation	$628,600	$85,400	$70,000	$120,100	$0	$120,100	$1,030	$950
Local Farm: Composting	$978,800	$101,000	$76,200	$140,800	$65,430	$75,370	$880	$760
Local Farm: Composting with AgBags	$978,800	$101,000	$76,200	$202,000	$65,430	$137,000	$1,190	$1,065
Regional Facility: Composting with Liquid/Solids Separation at Farms (2)	$2,651,000	$272,900	$206,300	$689,900	$562,300	$127,600	$160	$135
With AgBags	$2,651,000	$272,900	$206,300	$871,000	$562,300	$308,700	$230	$205
Regional Facility: Composting with Regional Digester	$9,842,000	$1,013,000	$766,000	$1,758,000	$1,062,000	$696,000	$685	$585
With AgBags	$9,842,000	$1,013,000	$766,000	$1,869,000	$1,062,000	$807,000	$730	$630
Regional Facility: Composting with Regional Digester and Chemical Precipitation	$10,510,000	$1,082,000	$818,000	$2,179,000	$1,317,000	$862,000	$780	$670
With AgBags	$10,510,000	$1,082,000	$818,000	$2,388,000	$1,317,000	$1,071,000	$860	$755

(1) Total cost per cow equal to the annualized capital cost plus the net operating cost. Design bases for single farm and regional facility are 200 and 2,500 cows, respectively.

(2) Capital and operating costs do not include the cost of liquid/solids separation equipment at the farms.

dewatered anaerobically digested manure and $80 per cow for the regional facility using dewatered anaerobically digested manure with phosphorus precipitate added.

Grant funding and low interest loan options can have a significant effect on the overall project cost. If the capital cost can be substantially covered, then the costs are reduced to the operating costs of the project. In most cases this will reduce the cost per cow to half the cost. As Table 6-2 shows, even considering only the capital costs, there is an overall cost to these manure management options. One factor that is not included here is the reduction in cost due to avoidance of costs the current manure management system. For instance, on farm composting takes all of the manure, therefore the current costs for land application are avoided.

6.2 POULTRY MANURE

6.2.1 Composting (Local and Regional)

The most applicable composting method for poultry manure is a bin composting system. Since poultry farms are fairly large, the distinction between a regional facility and a local facility is minor. A "local" solution at a farm with many poultry houses may have multiple composting facilities as well. It is possible to compost whole poultry manure without using any amendment.

A bin composting facility for poultry manure would consist of a series of long concrete bins. A bin turner would be needed for each set of four bins. The bin walls support a compost turner that travels down the length of the bin, turning the compost and moving it down the length of the bin. With this system the feed is loaded into one end of the bin and it is moved down the length of the bin by the compost turner until it is finally moved out of the bin on the discharge end. From here it is removed for curing, screening and storage. While there are many manufactures of compost turners for agitated bins, turners are primarily designed for larger facilities. Most turners move the compost 7 to 15 feet per pass. Assuming 15 turns (five days per week for three weeks), each bin would be 105 to 225 feet long.

The bins would be aerated by process fans which blow air up through the compost. The bins would be located inside a building and the building air would be collected and treated with an ammonia scrubber and biofilter for odor control.

6.2.2 Waste-to-Energy

Clearview Renewable Power, LLC is currently developing a process that is proposed to utilize poultry waste for the generation of electrical energy. The conceptual design developed by Clearview Renewable Power, LLC, is based on a 20MW Net-to-the-Grid biomass gasification cogeneration facility. The facility is proposed to be located near the KofKoff Egg Farms. The facility would utilize poultry manure, produced by the farm, and wood waste as fuel to generate electricity using cogeneration gasification biomass energy technology. The facility is estimated to have an average daily biomass capacity of 340 tons of poultry manure a day, essentially 100 percent of the poultry manure produced at The KofKoff Farms. The facility could potentially process all manure produced by the KofKoff Farms and substantially reduce nutrient loadings in the state.

The facility would cogenerate and deliver approximately 20MW Net-to-the-Grid sustainable/renewable energy and 20,000 lb/h of steam. The generated steam could be utilized in the on-farm egg washing and refrigeration process, and the barn heating process. A new high temperature hot water and chilled water distribution system would be included. The new high temperature hot water and chilled water distribution system would reduce the Farms' thermal energy cost. Currently, costs related to energy used to wash and refrigerate eggs, and to heat the barns, exceeds $1 million dollars per year. In addition the 20MW generated by the facility will improve the efficiency and reliability of BL&P's local electric distribution. The market value for the renewable energy is estimated to be worth $8.2 million per year for 20MW with an 85% capacity factor and renewable energy credits equal to $.055/KWh. (Clearview Renewable Power, LLC, 2005)

Clearview Renewable Power, LLC has submitted grant applications to the Clean Energy Fund to assist in the development of this project. According to the proponents of this project, the subsidy from the Clean Energy Fund would be essential for this project to proceed. The total estimated cost of the project was not fully disclosed to Wright-Pierce during this evaluation, therefore it is not possible to estimate total capital and/or O & M cost.

6.2.3 Nutrient Distribution

Both options considered for poultry manure use the whole manure to generate a new product (either compost or a high nutrient ash). Therefore there are no nutrients to return to the traditional land application fields for either option.

6.2.4 Economic Analysis for Poultry Manure Options

Economic information is not available for the co-combustion process as this option is being developed by private parties.

An economic analysis was performed for each of the composting scenarios described in Section 6.2.1 above. Costs are presented in Appendix C. As with the Dairy manure cost estimates, these planning-level costs were developed using standard cost estimating procedures consistent with industry standards utilizing concept layouts, unit cost information, and planning-level cost curves, as necessary. Total project capital costs include an allowance of 42% of the estimated construction costs to account for construction contingency, design and construction engineering, permitting, as well as financing, administrative and legal expenses. The project cost information presented herein is in current dollars and is based on an ENR Index 7478 from August 2005. The capital cost for each scenario, both total and annualized, is shown in Table 6-3.

These estimates have been developed primarily for comparing alternative solutions and are generally reliable for determining the relative costs of various options. Many factors arise during final design and project implementation (e.g. foundation conditions, owner selected features and amenities, code issues, etc.) that can not be definitively identified and estimated at this time. These factors are typically covered by the 42% allowance described above; however, this allowance may not be adequate for all circumstances.

These estimates also include a 35% of equipment cost allowance for installation as well as an cost allowance for electrical systems from 18% to 20% of the total equipment cost. These allowances may be different for installations at existing farms or situations where an outside contractor is not used for installation or electrical service modifications are not needed.

Annual operating and maintenance costs have also been developed for each scenario and include such items as transportation labor, power, fuel, chemicals and laboratory costs. Indirect operating expenses such as overhead, utilities, taxes, insurance and administration costs are included in the operating expenses as a percentage of the scenario project cost. A sinking fund cost line item is also included for equipment replacement. It is assumed in the estimate that all equipment will have an effective operating life of 20 years. It should be noted that over the past several years, equipment and construction costs have increased significantly greater than average inflation and these costs are anticipated to continue to rise. This increase in costs is due to many factors including increased fuel costs but also increased materials costs due to world-wide demand for building materials, especially steel.

Capital costs included buildings for equipment, offices and maintenance areas and it was assumed that the active composting and curing areas would need to be paved and that suitable subgrade material would need to be imported.

To offset operating costs, income sources for compost sales have been included in the economic analysis. The wholesale market price of compost varies with the primary factors influencing revenue being annual volume of compost produced, storage capacity of the facility and product quality. Good quality finished manure compost can sell wholesale for $5 to $10 per cubic yard loaded at the facility. Delivered wholesale pricing can be $12 to $16 per cubic yard. In general, small producers of exceptional compost that can sell to a local market, typically less than 20 miles distant, and can receive certification as "organic" can get a premium price (e.g., $25 to $35 per cubic yard). Larger producers that have limited storage, produce an average quality of product and need to rely on larger shipping area will generate less revenue. For the purposes of this study, it is assumed that the poultry compost would be sold for an average price of $15 per cubic yard.

The estimated annual operating expenses and income for poultry composting are shown in Table 6-3. Total annualized capital costs are included for two financing scenarios, 6% and 2%. The total cost per ton of manure for each financing scenario is also included. The total cost for the composting option is $91 per ton assuming 6% interest and $75 per ton assuming 2% interest. This cost does not incorporate the savings for eliminating the current manure handling costs.

TABLE 6-3
SUMMARY OF POULTRY OPTION ECONOMIC ANALYSIS

Capital Cost	
Total	$17,500,000
Annualized 6% Interest	$1,533,000
Annualized 2% Interest	$1,075,000
Operating Costs/Income	
O&M	$1,347,000
Income	$226,000
Net Cost	$1,121,000
Total Cost Per Ton	
@ 6% Interest	$91/ton
@ 2% Interest	$75/ton

SECTION 7
REVIEW OF OTHER FACTORS

There are a number of factors besides the technical and economic feasibility of each option which are important to consider in choosing the most appropriate options for the state. This includes the benefits and impacts on other important State goals such as reducing air/water pollution, the ability to redistribute nutrients, and impacts on fuel use and renewable energy goals. To provide a more complete review of the options, each short listed technology was evaluated for the following factors:

- Impact on water pollution
- Ability to redistribute nitrogen and phosphorus
- Impact on air emissions/odor control
- Ability to develop renewable energy
- Greenhouse gas and Connecticut Climate Change Action Plan.
- Ability to meet the CT Class I Renewable Portfolio Standard

Each of these is discussed briefly below. This evaluation is summarized in comparison tables for each option located in Section 10 and in the Executive Summary.

7.1 IMPACT ON WATER POLLUTION

The goal of implementing one or more of the options considered is to reduce the amount of water pollution by allowing better management of manure and reducing the over application of nutrients to farmland. Each of the options considered is discussed briefly below.

7.1.1 Dairy Manure Options

7.1.1.1 Dewatering Options

Dewatering options in and of themselves are neutral to water pollution impacts. The dewatering options separate the solids from the liquid phases of the manure and allow better use of the other manure handling technologies but do not significantly alter the potential for water pollution.

7.1.1.2 Anaerobic Digestion

Anaerobic digestion used alone is neutral or negatively impacts water pollution. Anaerobic digestion does not remove either nitrogen or phosphorus. As the digester breaks down more complex compounds found in the manure, the form of nitrogen and phosphorus will be modified to the more soluble forms of ammonia and phosphate. These forms more easily move into the groundwater than forms still bound in solids, therefore, over application of anaerobic digester effluent can have a more negative effect on water pollution than the whole manure would have. However, the same amount of nutrients must be land applied. Because anaerobic digestion destroys weed seeds and reduces odor levels, land application of the effluent could occur on cropland that would not be available for whole manure application.

7.1.1.3 Chemical Precipitation of Phosphorus

Chemical precipitation of phosphorus will reduce water pollution. Removal of phosphorus from the land applied manure will help prevent over application of phosphorus to the land. The precipitated phosphorus can be transferred to other sectors for use.

7.1.1.4 Composting

Composting positively impacts water pollution. Compost is a slow release fertilizer that is used in many non-agricultural markets such as soil blending, residential users, landscapers etc. Compost helps hold nutrients and stabilize slope and soil rather than allowing them to wash into the surface water.

7.1.1.5 Poop Pots/Paper Products

Alternative products such as poop pot or paper products positively impact water pollution by removing nutrients from the traditional land application on farms to a horticultural, landscaping, residential use.

7.1.2 Poultry Manure Options

7.1.2.1 Co-Combustion

Co-combustion positively impacts water pollution by removing nutrient from traditional land application, however, the pollution control of the combustion exhaust may generate wastewater which must be treated.

7.1.2.2 Composting

As with dairy manure composting, poultry manure composting positively impacts water pollution. Compost is a slow release fertilizer that is used in many non-agricultural markets such as soil blending, residential users, landscapers etc. Compost helps hold nutrients and stabilize slope and soil rather than allowing them to wash into the surface water.

7.2 ABILITY TO REDISTRIBUTE NITROGEN AND PHOSPHORUS

7.2.1 Dairy Manure Options

7.2.1.1 Dewatering Options

Dewatering separates liquid and solid fractions of the manure. Many of the nutrients are found in the solid phase. Although not all of the solids are separated from the liquid phase, dewatering produces a liquid phase and solid phase that can be treated separately. This separation is important for other treatment options such as phosphorus precipitation and composting.

7.2.1.2 Anaerobic Digestion

Anaerobic digestion does not contribute significantly to the ability to redistribute nitrogen and phosphorus. All of the nutrients remain in the digester effluent and must still be handled. The advantage of anaerobic digestion with respect to redistribution of nutrients is the ability to apply the effluent to land that would not be available for application of whole manure due to either odor concerns or the presence of weed seeds.

7.2.1.3 Chemical Precipitation of Phosphorus

Although it has not been proven at a full scale application, chemical precipitation of phosphorus has significant potential for the redistribution of phosphorus. A large fraction of the phosphorus can be removed from the liquid manure in this option. This treated effluent can then be applied at higher application rates to the land and the phosphorus can be transferred to other market sectors.

7.2.1.4 Composting

Composting has significant possibility to transfer nutrients to other markets. Compost has a well developed market in soil manufacturing, landscaping, horticulture and residential uses. The ability to transfer nutrients is related to the fraction of the manure which is composted. For small scale systems, composting the whole manure may be feasible and can redirect all of the nutrients from the manure to other markets. For larger, regional facilities it may be most economical to compost only the solid fraction after dewatering the manure. This method can redirect a significant portion of the nutrients to other markets.

7.2.1.5 Poop Pots/Paper Products

The Poop Pot and Paper technology has the ability to transfer nutrients to an entirely different market. It uses fiber from anaerobically digested manure as a feedstock for its products. Since it only uses the fiber fraction, only this portion of the nutrients will be redistributed.

7.2.2 Poultry Manure Options

7.2.2.1 Co-Combustion

Co-combustion of the poultry manure will transfer all nutrients to another market.

7.2.2.2 Composting

Composting of poultry manure will transfer all nutrients to another market. As discussed with dairy manure composting above, the composting market is well developed and has many users.

7.3 IMPACT ON AIR EMISSIONS / ODOR CONTROL

Most manure handling methods will generate some odor as manure is handled and moved from process to process. Much of this odor can be handled by siting manure handling facilities in areas away from sensitive neighbors.

7.3.1 Dairy Manure Options

7.3.1.1 Dewatering Options

Dewatering dairy manure generates a local source of odor emissions, however, it will not generate any criteria air pollutants. Proper siting of the dewatering operations will allow odors to disperse before impacting neighbors.

7.3.1.2 Anaerobic Digestion

Anaerobic digestion has a significant impact on odors generated. In fact, odor control is a major reason why some large farms have moved to incorporate anaerobic digestion into their manure handling systems. Anaerobic digestion by itself does not generate criteria pollutants, however the combustion of the digester gas generated in the process will generate NOx and low levels of carbon monoxide and particulate. Combustion of the digester gas occurs when digester gas is used to generate power, heat or is flared for disposal.

7.3.1.3 Chemical Precipitation of Phosphorus

Chemical precipitation of phosphorus will not generate any new criteria pollutants. The process may generate some odor as manure liquids are mixed and transferred to different tankage.

7.3.1.4 Composting

Composting will not generate any new criteria pollutants. Composting will generate odors even when it is properly operated. Odor control or remote siting should be considered for composting facilities.

7.3.1.5 Poop Pots/Paper Products

Production of poop pots or paper products will generate criteria pollutants only to the extent that fuels are burned to generate heat for drying the products. As composted digested manure solids are used in the production of these products, there is likely to be only low levels of odor from the process.

7.3.2 Poultry Manure Options

7.3.2.1 Co-Combustion

Co-combustion of poultry manure will generate criteria pollutants including NOx, carbon monoxide, and particulate. The level of criteria pollutants generated will depend on the type and efficiency of emission controls used with the process. As with dairy manure, some odor will be generated in the handling of the manures. The amount of off-site odor will depend on the odor controls put in place and the location of the facility.

7.3.2.2 Composting

Composting will not generate any new criteria pollutants. Composting will generate odors even when it is properly operated. Odor control or remote siting should be considered for composting facilities.

7.4 ABILITY TO DEVELOP RENEWABLE ENERGY

7.4.1 Dairy Manure Options

Of the options considered in more detail for dairy manure treatment, only anaerobic digestion has the potential to produce renewable energy. Anaerobic digestion produces digester gas which contains methane. The digester gas can be burned to produce either heat or electricity.

7.4.2 Poultry Manure Options

Of the options considered in more detail for poultry manure, only co-combustion has the potential to produce renewable energy. The proposed co-combustion process will produce power as well as steam and waste heat. The proposal includes use of steam and waste heat in the egg processing plant and sale of power to the grid.

7.5 GREENHOUSE GAS AND CONNECTICUT CLIMATE CHANGE ACTION PLAN

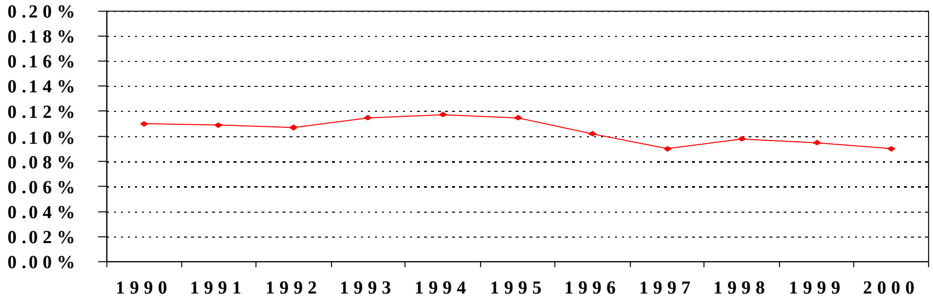
7.5.1 Connecticut Climate Change Action Plan

The Connecticut Climate Change Action Plan[1] was developed by a steering committee of a broad range of stakeholders. This action plan, released in February 2005, develops strategies to reduce Connecticut's collective emissions of greenhouse gasses to 1990 levels by 2010, and 10% below that level by 2020.

The majority of greenhouse gas emissions in Connecticut come from fossil fuel combustion. Management of agricultural manure is identified as a source of greenhouse gas emissions, accounting for less than 0.2% of the state's annual emissions.

[1] http://www.ctclimatechange.com/StateActionPlan.html

FIGURE 7-1
PERCENTAGE OF CONNECTICUT GREEN HOUSE GAS EMISSIONS ATTRIBUTED TO MANURE MANAGEMENT, 1990 – 2000[2]



One recommendation in the Connecticut Climate Change Action Plan deals directly with management of agricultural manure. Recommendation #35 calls for the installation of "centralized manure digesters' for the generation of energy. The plan calls for the installation of one unit by 2010, two units by 2015, and three units by 2020. Accounting for reductions of greenhouse gas emissions and offsets from energy generation, the Connecticut Climate Change Action Plan estimates that this could save the equivalent of 0.017 million tons of CO_2 by 2010, and the equivalent of 0.052 million tons of CO_2 by 2020. For reference, Connecticut's total greenhouse gas emissions were 46.450 million tons of CO_2 equivalent in 2000, 41.695 tons of CO_2 equivalent in 1990.

7.5.2 Greenhouse Gas Credits

Because of its emissions profile, there has been significant interest from developers of anaerobic digestion facilities to participate in greenhouse gas offset markets – in effect deriving revenue from the carbon or methane not emitted. At this time, greenhouse gas offset markets in the United States are in the formative stages, and the revenue associated with carbon offsets is modest. Nationally, carbon offsets can presently be sold for between $1.00 and $2.00 per ton, and these transactions are generally used to satisfy voluntary reductions or are speculative.

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[2] Data Source: *Connecticut Climate Change Action Plan 2005: History of Connecticut's Climate Change Leadership*. February 15, 2005.

However, it is highly unlikely that trading greenhouse gas credits would be in the economic interest of an anaerobic digestion facility generating electricity. This is because it is generally accepted that energy producers must choose to participate in either the greenhouse gas market or the renewable energy credit market, but cannot participate in both. When a renewable energy producer sells a green credit (REC), they sell all of the non-price attributes associated with the generation – "including but not limited to the unit's fuel type, emissions, vintage and RPS eligibility."[3]

The sale of a renewable energy certificate, combined with the sale of greenhouse gas credits, is referred to as "partial double sale". In this instance, the purchaser of the renewable energy certificate reasonably expects to own and control all generation attributes, but one attribute – greenhouse gas emissions – is sold to another party. While each state addresses this issue separately, the Green Electricity Marketing Guidelines prepared by the National Association of Attorneys General discourage this practice.[4]

7.5.3 Dairy Manure Options

None of the dairy manure options considered will produce more greenhouse gases than the natural decomposition of the manure, therefore, all options would be greenhouse gas neutral. Only the anaerobic digester options contribute to meeting the goals of the Connecticut Climate Change Plan.

7.5.4 Poultry Manure Options

As with the dairy manure, none of the poultry manure options considered will produce more greenhouse gases than the natural decomposition of the manure. All poultry manure options are greenhouse gas neutral. Although not specifically mentioned in the Connecticut Climate

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[3] 225 CMR 14.02: Definitions – Massachusetts Renewable Portfolio Standard
[4] Holt, Ed. "Renewable Energy Certificates and Generation Attributes." *Regulatory Assistance Project Issues Letter*. May 2003.

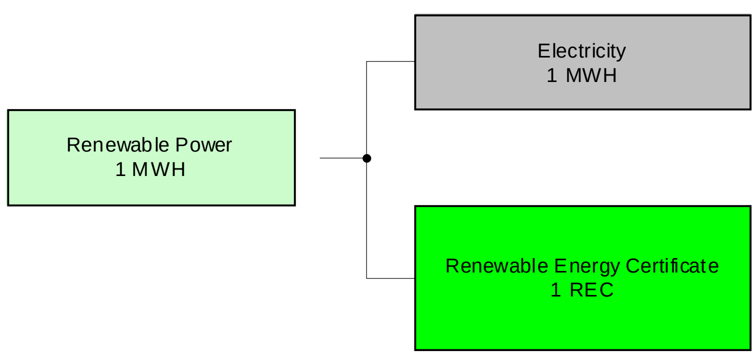
Change Plan, co-combustion of poultry manure meets some of the plans goals by using agricultural manure to generate power and heat for use by the egg processing plant. This energy is replacing energy currently produced by using fossil fuel generated power and heat.

7.6 ABILITY TO MEET THE CONNECTICUT CLASS I RENEWABLE PORTFOLIO STANDARD

7.6.1 Regional Markets for Renewable Power

Electricity generated from renewable sources produces two distinct products –the electricity and the "green" or renewable attributes associated with that electricity. These renewable attributes are referred to as Renewable Energy Certificates, or RECs (also Green Tag, Green Credits, and other names). For each Megawatt Hour of electricity generated, one REC is generated. These two products, electricity and RECs, can be separated, or unbundled, and sold individually.

FIGURE 7-2
PRODUCTS FROM RENEWABLE ENERGY



Three states in New England – Connecticut, Massachusetts and Rhode Island – have "renewable portfolio standards" (RPS) that currently provide meaningful economic opportunities for renewable generation facilities to operate. An RPS is essentially a mandate that any seller of electricity operating in that state must derive a certain portion of that electricity from renewable sources. Each state defines what qualifies as "renewable" for purposes of their portfolio standard, so that generation that qualifies in one state does not necessarily qualify in other states.

Generation facilities based in Connecticut can sell RECs to customers in Connecticut, Massachusetts and Rhode Island, given the limitations described below.

7.6.1.1 Connecticut Renewable Portfolio Standard

Connecticut has a renewable portfolio standard that requires that 6% of electricity sold in the competitive marketplace to come from renewable generation in 2002, increasing annually. Connecticut has two classes of renewables; generation from "new, sustainable biomass" (Class 1, along with wind, landfill gas, and solar) receives preference over some other types of renewable power.

Year	Class 1 RPS Percentage	Class 2 RPS Percentage
2004	1.0	5.5
2005	1.5	5.5
2006	2.0	5.5
2007	3.5	5.5
2008	5.0	5.5
2009	6.0	5.5

Qualification of Dairy Manure Anaerobic Digestion Generation: The Connecticut Renewable Portfolio Standard does not list electricity from anaerobic digestion as a qualifying source, though does allow the Department of Public Utility Control to allow technologies in on a case-by-case basis. One anaerobic digestion facility, Blue Spruce Farm in Vermont, began the application process to qualify for the Class 1 Connecticut RPS, but withdrew before a final decision was reached[5]. A developer would need to go through the qualification process prior to becoming assured that they would qualify for the Connecticut RPS, Class 1.

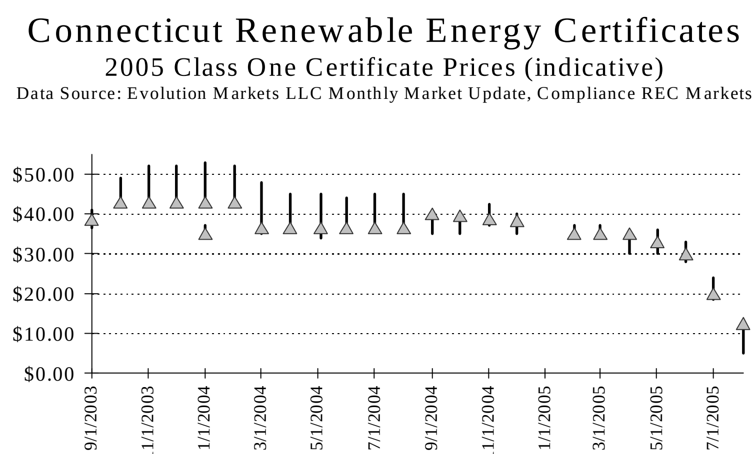
Qualification of Poultry Manure Gasification Co-Generation Facility: The statute regarding qualification for the Connecticut Class 1 Renewable Portfolio Standard is not clear regarding use of poultry litter as a fuel. While it is likely that such a facility could be eligible, a project

[5] Connecticut Department of Public Utility Control, Docket # 04-10-32.

developer would need to petition the Connecticut Department of Utility Control (DPUC) for an Advisory Ruling. Given the language of the statute, it is likely that a facility that emitted less than 0.75 pounds of NOx per million BTU would be included in the Class 1 RPS.

Price Premium: Demand for Connecticut-qualified Class 1 RECs has dropped significantly in recent months. With a price cap of $55.00 (fixed, not adjusted for inflation), Connecticut Class 1 RECs for calendar year 2005 traded between $30 and $40[6] for much of this year. However, with some new generation coming on-line, prices have dropped to under $10 per 2005 REC. Prices for RECs may rise in future years as overall demand grows. RECs also trade for forward years. The price history of 2005 RECs is summarized below.

FIGURE 7-3
PRICE OF CONNECTICUT CLASS 1 RECS



It should be noted that there is a strong possibility that Connecticut Class 1 REC prices will not remain at their current levels, and facilities considering investments in order to participate in the REC market should carefully analyze future supply and demand risks.

[6] Evolution Markets LLC. *Monthly Market Update: Compliance REC Markets.*

7.6.1.2 Massachusetts Renewable Portfolio Standard

Massachusetts has a renewable portfolio standard that required 1% of electricity be procured from eligible providers in 2003, with the percentage required climbing annually until at least 2009, when 4% renewable power will be required.

Year	RPS Percentage
2003	1.0
2004	1.5
2005	2.0
2006	2.5
2007	3.0
2008	3.5
2009	4.0

Qualification of Anaerobic Digestion Generation: The Massachusetts Division of Energy Resources has already qualified one anaerobic digestion facility, Blue Spruce Farm in Vermont, for participation in the RPS[7].

Participation by Connecticut Facilities: Connecticut generators that sell electricity onto the grid in the ISO-New England region may participate in the Massachusetts RPS.

Price Premium: Demand for Massachusetts-qualified RECs currently exceeds supply, and the price reflects this. With a price cap of $50.00 (in 2003 dollars, adjusted annually for inflation[8]), Massachusetts RECs for calendar year 2005 are trading near the price cap[9]. This means that <u>in addition to receiving payment for the sale of electricity</u>, a Massachusetts RPS qualified generator could receive roughly another $50 / megawatt hour ($0.05 per kWh). RECs also trade for forward years. The price history of 2005 RECs is summarized below.

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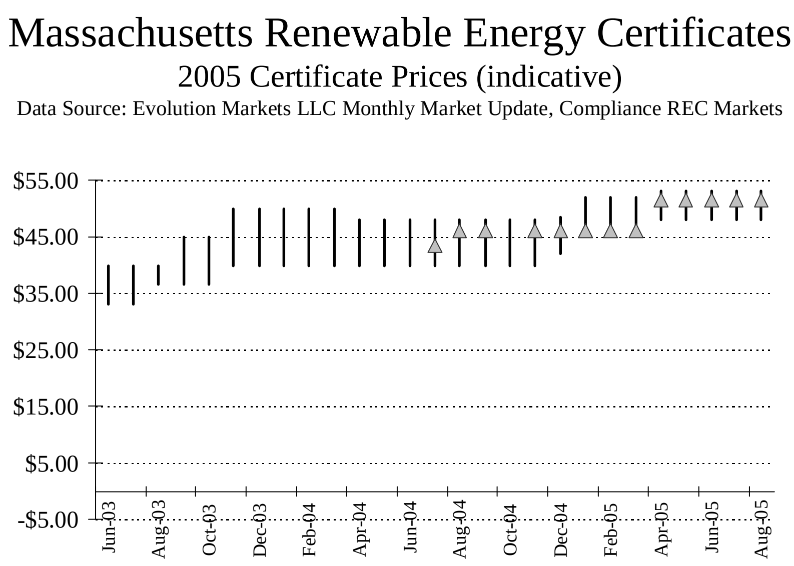
[7] Massachusetts Division of Energy Resources. *Statement of Qualification – Blue Spruce Farm, Inc.* MA RPS ID #: AD-1032-04. September 29, 2004.
[8] The 2005 Alternative Compliance Payment, which serves as the price cap, is $53.19 per MWh.
[9] Evolution Markets LLC. *Monthly Market Update: Compliance REC Markets.* August 2005.

FIGURE 7-4
PRICE OF MASSACHUSETTS RECS



It should be noted that there is a strong possibility that REC prices will not remain at their current levels, and facilities considering investments in order to participate in the REC market should carefully analyze future supply and demand risks. Massachusetts is currently considering policy options that would allow a number of older biomass facilities to participate in the RPS[10], likely causing a significant decrease in REC prices.

7.6.1.3 Rhode Island Renewable Portfolio Standard

In June 2004, Rhode Island established a renewable portfolio standard. This RPS begins in 2007, and increases annually until 2019. It contains provisions for both new and existing renewable generation.

[10] http://www.mass.gov/doer/rps/notice_of_inquiry.htm

Year	Existing	New
2007	2.0%	1.0%
2008	2.0%	1.5%
2009	2.0%	2.0%
2010	2.0%	2.5%
2011	2.0%	3.5%
2012	2.0%	4.5%
2013	2.0%	5.5%
2014	2.0%	6.5%
2015	2.0%	8.0%
2016	2.0%	9.5%
2017	2.0%	11.0%
2018	2.0%	12.5%
2019	2.0%	14.0%

Qualification of Anaerobic Digestion of Dairy Manure or Gasification of Poultry Manure Generation: The Rhode Island Renewable Portfolio Standard specifically lists "agricultural waste" as a qualifying fuel. It is expected that an anaerobic digestion using manure as a fuel would qualify for the RPS.

> "Eligible biomass fuel: means fuel sources including brush, stumps, lumber ends and trimmings, wood pallets, bark, wood chips, shavings, slash and other clean wood that is not mixed with other solid wastes; agricultural waste, food and vegetative material; energy crops; landfill methane; biogas; or neat bio-diesel and other neat liquid fuels that are derived from such fuel sources."[11] (Emphasis added)

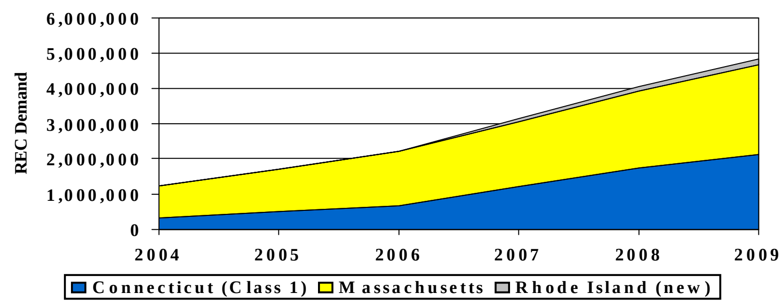
Ability of Connecticut Generators to Participate. Qualifying Connecticut renewable energy facilities that sell into the ISO-New England region are eligible to participate in the RPS.

Price Premium. As the Rhode Island RPS has just been established, there is no pricing available at this time. There is a price cap of $50.00 per REC (2003 dollars), which will be adjusted annually for inflation.

Total Demand for High-Value RECs

The demand for high-value RECs will grow in coming years, as state renewable requirements increase and overall electricity demand in the region grows.

FIGURE 7-5
ANTICIPATED NEW ENGLAND HIGH-VALUE REC DEMAND 2004-2009



Future REC supply is unknown at this point, and is highly dynamic. A number of biomass, wind and landfill gas facilities may be built or re-tooled, but completion of many of these projects is far from certain.

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[11] Rhode Island General Assembly. *An Act Relating to Public Utilities & Carriers – Renewable Energy Standard.* 2004 Session, House Bill 7375 as amended.

SECTION 8
FUNDING SOURCES

This section of the report identifies and reviews existing funding assistance sources that can assist CAFO operators in implementing manure waste management projects. It also presents a discussion of future potential funding assistance tools, and provides recommendations for consideration by the Advisory Board.

The options and tools presented in this section are described in the following manner:

- Section 8.1 discusses existing federal sources
- Section 8.2 discusses existing state sources
- Section 8.3 presents a discussion of potential new sources
- Section 8.4 provides recommendations for consideration by the Advisory Board

8.1 FEDERAL SOURCES OF FUNDING

Numerous federal funding sources are applicable to the farming industry in Connecticut. However, few sources are oriented towards manure management and pollution control programs. For the sake of completeness, most of the available programs administered by USDA Natural Resources Conservation Service (NRCS) and USDA Rural Development (RD) are listed in Appendix C.

Programs with direct potential applicability to manure management projects of the type considered in this report are the Environmental Quality Incentives Program (EQIP) and the Renewable Energy and Energy Efficiency Program.

Of the USDA-NRCS programs, the EQIP funding is the most important in terms of offering potential direct support for the capital costs of manure management facilities. According to USDA-NRCS representatives in Connecticut, the EQIP program is oriented towards single farms, not groups of farms or cooperatives. Therefore, the program is potentially applicable to a single-farm manure management system, and to the on-farm components of a regional manure management system. EQIP funding can support up to 75% of the total cost of eligible projects, to a maximum of $450,000 per farm over the life of the 2002 Farm Bill (2002 to 2007).

Additional discussions with NRCS indicate that it is theoretically possible for multiple farmers to apply for EQIP funds for a single, joint waste management project, provided that each farmer is individually financially responsible for his or her component of the project. In other words, if a regional manure management project had 10 farms as participants, it is possible to consider that each of the 10 farms could apply separately to USDA-NRCS for EQIP funding. Each application would then be considered on its own merits as a separate project. This has not been done as yet with EQIP but there is no reason that it could not be presented to USDA-NRCS for consideration.

The level of funding committed in Fiscal Year 2005 for Connecticut for the EQIP program is $4.71 million. Funding is allocated annually by Congress. In Connecticut, funding decisions are dependent on many factors including the range of proposals received and the ranking applied to proposals. Shifting priorities in federal funding may change the amount of EQIP program support potentially available to Connecticut farmers.

The Conservation Innovation Grants (CIG) program, which is a relatively new program administered by USDA-NRCS at a national level, has supported a wide variety of hands-on projects oriented towards innovative means of farm waste management. No projects have been supported in Connecticut to date. However, it appears that this program could be applicable to research into innovative means of managing farm wastes, including efforts to combine farm wastes with other types of wastes in Connecticut. It is not judged, however, that the CIG program would be suited to provide substantial capital support to a waste management project.

In addition to programs administered through USDA-NRCS, the study team has examined programs supported by USDA Rural Development that could be applicable to renewable energy projects.

TABLE 8-1
POTENTIAL FEDERAL FUNDING SOURCES THROUGH
UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)

Program	Through	Description	Applicability	Funding in FY 2005
EQUIP and NRCS Technical Support	USDA Natural Resources Conservation Service (NRCS)	The program funds up to 75% cost sharing per farm, up to 450K funding per farm over the life of the farm bill (2002-2007). NRCS staff also provide technical assistance to farmers.	In wide use in CT	$4.71 million
Business and Industry Program	USDA Rural Development	The program provides loan guarantees to business and industry located in defined rural areas	Not applicable to agricultural production but could be potentially applicable to support services such as manure management	$5 million to date in CT (for a nursery operation)
Renewable Energy and Energy Efficiency Improvements Program	USDA Rural Development	Provides competitive grants and loans to farmers undertaking projects in biomass, wind, solar, hydrogen, and energy efficiency	Applicable in CT, however, no applications to date from CT	$22.8 million nationally, three fiscal years running

The *Renewable Energy and Energy Efficiency Improvements Program* is applicable to farmers, ranchers, and rural small businesses. According to the Small Business Administration (SBA), should a regional waste management facility fall under NAICS category 562219 (other non-hazardous waste management) the facility would qualify as a small business if annual sales were up to $10.5 million. This is likely in the case of a regional facility in Connecticut, thus, this program should be potentially applicable to a regional project in Connecticut.

According to available information, the program has, on a national level, provided funding support of nearly $13 million for digesters and bioenergy projects in FY 2004. That program continues for five years, and it is an ongoing application process. According to USDA-RD representatives, the program has not yet seen any applications from Connecticut. In this program, up to $500,000 per application can be considered, with up to a 25% grant and 75% guaranteed loan.

The Business and Industry Program administered by USDA-RD provides guaranteed loans to rural small businesses. These cannot be agricultural producers. However, discussion with USDA-RD representatives suggests that a regional manure management facility could be justifiably considered a small business in support of the farming industry, therefore, the loan program could have applicability.

8.2 STATE SOURCES OF FUNDING

State sources of funding for farmers in Connecticut are listed in Appendix D. Of the programs listed, the single program with direct potential applicability to manure waste management projects is the Environmental Assistance Program (EAP). Information on the EAP has been obtained from review of the Connecticut Department of Agriculture (DOAG) website, discussion with USDA-NRCS representatives, and discussion with representatives of DOAG.

The EAP is designed to provide potential support funding for a project, up to a level of 90% of the total project cost. Under the existing program rules, the program can support up to $40,000 per project component per farm. In other words, a single farm could apply for multiple components, such as a manure separator, storage lagoon, and so on. The EAP is clearly applicable to waste management programs and projects of farmers in Connecticut. Its purpose is to assist farmers in supporting a project where the farmer would be making use of EQIP financing, therefore it is designed to provide “top-up” financing support. Typically, EAP has worked closely with EQIP, and DOAG cooperates closely with USDA-NRCS in Connecticut.

The Commissioner of Agriculture makes a determination on the full number of projects for which financing is requested. From this, a recommendation for EAP funding is provided to the Bond Commission. At that point, the Commission makes a decision on providing the funds to the program. Historically there have been delays in the actions of the Bond Commission, resulting in some uncertainty with regard to program funding.

Discussion with CT DOAG also suggests that the EAP could be applicable to a regional facility as well as to a single farm. The EAP has not yet been used in this fashion in Connecticut.

8.3 POTENTIAL NEW SOURCES OF FUNDING

In addition to the existing federal and state sources of funding for farms in Connecticut, the study team and the Advisory Board have discussed potential new sources of funding. The primary potential source is the use of the *Clean Water Fund* (CWF) for partial financing of agricultural waste management projects undertaken by the private sector.

This concept has been discussed with various members of the Advisory Board on several occasions. The underlying concept is that modifications would be made to the funding mechanisms in the CWF to provide partial financing assistance to farmers, groups of farmers, and/or other entities for partial financing of agricultural waste management projects. Currently, the CWF consists of five accounts: the Water Pollution State Account; the Federal Revolving Loan Account; the Long Island Sound Clean-up Account; the River Restoration Account; and the Drinking Water Revolving Fund Account. Priorities under the CWF are identified on an annual basis. Funding applications are made to the state and funds are identified accordingly. However, the actual disbursement of funds is dependent on approvals by the Legislative Bond Commission.

Eligible parties that may apply for funds under the state’s CWF programs are currently municipalities. The modifications to allow the fund to provide financing to the private sector are not fully known, nor is it known if such modifications would be solely administrative or if they would require legislative changes.

Individual states have considerable flexibility in how they establish their instate programs for distribution of federal Clean Water Act funds to fund waste management and treatment facilities. It is noted that at least one other state has developed a revolving loan program to provide financing to farmers for pollution control projects. This is North Dakota, which has developed the *North Dakota Livestock Waste Management System Loan Program* under which farmers can apply for up to $100,000 in low interest loans in support of waste management system construction and upgrading. Discussion with representatives of that program has indicated that there is insufficient history with the project to clearly define how successful this program is or might become.

8.4 RECOMMENDATIONS

In view of the findings presented in the previous three subsections, several recommendations for consideration by the CAFO Advisory Board are presented below.

Groups interested in a regional manure facility should examine the applicability of EQIP funding for a regional project in which participant farmers would apply individually for support. The groups should also examine the applicability of the DOAG EAP funding for a regional manure management project.

Groups interested in a regional manure facility should review the availability of federal funding under the USDA-NRCS *Renewable Energy and Energy Efficiency Program* such that farmers who are considering undertaking energy efficiency or methane digester projects can look to this fund for support. Further, the groups should examine this program in light of its potential to support a regional digester project.

The DEP should consider the possibility of modifying the Clean Water Fund program(s) to include agricultural waste management projects. The Department could investigate the programs of other states such as South Dakota to explore how those programs have assisted farmers.

The DEP, working cooperatively with the CT DOAG, should ensure that there is a suitable program for educating legislators on the importance of adequate funding for the waste management needs of the CAFO farms in Connecticut and work to develop adequate funding programs. When the CAFO General Permit is issued, there needs to be sufficient funding support in place for the regulated community.

SECTION 9

REGULATORY REVIEW

A regional manure management facility crosses many regulatory areas, including agricultural regulations (manure management), environmental regulations (solid waste facility, air discharge), power generation, sale and transmission regulations. The State of Connecticut regulations were reviewed in each of these areas for applicability to a regional manure management facility and are discussed briefly below.

9.1 AGRICULTURAL REGULATIONS

The most applicable agricultural regulation is the new General Permit on Concentrated Animal Feeding Operations regulations. These new rules, while technically regulations under the Department of Environmental Protection, apply to dairy and poultry farms of a certain size. These regulations have been detailed in the Technical Report on Impact of General Permit on Concentrated Animal Feeding Operation in Connecticut dated March 2003.

9.2 ENVIRONMENTAL REGULATIONS

The Connecticut Department of Environmental Protection (DEP) has multiple regulatory permits that are designed to prevent the contamination of the environment due to large-volume waste management facilities. At the detailed design phase, the DEP offers the opportunity for the project planners to have a roundtable discussion with all permitting representative in order to determine exactly which permits apply to the type of facility proposed for construction. The types of permits which might be applicable are discussed briefly below.

- **CAFO General Permit** - The General Permit for Concentrated Animal Feeding Operations is currently being developed by the DEP. Once issued, this General Permit will regulate manure management activities practiced on larger farms which meet the definitions in the permit. The NRCS requires a Comprehensive Nutrient Management Plan (CNMP) as part of approval for funding under the EQIP funding program. When the General Permit is issued, CNMPs recently developed with NRCS will meet permit requirements for most CAFOs in Connecticut.

- **Solid Waste Management Facility** - Once manure is removed from individual farms, handling/treatment facilities are no longer considered "agricultural" but would be regulated by the solid waste management regulations. The permit would highly depend on the type of material produced and the size of the operation. For solid waste permitting contact Kim Hudak (Phone 860-424-3396) at the DEP Solid Waste Management Program.

- **Waste Transporter Permit -** Based on preliminary discussions with the DEP, transport of manure would be exempt from the waste transporter regulations. This should be verified in writing as the project moves into a preliminary design stage.

- **Air Discharge Permit -** The regional digester will emit criteria pollutants from its emergency flare and from any device which burns the biogas (such as a generator engine or turbine). Connecticut air regulations require different permits and registrations depending on the level of air emissions from a facility. This permit must be obtained before beginning construction of the facility. The permit application should therefore be prepared upon completion of the preliminary design.

- **Land Application Permit -** Based on preliminary discussions with the DEP, application rates of the materials taken from a potential regional facility would be regulated by the individual Nutrient Management Plans developed by each land owner/farmer who would use the material as fertilizer. Therefore the regional facility would not need a separate Land Application permit; that is unless it planed on using the discharged material on land owned by the facility itself.

- **Wastewater Discharge Permit (NPDES) -** All waste produced by a regional facility would be land applied either at the dairies or at other farms in the area, or processed for sale off-site. No wastewater will be discharged to the environment or to any local sewer. Therefore no wastewater discharge permit is necessary.

- **NPDES Stormwater Permit -** Construction sites of greater than 5 acres are categorically included in the federal stormwater regulations. After construction and during continual use, a stormwater management plan will likely be required for the Regional Facility.

9.3 POWER REGULATIONS

9.3.1 Net Metering and Interconnection

Net metering allows owners of small energy generation facilities to get credit for electricity generation provided to the grid, while simultaneously allowing internal use by a facility when necessary. For a net metered facility, the electricity meter will run forwards when the facility is using electricity from the grid and will run backwards when the renewable energy system is producing more electricity than is being used. Billing at the end of the month is based on net electricity usage.

Connecticut, along with thirty-five other states, has a net metering provision. However, net metering is limited to residential Class 1 renewable generators under 100 kilowatts[1]; it is unlikely that anaerobic digestion would be at this scale or in this customer class.

Strict rules govern interconnection of renewable energy generators to the electricity grid, allowing access by distributed generation providers and safeguarding the electricity transmission and distribution system. In Connecticut, the two utilities responsible for the vast majority of the transmission and distribution system, Connecticut Light & Power and United Illuminating, have adopted rules for distribution systems less than 25 MW in size[2].

[1] Connecticut Public Law 03-135, enacted June 26, 2003.
[2] Connecticut Department of Public Utility Control Docket 03-01-15, enacted April 30, 2004.

The rules provide a standard application process and provide limits on the amount of time the utilities have to review and decide upon an interconnection. There are up to eleven steps in the process, as described below[3]:

1. Submission of application for interconnection;
2. Utility reviews application;
3. Utility conducts feasibility study;
4. Applicant authorizes an impact study;
5. Utility performs impact study;
6. Applicant authorizes electric power system facility study;
7. Utility performs electric power system facility study;
8. Applicant executes interconnection agreement, authorizes work and defrays costs;
9. Project construction;
10. Applicant completes commissioning, pre-parallel testing;
11. Final acceptance, cost reconciliation, authorization to connect.

[3] From the *Database of State Incentives for Renewable Energy*, www.dsireusa.org

SECTION 10
SUMMARY AND RECOMMENDATIONS

This section summarizes the options considered for individual and regional dairy and poultry manure management and provides recommendations on manure management alternatives and implementation.

10.1 TECHNOLOGY COMPARISON

In order to compare the technologies under consideration, comparison tables were developed listing each option and the list of evaluation parameters. The individual dairy farm options, regional dairy manure facility options and poultry manure options are discussed below.

10.1.1 Individual Dairy Farm

Three options were considered for the individual dairy farm: liquid/solid separation, composting whole manure, and chemical precipitation of phosphorus. Table 10-1 summarizes the dairy manure farm options. Many of the parameters are the same for the three options developed. Air Emissions Impacts are neutral, no renewable energy is produced, and greenhouse gases and criteria air pollutants are the same as existing methods.

The liquid/solids separation does not necessarily move any nutrients away from the traditional land application but it does allow different application methods to be used and the possibility of exporting solids to another market. It may also allow liquid injection on grasslands and corn fields not available for surface application of manure. By comparison, whole manure composting has the potential to move all of the nutrients away from the traditional land application and chemical precipitation moves a majority of the nutrients off farm.

TABLE 10-1

	Dairy Manure - Individual Farm Options		
Review Parameter	**Liquid/Solid Separation**	**Composting Whole Manure**	**Liquid/Solid Separation and Chemical Precipitation**
1. Technical Feasibility	High, Similar Facilities Exist	High, Similar Facilities Exist	Moderate. Not many Full size facilities
2. Economic Feasibility	$730 per cow per year Cap. Cost = $516,600	$880 per cow per year Cap. Cost = $979,000	$1,030 per cow per year Cap. Cost = $628,600
3. Nutrients moved to a new market	19% of N 50% of P (31% of N is lost)	24% of N 100% of P (76% of N is lost)	29% of N 92% of P (46% of N is lost)
4. Water Pollution Impacts	Neutral	Reduction	Reduction
5. Air Emission Impacts(2)	Neutral	Neutral	Neutral
6. Renewable Energy Production	None	None	None
7. CT Class I Renewable Portfolio Standard	Does Not Meet	Does Not Meet	Does Not Meet
8. Greenhouse Gases (1):	No Change	No Change	No Change
9. Criteria Air Pollutants	No Change	No Change	No Change
10. Funding Mechanisms	EQUIP Funding	EQUIP Funding	EQUIP Funding
11. Contribution to Climate Change Action Plan	N/A	N/A	N/A

10.1.2 Regional Dairy Manure Facility Options

Three options were considered for the regional dairy manure facilities: composting dewatered manure assuming dewatering occurs at the individual farm, anaerobic digestion of the whole manure followed by liquid/solid separation and composting of the solids, and anaerobic digestion of the whole manure followed by liquid/solid separation, chemical precipitation of phosphorus and composting of the manure solids and phosphorus precipitate. Table 10-2 summarizes the regional dairy manure options.

TABLE 10-2

	Dairy Manure - Regional Facility Options		
Review Parameter	**Composting with Liquid/Solid Separation at Farms**	**Anaerobic Digestion And Composting (or Poop Pots)**	**Anaerobic Digestion, Composting, and Chemical Precipitation**
1. Technical Feasibility	High, Similar Facilities Exist	High, except for Poop Pots which has not been demonstrated at full size facility	High
2. Economic Feasibility	$160 per cow per year	$685 per cow per year	$780 per cow per year
3. Nutrients moved to a new market	7% of N 50% of P (51% of N is lost)	7% of N 50% of P (60% of N is lost)	11% of N 93% of P (66% of N is lost)
4. Water Pollution Impacts	Reduction	Reduction	Reduction
5. Air Emission Impacts[2]	Neutral	Significant Odor Reduction Increase in Criteria Pollutants	Significant Odor Reduction Increase in Criteria Pollutants
6. Renewable Energy Production	None	Digester Gas Produced. Can be used for Power and/or Heat Production	Digester Gas Produced. Can be used for Power and/or Heat Production
7. CT Class I Renewable Portfolio Standard	N/A	No, but could apply	No, but could apply
8. Greenhouse Gases [1]:	No Change	No Change if digester gas is burned	No Change if digester gas is burned
9. Criteria Air Pollutants	No Change	Increased	Increased
10. Funding Mechanisms	EQUIP Funding	EQUIP Funding	EQUIP Funding
11. Contribution to Climate Change Action Plan	No	Yes	Yes

1. Without treatment, manures are digested in soils to CO_2. With each of these options the manure carbon eventually is transferred to the CO_2 form.

2. Biogas production from Anaerobic digestion. Combustion of biogas increases NOx, SOx, and PM emissions.

All of the regional options are technically feasible and have the potential to move 50% of the nutrients to other markets. The option using chemical precipitation could move up to 93% of the phosphorus to a different market. The composting only option is neutral to air emission impacts, positive to water pollution impact and does not create any renewable energy. The two options with anaerobic digestion can produce renewable energy and should be able to meet Connecticut Class I renewable portfolio standards but must apply for such a designation. Since the digester gas will be burned, there will be an increase in criteria air pollutants. Anaerobic digestion will decrease the odor produced.

10.1.3 Poultry Manure Options

Two options for poultry manure operations were considered: Co-combustion with waste wood and composting whole manure. No distinction was made between individual farm and regional facilities for poultry manure since the individual farms are of a size that a regional facility would be. Table 10-3 summarizes the poultry manure options. Both options are technically feasible. Costs were not available for the co-combustion option so a comparison of costs cannot be done.

The co-combustion option generates ash, power, steam and heat. The ash is high in phosphorus and can be a saleable product. The power steam and heat will be used at the farms for the egg processing facility. The co-combustion option will generate criteria air pollutants due to the combustion process but these can be controlled to meet air quality criteria.

The composting option will have a positive impact on water quality which minimizes water pollution since compost is a slow release fertilizer and is less likely to leach into surface or groundwater than inorganic forms of fertilizer. Odor is generated in a composting process but can be controlled with appropriate odor control equipment.

TABLE 10-3

	Poultry Manure Options	
Review Parameter	**Co-Combustion with waste wood**	**Composting Whole Manure**
1. Technical Feasibility	High	High, Similar Facilities Exist
2. Economic Feasibility	Unavailable	$91 per ton
3. Nutrients moved to new market	100% of N 100% of P	100% of N 100% of P
4. Water Pollution Impacts	Reduction	Reduction
5. Air Emission Impacts	Increased	Neutral
6. Renewable Energy Production	Power, Steam, and Heat produced	None
7. CT Class I Renewable Portfolio Standard	No, but could apply	N/A
8. Greenhouse Gases [(1)]	No Change	No Change
9. Criteria Air Pollutants	Increased	No Change
10. Funding Mechanisms	Private Sector EQUIP Funding	Private Sector EQUIP Funding
11. Contribution to Climate Change Action Plan	Yes	No

10.2 IMPACTS ON NUTRIENT SURPLUS OF MANURE MANAGEMENT OPTIONS

Table 10-4 presents a summary of the estimated statewide nutrient reductions for dairy and poultry manure based on five management scenarios. The implemented manure management scenarios include the following:

- § Management of all poultry manure in New London County by co-combustion or composting, (assuming all manure is transferred to other markets);
- § Management of all poultry manure in New London County and four regional dairy manure composting facilities serving New London, Windham, Tolland, Litchfield and Hartford counties, (assuming all poultry manure and all dairy compost is transferred to other markets and dairy dewatered liquid is land applied at the participating dairy farms);
- § Management of all poultry manure in New London County and all dairy manure on CAFO farms using composting of whole manure, (assuming all poultry manure and all dairy manure is transferred to other markets), and;
- § Management of all poultry manure and all dairy manure using regional composting of dewatered manure and on-farm composting of whole manure, (assuming all poultry and diary manure is transferred to other markets except for the dewatered liquid which is land applied at the participating farms of the regional facilities).

This table only addresses the dairy and poultry manure and not all manure in the state.

TABLE 10-4
STATEWIDE DAIRY AND POULTRY NUTRIENT REDUCTIONS

Implemented Management Scenario	Poultry & Dairy Nutrient Reduction (lbs)		Poultry & Dairy Nutrients Land Applied (lbs)		% of Available Land Required	
	N	P	N	P	N	P
Current [1]	0	0	10,278,739	2,709,839	101%	144%
Poultry	4,312,631	1,635,825	5,966,109	1,074,013	58%	57%
Poultry & Regional Dairy	5,791,141	1,900,012	4,487,599	809,826	44%	43%
Poultry & All CAFOs [2]	5,977,301	1,973,555	4,301,438	736,284	42%	39%
All Poultry and Dairy	8,154,868	2,606,271	2,123,871	103,568	20%	6%
Notes:						
(1) All Dairy and Poultry Manure						
(2) Assumes that All CAFO cows that are within the geographic region of regional facility locations will be a part of regional manure management. All CAFO cows that are not within regional facility sphere of influence are assumed to have manure managed by on farm composting.						

The management of poultry manure in New London County has the single largest impact on the reduction of nutrients statewide. Implementing four regional composting facilities at the highest dairy density locations in the state is estimated to further reduce nitrogen and phosphorus and increase the percent of available land by approximately 14% and 15%, respectively. Providing manure management at all CAFO dairy farms would only provide a marginal reduction in nutrients comparatively. Although if all dairy farms are included the reduction is much greater, this assumes that the individual farms are composting whole manure where all the nutrients are leaving the farm. This case is unlikely to occur.

Table 10-5 presents the nutrient reductions for all manure and diary and poultry manure on a county by county basis assuming that all the poultry manure is managed with one of the two options and that four regional dairy manure composting facilities have been implemented. Some counties see little or no reduction in the overall percentage of available acres needed as the manure in these counties are neither dairy nor poultry manures targeted for a regional facility. Although the impact of dairy and poultry manure management can be seen in Table 10-4, the impact of improved poultry and diary manure management is less evident when all manures are considered. Table 10-5 shows that when all manure is considered, almost every county has more manure generated than it has grasslands and corn fields to handle. While implementing the CAFO General Rule will help with the nutrient surplus, addressing the other manures will be necessary to deal with the statewide nutrient surplus.

TABLE 10-5
PERCENTAGE OF AVAILABLE ACRES NEEDED FOR AGRONOMIC NUTRIENT APPLICATION FOR CURRENT CONDITIONS AND IMPLEMENTATION OF POULTRY AND REGIONAL DAIRY OPTIONS

AREA	CURRENT CONDITIONS ALL MANURE		Poultry and Regional Dairy Option Implemented			
			ALL MANURE		DAIRY AND POULTRY	
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
State	149%	213%	92%	112%	44%	43%
Fairfield	75%	96%	75%	96%	15%	17%
Hartford	86%	114%	78%	106%	22%	22%
Litchfield	83%	99%	71%	87%	34%	33%
Middlesex	92%	117%	92%	117%	34%	35%
New Haven	94%	120%	94%	120%	40%	42%
New London	325%	567%	93%	111%	45%	44%
Tolland	138%	159%	118%	140%	63%	60%
Windham	133%	152%	112%	132%	61%	59%

10.3 COST OF IMPLEMENTATION

Since it is not possible to predict which CAFO farms will choose to be involved in the regional facilities, the costs of implementation have been split into regional facilities and all CAFO farms. There will be some overlap between these two categories but it should be noted that some of the CAFO animals are outside of the assumed regional facility areas.

10.3.1 Regional Dairy Manure Facilities

Assuming that all four regional composting facilities are built and operated, the overall capital cost would be four times $2.65 million or $10.6 million.

10.3.2 Dairy CAFO Farms

If all CAFO sized farms choose to use whole manure composting the overall capital cost would be approximately $980,000 per two hundred cows so with 19,457 cows currently associated with CAFO farms, the total capital cost for all CAFO farms would be $95.4 million.

10.3.3 Poultry Farms

If all CAFO sized farms choose to use whole manure composting the overall capital cost would be roughly $17,500,000 per Million birds so with 4.5 million birds currently associated with CAFO farms, the total capital cost for all CAFO farms would be $79 million.

The Co-combustion of poultry manure option is moving towards development, however, as this option is being developed privately, the cost information in not publicly known.

10.4 RECOMMENDATIONS

The goal of this study was to identify economically and technically feasible manure management methods for the dairy and poultry farms to manage manure from CAFOs in the State of Connecticut. While technically feasible options were identified, the capital and operating costs for all the options are high, considering the economics of dairy and poultry farms, and may preclude their implementation. Successful implementation of the CAFO General Rule must include maintaining viable local farms while addressing nutrient issues. Providing funding assistance will be critical to this end.

Based on the ability to impact the nutrient surplus in the State, the focus should be on implementing the poultry manure co-combustion option and regional dairy composting facilities. Towards this end, the following is recommended.

10.4.1 Development approach

10.4.1.1 State-wide Approach

As indicated in the nutrient distribution discussion above, the biggest impact on the nutrient surplus occurs by managing the poultry manure and then by instituting regional dairy manure facilities. Several regions of the state have already started thinking about large scale poultry manure facilities and regional dairy manure facilities including the poultry farms in New London County, a group of dairy farms in the Canaan area of Litchfield County and a group of dairy farms in the Woodstock area of Windham County. These efforts should be encouraged and supported by the State agencies. In addition, regional dairy facilities in Tolland County and New London County should be encouraged.

To take the next step towards reducing the nutrient surplus, assistance must be provided to farms outside of the regional areas and smaller farms to help them implement options to allow moving nutrients off the traditional land application. Composting and phosphorus precipitation have the best ability to move nutrients off-site, however, many farms need more technical advice on how to produce a high quality compost and how to best market this product. The Department of Agriculture or the NRCS should expand their services to address these issues. For instance, the Department of Agriculture could implement a marketing effort/support for Connecticut produced composts or alternative products (such as poop pots) in the same way that they assist with Connecticut produced agricultural products. Due to the different nature of these products, this support may need to come from a different group or division within the Department of Agriculture.

Although it is beyond the scope of this study, other forms of manure (non-dairy, non-poultry) should be identified and addressed. It may be that they are managed differently than the poultry and dairy manures to the extent that they do not impact nutrient surpluses on the land typically used for poultry and dairy manures. These other manure sources represent half of the nutrients produced by manures in the state.

It is recommended that state and/or federal agencies conduct a mass balance study of land-applied nutrients by State and regionally on a watershed basis to assess the existing total land application of nutrient (originating in both agricultural and non-agricultural sectors) to ensure that the disposal of agricultural-related nutrients does not aggravate a possible existing nutrient excess on non-agricultural lands. Nutrient export plans could be developed (where needed) as a component of nutrient management plans.

10.4.1.2 Approach Towards Developing Regional Facilities

The first step in developing a regional anaerobic digester facility is to assess interest and start building an organization to spearhead the project. At this stage, it is beneficial to have an established organization take a central role. This organization may be a town committee or manager, a farmers cooperative, or one of the state agencies such as the DEP or the NRCS. At least two of the areas where a regional facility would make sense, some interest and coordination has been started. Meetings to introduce some of the options and assess the interest level in them will be needed. Discussion should include how the regional facility will be organized (farmers cooperative, independent non-profit operation, independent for-profit organization, etc), an assessment of interest level and identification of people interested in moving the project forward Subsequent meetings will be needed to discuss financing and organizational structure.

In the early stages of organizing the focus should be on how to organize adequately to get sufficient "seed" funding to pay for an organizer to help move the project to the next phase. This is where a small grant form the Rural Development may be applicable. Such funding could be used to organize an interim board and bring on a part-time or full-time temporary director to move the project along and continue developing both interest in the project and organization structure for management of a regional facility. The ultimate organization will develop over time as the interim team (director or board of directors) develops the statement of purpose of the organization and funding is developed. It would be prudent at the early stages of forming the organization to involve a lawyer who is familiar with Connecticut State rules and regulations for forming whatever type organization is agreed upon.

At this point in the process it is useful to have an existing organization, such as a township or other county organization "sponsor" the newly developing organization. The "sponsor" can provide basic office accessories such as an address, telephone and fax numbers, access to copying and word processing, and space in which to meet. This approach avoids the initial expense of setting up an office specifically for the regional facility organization for this early stage of development.

Once an interim organization has been established and initial development financing secured, it will be possible to proceed with evaluations of possible sites and conceptual and preliminary designs of the facility. At this point a firmer cost estimate should be developed and regulatory agencies and utilities contacted to begin the permit application processes. An approach for both facility financing addressing both capital and O&M costs and final design and construction should also be developed at this time. It may be most cost effective to use a design-build approach with a vendor performance guarantee for a portion of the facility such as the anaerobic digester but use a traditional design-bid-build approach for the site development and electrical portions of the project.

10.4.2 Political Advocacy

- This report should be used to educate legislators on the importance of adequate funding for the waste management needs of the CAFO farms in Connecticut. When the CAFO General Permit is issued, there needs to be sufficient funding support in place for the regulated community.
- Work to develop policies, incentives, and funding assistance which tie nutrient management solutions to the benefits of maintaining agricultural operations throughout

the state. These benefits include potential for renewable energy production, open space maintained by farms, food security provided by having local (in-state) producers, reduced costs to the state and towns by maintaining farms (less housing development, therefore lower school costs etc), the economic contribution farms provide to local and state community (i.e. other businesses and jobs dependent on the existence of farms) and maintenance of strong local communities and cultural heritage (as farmers are tied to the land and communities).

- Farmers in Connecticut could use additional support in developing options which are well suited to their specific situation. This assistance would include funding for pilot tests of dewatering equipment or demonstration projects of small scale composting.
- Work to add anaerobic digestion of agricultural residuals and co-combustion of manure to the Connecticut Class I Renewable Portfolio Standard.
- State and Federal agencies should develop policies and incentives for nutrient export (inter-regional) to transfer manure and related by-products such as compost to alleviate issues of excess nutrient on one region and reliance on commercial inorganic fertilizers in other regions.

10.4.3 Project Development

There are several fronts on which the DEP or other State Agencies or local organizations can work to move forward alternative manure management methods. These include the following:

- Work with the groups in North Cannan area, the Woodstock area, Ellington area and New London area to develop and assess interest in a regional facility.
    - Involve all dairies in the area early in the process to foster interest and support.
    - Obtain "seed" funding to start the development process in each area.
    - Identify a local sponsor organization.
    - Proceed with site selection and preliminary design once the preliminary organization and initial development funding has been secured.

- Technologies to track and/or test that are not ready for full scale implementation

- Dewatering Options
  - Pilot testing of screw press technology for dairy manure at interested farms. Manufacturer's guaranteed solids capture rate based on pilot testing data. Also, at least one manufacturer has stated that they will not sign contracts with individual farmers. Therefore, CT DEP or other entity will need to fund and spearhead any pilot testing program.
  - Jannanco dewatering system shows promise but they have not yet published their results. If they are able to capture a high percentage of solids in a relatively high solids content cake, this will make composting facilities at individual farms smaller and more cost effective while still removing a large portion of the nutrients.
  - Development of high recovery dewatering - Tinedale in Wisconsin. Regional facilities may obtain higher nutrient removal by using a high recovery dewatering system. Such a system requires a review of higher technology options and a conceptual design caparison of the options.
- Poop Pots / Paper production show good potential as a nutrient removal mechanism. Testing should be done to determine the nutrients removed in the pots and provide assistance in the scaling up of the current technology to a full scale production.
- Phosphorus Precipitation - pilot testing to determine appropriate chemical dosing requirements. Get chemical supplier and equipment vendors to help determine proper alum dose on representative manure samples.

10.4.4 Facility Siting, Operations and Commodity Sales

- Site Regional Digester/co-combustion Facilities near power/heat users who would be willing to purchase power directly from the regional facilities.

- Work with local planning and zoning boards and inland wetlands commissions to review plans for regional facilities.

- Farmers have expressed a need for assistance in marketing any products from manure such as compost. There are several methods to acquire this assistance:
    - Hire a compost broker. There are several organizations currently marketing compost for other compost producers in the New England area. Compost brokers have contacts with groups trying to purchase compost and are able to match the level of compost quality with the needs of compost users. They work in several ways either charging a fee, or for a portion of the sales or for a combination of fee and a portion of the sales. Compost brokers will charge to cover their marketing cost and to generate a small profit, as such the price that the composter sees will be reduced.
    - Develop Marketing assistance through CT Dept of Agriculture similar to the existing group which promotes CT grown products. This approach could be implemented to help farmers market their compost without having to pay as much for marketing. It would help the farmers keep a greater portion of the compost sales and thus make this method of manure management more feasible.

10.4.5 Funding Options

The next steps in regional facility development and individual farm solutions includes development of feasibility studies for specific sites and situations, development of business plan and preliminary design of the chosen solution. To facilitate and assist in funding these tasks and the final design and construction phases the following is recommended.

- DEP should seek additional funding for Connecticut under Section 319 Non-Point Source Fund from the Clean Water Act.

- DEP should consider the possibility of modifying the Clean Water Fund program(s) to include agricultural waste management projects. The Department could consider the programs of other states such as South Dakota to explore how those programs have assisted farmers.

- Lobby USDA for Rural Development funds for Connecticut for feasibility studies, business plans and preliminary designs for regional and individual farms solutions.

- DEP should seek Clean Water Fund increase for construction phases of manure management facilities for regional facilities and individual farms.

- NRCS in Connecticut should seek additional EQIP Funding for Connecticut to address farmers' needs with regional or individual farm modifications.

- The Department of Agriculture should establish funding for EAP in line with farmers needs to meet the proposed CAFO regulations. Funding for four regional composting facilities at a one facility per year rate and on the order of 10 individual farms per year for liquid/solid separation systems should be considered. The estimated funds needed would be $2.7 million for the regional facility and $5.2 million for 10 farms ($0.52 million per farm) for liquid/solid separation. The total fund would be a total of $7.9 million per year.
- Explore using existing funding mechanisms such as Department of Agriculture Environmental Assistance Program (EAP) or USDA Rural Development to fund feasibility studies, business plans and preliminary designs of regional facilities and individual farms solutions.

- Farmers should seek EQIP and EAP Funding to address modifications such as storage facilities and liquid/solid separation needed on farms to meet proposed CAFO requirements or participation in regional facilities.

- Use the NRCS Conservation Innovation Grant (CIG) as a source of funding for Alternative Technologies as site specific feasibility of these technologies is solidified.

- Groups interested in a regional manure facility should examine the applicability of EQIP funding for a regional project in which participant farmers would apply individually for support. They should also examine the applicability of the DOAG EAP funding for a regional manure management project.

- Groups interested in a regional manure facility should review the availability of federal funding under the USDA-NRCS *Renewable Energy and Energy Efficiency Program* such that farmers who are considering undertaking energy efficiency or methane digester projects can look to this fund for support. Further, they should examine this program in light of its potential to support a regional digester project.

APPENDIX A.1

DEFINITIONS OF AFOs DESIGNATED AS CAFOs

The General Permit defines AFOs and CAFOs. The General Permit defines an Animal Feeding Operation (AFO) as:

> …a lot or facility (other than an aquatic animal production facility) where the following conditions are met: (i) animals (other than aquatic animals) have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and (ii) crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.

The regulatory instrument then goes on to define a Concentrated Animal Feeding Operation (CAFO) in three categories as follows:

> …an "animal feeding operation" that meets any of the three following criteria:
>
> A. Operations that stable or confine a number equal to or greater than the numbers of animals specified in any of the following categories:
>
> 1. 1,000 cattle other than mature dairy cows or veal calves. Cattle includes but is not limited to heifers, steers, bulls and cow/calf pairs,
> 2. 1,000 veal calves,
> 3. 700 mature dairy cattle whether milked or dry,
> 4. 2,500 swine each weighing 55 pounds or more,
> 5. 10,000 swine each weighing less than 55 pounds,
> 6. 500 horses,
> 7. 10,000 sheep or lambs,
> 8. 55,000 turkeys,
> 9. 82,000 laying hens,
> 10. 125,000 chickens other than laying hens,
> 11. 5,000 ducks (outdoor operations),
> 12. 75,000 ducks (indoor operations).
>
> B. Proposed new operations at a new location which will generate more than 1000 gallons per day of process-generated wastewater **or** which stable or confine greater than or equal to the numbers of animals specified in the following categories:
>
> 1. 300 cattle other than mature dairy cows or vela calves. Cattle includes but is not limited to heifers, steers, bulls and cow/calf pairs,
> 2. 300 veal calves,
> 3. 200 mature dairy cattle whether milked or dry cows,
> 4. 750 swine each weighing less than 55 pounds,
> 5. 3,000 swine each weighing less than 55 pounds,
> 6. 150 horses,
> 7. 3,000 sheep or lambs,
> 8. 16,500 turkeys,
> 9. 37,500 chickens other than laying hens,
> 10. 25,000 laying hens,
> 11. 1,5000 ducks.
>
> C. Any other animal feeding operation that the Commissioner designates as a CAFO.

Therefore, the CAFO General Permit effectively creates four categories of CAFOs, as listed in Table A-1.

TABLE A-1
CATEGORIES OF CAFOs CREATED BY THE GENERAL PERMIT

Type	CAFO Type	Criteria
Type 1	Existing AFO, defined as a CAFO	Criteria (a), definition
Type 2	Existing AFO, potentially triggered as a CAFO	Criteria (b), reviewed by DEP
Type 3	New AFO, defined as a CAFO	Criteria (b), definition
Type 4	Existing or new AFO, designated by Commissioner	Criteria (c), designation

A.2 CONNECTICUT AFOs TRIGGERED BY THE CAFO GENERAL PERMIT

The database provided by DOA has been reviewed to identify farms that may be Type 1 or Type 2 farms per the CAFO General Permit. Clearly, the database is not of any particular use with regard to identifying farms of Type 3 or 4, as those types are defined as new operations, or any existing operations designated by the Commissioner.

A.2.1 Type 1 CAFOs

The database identifies the number of animals present at 415 farms. Table A-2 lists the nine AFOs that are triggered as Type 1 CAFOs based on the definitions in the CAFO General Permit. For the purposes of developing this list, the number of mature cows at dairy farms has been assumed to be 67% of the total number of animals at dairy farms, allowing for 33% of the animals as replacement stock. As indicated in the table, a total of nine farms are triggered as Type 1 CAFOs, seven of which are poultry farms and the remainder being dairy farms.

TABLE A-2
TYPE 1 CAFOs TRIGGERED BY THE GENERAL PERMIT

Type of Operation	Database Number	Town	Number of Animals
Dairy Farm	279	North Canaan	Dairy - 1300, Beef - 30, Horses - 1
Dairy Farm	155	Woodstock	Dairy - 1231
Poultry Farm	19	Bozrah	Layers - 1,200,000, Growout - 400,000
Poultry Farm	32	Bozrah	550,000
Poultry Farm	344	Lebanon	1,300,000
Poultry Farm	308	Franklin	440,000
Poultry Farm	309	Hebron	210,000
Poultry Farm	310	Colchester	150,000
Poultry Farm	311	Lebanon	220,000

A.2.2 Type 2 CAFOs

The farms database has been reviewed to identify those AFOs that are triggered as potential CAFOs by criteria (b) in the CAFO General Permit. These AFOs are listed in Table A-3. As with the development of the list for the Type 1 CAFOs, the number of mature cows at dairy farms has been assumed to be 67% of the total number of animals present at dairy farms. A total of 34 farms are potentially triggered as Type 2 CAFOs, all of which are dairy operations.

TABLE A-3
TYPE 2 CAFOs POTENTIALLY TRIGGERED BY THE GENERAL PERMIT

Type of Operation	Database Number	Town	Number of Animals
Dairy Farm	135	Columbia	300
Dairy Farm	261	New Preston	300
Dairy Farm	45	North Stonington	300
Dairy Farm	81	Wallingford	300
Dairy Farm	217	Thompson	305
Dairy Farm	229	Lebanon	320
Dairy Farm	86	Wallingford	320
Dairy Farm	246	Woodstock	320
Dairy & Fruit Farm	302	Thompson	342
Dairy Farm	56	Baltic	350
Dairy Farm	278	North Canaan	Dairy-350, Beef-6
Dairy Farm	276	Washington	350
Dairy Farm	185	Ellington	380
Dairy Farm	300	Woodstock	400
Dairy Farm	214	Coventry	425
Dairy Farm	132	Hebron	425
Dairy Farm	66	Lebanon	Dairy-450, Horse-1
Dairy Farm	240	North Branford	450
Dairy Farm	265	North Canaan	Dairy-450, Beef-2
Dairy Farm	130	Canterbury	500
Dairy Farm	41	North Stonington	500
Dairy Farm	90	Scotland	500
Dairy Farm	248	Hampton	Dairy-510, Beef-1, Horses-4
Dairy Farm	353	Woodbury	Dairy-565, Swine-30
Dairy Farm	89	Franklin	580
Dairy Farm	42	North Franklin	600
Dairy Farm	280	Storrs	630
Dairy Farm	123	Union	670
Dairy Farm	333	Sterling	700
Dairy Farm	153	Ellington	800
Dairy Farm	49	North Canaan	800
Dairy Farm	277	North Canaan	800
Dairy Farm	154	Union	924
Dairy Farm	150	Ellington	1010

A.2.3 Other AFOs Without Animal Number Information

The database reviewed for this project also lists a number of facilities without providing the numbers of animals. Therefore, depending on the numbers of animals present, these facilities may be Type 1, Type 2, or non-triggered CAFOs. In total, some 128 facilities have no data on numbers of animals. It is noted that of this 128, only 11 are dairy farms, and the majority are indicated as sheep or goat operations.

A.2.4 Manure handling, bedding types

NRCS has provided information on the types of bedding and current manure handling processes currently being used on the Type 1 and potential Type 2 CAFO farms that have worked in the past with them in the past. The following table is a summary of this compiled data.

TABLE A-4
CURRENT BEDDING AND MANURE MANAGEMENT PRACTICES

Operation	Database Number	Town	Manure Management	Current Bedding Material Used
Dairy Farm	279	North Canaan	2 WSF, separator	Sawdust
Dairy Farm	155	Woodstock	WSF	Sawdust and Sand
Poultry Farm	19	Bozrah	WSF	None
Poultry Farm	32	Bozrah	WSF	None
Poultry Farm	344	Lebanon	WSF	None
Poultry Farm	308	Franklin	Unknown	Unknown
Poultry Farm	309	Hebron	Unknown	Unknown
Poultry Farm	310	Colchester	Unknown	Unknown
Poultry Farm	311	Lebanon	Unknown	Unknown
Dairy Farm	135	Columbia	Unknown	Sand
Dairy Farm	261	New Preston	Unknown	Unknown
Dairy Farm	45	N. Stonington	WSF	Sawdust
Dairy Farm	81	Wallingford	Unknown	Unknown
Dairy Farm	217	Thompson	WSF	Sand
Dairy Farm	229	Lebanon	Separator	Sand or Rec. Solids
Dairy Farm	86	Wallingford	Unknown	Unknown
Dairy Farm	246	Woodstock	Field Stack	Sand
Dairy & Fruit Farm	302	Thompson	WSF	Sand
Dairy Farm	56	Baltic	WSF	Sand and Sawdust
Dairy Farm	278	North Canaan	Separate	Sawdust or Rec. Solids
Dairy Farm	276	Washington	WSF	Unknown
Dairy Farm	185	Ellington	Dairy out of Business, Beef Cattle only	
Dairy Farm	300	Woodstock	Daily Spreading	Sand
Dairy Farm	214	Coventry	WSF	Sand
Dairy Farm	132	Hebron	WSF	Sand
Dairy Farm	66	Lebanon	Dairy out of Business	
Dairy Farm	240	N. Branford	Field Stack	Unknown
Dairy Farm	265	North Canaan	Unknown	Unknown
Dairy Farm	130	Canterbury	Unknown	Sand
Dairy Farm	41	N. Stonington	WSF	Unknown
Dairy Farm	90	Scotland	WSF and Spreading	Sand
Dairy Farm	248	Hampton	Unknown	Unknown
Dairy Farm	353	Woodbury	Daily Spreading/WSF	Sand
Dairy Farm	89	Franklin	WSF and Spreading	Sand
Dairy Farm	42	N.Franklin	WSF	Sand
Dairy Farm	280	Storrs	WSF	Sand
Dairy Farm	123	Union	Separator	Sawdust or Rec. Solids
Dairy Farm	333	Sterling	WSF	Sand
Dairy Farm	153	Ellington	WSF	Sand
Dairy Farm	49	North Canaan	WSF	Sawdust
Dairy Farm	277	North Canaan	WSF	Unknown
Dairy Farm	154	Union	Unknown	Sand
Dairy Farm	150	Ellington	WSF	Sand

WSF - Waste Storage Facility
UNKNOWN - Information not available

APPENDIX B

Summary of Calculated Nutrient Loading By Animal Type and County

Nitrogen*

	Fairfield	Hartford	Litchfield	Middlesex	New Haven	New London	Tolland	Windham	State
Dairy Cows	34,013	247,043	1,266,158	134,774	234,256	1,321,908	1,100,439	1,595,292	**5,933,883**
Dairy Heifers @ 60%	5,825	42,311	216,854	23,083	40,121	226,402	188,471	273,224	**1,016,291**
Beef Cows	32,489	111,748	254,573	55,874	97,780	137,959	119,910	159,618	**969,951**
Other Cattle	19,732	97,543	311,677	48,833	68,503	317,200	305,844	373,479	**1,542,811**
Sheep & Lambs	5,847	4,829	22,371	3,614	6,964	30,173	9,839	8,032	**91,668**
Hogs & Pigs	3,358	64,809	37,190	12,760	16,034	64,474	14,775	57,926	**271,326**
Horses	76,869	130,874	175,616	88,202	107,715	185,865	96,382	74,602	**936,126**
Goats - All	1,601	8,620	9,323	2,963	4,235	4,894	3,936	3,128	**38,699**
Poultry Layers	2,696	3,258	4,591	2,151	16,050	4,312,631	3,480	0	**4,344,857**
Poultry Broilers	35	402	275	0	0	0	404	31,024	**32,140**
Pheasants	0	4,656	0	0	0	0	22	0	**4,678**
Total	**182,466**	**716,093**	**2,298,627**	**372,254**	**591,659**	**6,601,505**	**1,843,503**	**2,576,325**	**15,182,432**

Phosphorus (as P_2O_5)*

	Fairfield	Hartford	Litchfield	Middlesex	New Haven	New London	Tolland	Windham	State
Dairy Cows	13,832	100,466	514,914	54,809	95,266	537,586	447,521	648,764	**2,413,158**
Dairy Heifers @ 60%	2,383	17,309	88,713	9,443	16,413	92,619	77,102	111,774	**415,756**
Beef Cows	24,040	82,689	188,373	41,345	72,353	102,084	88,728	118,111	**717,723**
Other Cattle	14,773	73,027	233,341	36,560	51,286	237,476	228,974	279,610	**1,155,046**
Sheep & Lambs	1,949	1,610	7,457	1,205	2,321	10,058	3,280	2,677	**30,556**
Hogs & Pigs	2,522	48,671	27,929	9,583	12,042	48,419	11,096	43,501	**203,763**
Horses	29,764	50,675	68,000	34,152	41,708	71,968	37,320	28,886	**362,473**
Goats - All	1,864	10,034	10,853	3,449	4,930	5,696	4,582	3,641	**45,049**
Poultry Layers	2,324	2,809	3,958	1,854	13,836	3,717,785	3,000	0	**3,745,566**
Poultry Broilers	18	206	141	0	0	0	207	15,865	**16,435**
Pheasants	0	1,552	0	0	0	0	7	0	**1,559**
Total	**93,469**	**389,047**	**1,143,678**	**192,399**	**310,155**	**4,823,691**	**901,816**	**1,252,829**	**9,107,085**

*Calculated values provided by the University of Connecticut

APPENDIX C

TABLE C-1
CT CAFO MANURE MANAGEMENT STUDY
ECONOMIC MODEL 200 COW SINGLE FARM
LIQUID/SOLIDS SEPARATION

Capital Costs		
Equipment Costs	$	182,200
Direct Installation Costs	$	94,800
Site Preparation, Buildings & Tanks Costs		$100,000
Indirect Installation Costs (Land, Legal, Engineering, Permitting, Contir	$	139,600
Total Capital Cost	$	516,600
Annual Capital Recovery Cost	$	70,200
Annual Costs		
Transportation Costs	$	-
Labor & Maintenance Costs	$	18,600
Chemical Costs	$	-
Bulking Agents/Wood Chips	$	-
Fuel Costs	$	-
Indirect Costs (Overhead, utilities, taxes, insurance, administration)	$	28,800
Sinking Fund	$	28,000
Total Annual Costs	$	75,400
Direct Annual Income		
Food Waste Tipping Fees	$	-
Compost Sales	$	-
Electricity Sales to Grid	$	-
Total Annual Income	$	-

TABLE C-2
CT CAFO MANURE MANAGEMENT STUDY
ECONOMIC MODEL 200 COW FARM
LIQUID/SOLIDS SEPARATION WITH CHEMICAL PRECIPITATION OF PHOSPHORUS

Capital Costs		
Equipment Costs	$	220,500
Direct Installation Costs	$	122,200
Site Preparation, Buildings & Tanks Costs	$	100,000
Indirect Installation Costs (Land, Legal, Engineering, Permitting, Conting	$	185,900
Total Capital Cost	$	628,600
Annual Capital Recovery Cost		$85,400
Annual Costs		
Transportation Costs	$	-
Labor & Maintenance Costs	$	14,500
Chemical Costs	$	37,700
Bulking Agents/Wood Chips	$	-
Fuel Costs	$	-
Indirect Costs (Overhead, utilities, taxes, insurance, administration)	$	33,900
Sinking Fund	$	34,000
Total Annual Costs	$	120,100
Direct Annual Income		
Food Waste Tipping Fees	$	-
Compost Sales	$	-
Electricity Sales to Grid	$	-
Total Annual Income	$	-

TABLE C-3
CT CAFO MANURE MANAGEMENT STUDY
ECONOMIC MODEL 200 COW SINGLE FARM COMPOSTING

Capital Costs		
Equipment Costs	$	289,800
Direct Installation Costs	$	111,430
Site Preparation, Buildings & Tanks Costs	$	288,000
Indirect Installation Costs (Land, Legal, Engineering, Permitting, Con	$	289,500
Total Capital Cost	$	978,730
Annual Capital Recovery Cost	$	100,800
Annual Costs		
Transportation Costs	$	-
Labor & Maintenance Costs	$	19,400
Chemical Costs	$	-
Bulking Agents/Wood Chips	$	7,600
Fuel Costs	$	37,700
Indirect Costs (Overhead, utilities, taxes, insurance, administration)	$	49,100
Sinking Fund	$	27,000
Total Annual Costs	$	140,800
Direct Annual Income		
Food Waste Tipping Fees		$0
Compost Sales		$65,430
Electricity Sales to Grid		$0
Total Annual Income	$	65,430

TABLE C-4
CT CAFO MANURE MANAGEMENT STUDY
ECONOMIC MODEL 2500 COW REGIONAL FACILITY
COMPOSTING WITH LIQUID/SOLIDS SEPARATION AT FARMS

Capital Costs		
Equipment Costs	$	710,200
Direct Installation Costs	$	318,600
Site Preparation, Buildings & Tanks Costs	$	838,000
Indirect Installation Costs (Land, Legal, Engineering, Permitting, Contir	$	784,000
Total Capital Cost	$	2,650,800
Annual Capital Recovery Cost	$	272,900
Annual Costs		
Transportation Costs	$	77,800
Labor & Maintenance Costs	$	232,900
Chemical Costs	$	-
Bulking Agents/Wood Chips	$	7,600
Fuel Costs	$	72,800
Indirect Costs (Overhead, utilities, taxes, insurance, administration)	$	229,800
Sinking Fund	$	69,000
Total Annual Costs	$	689,900
Direct Annual Income		
Food Waste Tipping Fees	$	102,400
Compost Sales	$	459,900
Electricity Sales to Grid	$	-
Total Annual Income	$	562,300

TABLE C - 5
CT CAFO MANURE MANAGEMENT STUDY
ECONOMIC MODEL 2500 COW REGIONAL FACILITY
COMPOSTING WITH REGIONAL DIGESTER

Capital Costs		
Equipment Costs	$	3,116,150
Direct Installation Costs	$	2,540,700
Site Preparation, Buildings & Tanks Costs	$	1,273,900
Indirect Installation Costs (Land, Legal, Engineering, Permitting, Contin	$	2,910,900
Total Capital Cost	$	9,841,650
Annual Capital Recovery Cost	$	1,013,300
Annual Costs		
Transportation Costs	$	273,700
Labor & Maintenance Costs	$	401,300
Chemical Costs	$	-
Bulking Agents/Wood Chips	$	25,100
Fuel Costs	$	64,600
Indirect Costs (Overhead, utilities, taxes, insurance, administration)	$	616,700
Sinking Fund	$	377,000
Total Annual Costs	$	1,758,400
Direct Annual Income		
Food Waste Tipping Fees	$	352,000
Compost Sales	$	307,500
Electricity Sales to Grid	$	402,400
Total Annual Income	$	1,061,900

TABLE C-6
CT CAFO MANURE MANAGEMENT STUDY
ECONOMIC MODEL 2500 COW REGIONAL FACILITY
COMPOSTING WITH REGIONAL DIGESTER AND CHEMICAL PRECIPITATION

Capital Costs		
Equipment Costs	$	3,233,600
Direct Installation Costs	$	2,581,800
Site Preparation, Buildings & Tanks Costs	$	1,585,600
Indirect Installation Costs (Land, Legal, Engineering, Permitting, Cont	$	3,108,300
Total Capital Cost	$	10,509,300
Annual Capital Recovery Cost	$	1,082,100
Annual Costs		
Transportation Costs	$	273,700
Labor & Maintenance Costs	$	453,500
Chemical Costs	$	242,800
Bulking Agents/Wood Chips	$	68,900
Fuel Costs	$	78,200
Indirect Costs (Overhead, utilities, taxes, insurance, administration)	$	673,600
Sinking Fund	$	388,000
Total Annual Costs	$	2,178,700
Direct Annual Income		
Food Waste Tipping Fees	$	352,000
Compost Sales	$	562,700
Electricity Sales to Grid	$	402,400
Total Annual Income	$	1,317,100

TABLE C-7
CT CAFO MANURE MANAGEMENT STUDY
ECONOMIC MODEL 200 COW SINGLE FARM
COMPOSTING WITH AGBAGS

Capital Costs		
Equipment Costs	$	289,800
Direct Installation Costs	$	111,430
Site Preparation, Buildings & Tanks Costs	$	288,000
Indirect Installation Costs (Land, Legal, Engineering, Permitting, Con	$	289,500
Total Capital Cost	$	978,730
Annual Capital Recovery Cost		$100,800
Annual Costs		
Transportation Costs	$	-
Labor & Maintenance Costs	$	54,200
Chemical Costs	$	-
Ag Bags©	$	26,400
Bulking Agents/Wood Chips	$	7,600
Fuel Costs	$	37,700
Indirect Costs (Overhead, utilities, taxes, insurance, administration)	$	49,100
Sinking Fund	$	27,000
Total Annual Costs	$	202,000
Direct Annual Income		
Food Waste Tipping Fees	$	-
Compost Sales	$	65,430
Electricity Sales to Grid	$	-
Total Annual Income	$	65,430

TABLE C-8
CT CAFO MANURE MANAGEMENT STUDY
ECONOMIC MODEL 2500 COW REGIONAL FACILITY
COMPOSTING WITH AGBAGS AND LIQUID/SOLIDS SEPARATION AT FARMS

Capital Costs		
Equipment Costs	$	710,200
Direct Installation Costs	$	318,600
Site Preparation, Buildings & Tanks Costs	$	838,000
Indirect Installation Costs (Land, Legal, Engineering, Permitting, Contir	$	784,000
Total Capital Cost	$	2,650,800
Annual Capital Recovery Cost	$	272,900
Annual Costs		
Transportation Costs	$	77,800
Labor & Maintenance Costs	$	232,900
AGBAGS	$	181,000
Bulking Agents/Wood Chips	$	7,508
Fuel Costs	$	72,800
Indirect Costs (Overhead, utilities, taxes, insurance, administration)	$	229,800
Sinking Fund	$	69,000
Total Annual Costs	$	870,808
Direct Annual Income		
Food Waste Tipping Fees	$	102,400
Compost Sales	$	459,900
Electricity Sales to Grid	$	-
Total Annual Income	$	562,300

TABLE C-9
CT CAFO MANURE MANAGEMENT STUDY
ECONOMIC MODEL 2500 COW REGIONAL FACILITY
COMPOSTING WITH AGBAGS AND REGIONAL DIGESTER

Capital Costs		
Equipment Costs	$	3,116,150
Direct Installation Costs	$	2,540,700
Site Preparation, Buildings & Tanks Costs	$	1,273,900
Indirect Installation Costs (Land, Legal, Engineering, Permitting, Contin	$	2,910,900
Total Capital Cost	$	9,841,650
Annual Capital Recovery Cost	$	1,013,300
Annual Costs		
Transportation Costs	$	273,700
Labor & Maintenance Costs	$	401,300
AGBAGS	$	111,000
Bulking Agents/Wood Chips	$	25,100
Fuel Costs	$	64,600
Indirect Costs (Overhead, utilities, taxes, insurance, administration)	$	616,700
Sinking Fund	$	377,000
Total Annual Costs	$	1,869,400
Direct Annual Income		
Food Waste Tipping Fees	$	352,000
Compost Sales	$	307,500
Electricity Sales to Grid	$	402,400
Total Annual Income	$	1,061,900

TABLE C-10
CT CAFO MANURE MANAGEMENT STUDY
ECONOMIC MODEL 2500 COW REGIONAL FACILITY
COMPOSTING WITH AGBAGS, REGIONAL DIGESTER AND CHEMICAL PRECIPITATION

Capital Costs		
Equipment Costs	$	3,233,600
Direct Installation Costs	$	2,581,800
Site Preparation, Buildings & Tanks Costs	$	1,585,600
Indirect Installation Costs (Land, Legal, Engineering, Permitting, Cont	$	3,108,300
Total Capital Cost	$	10,509,300
Annual Capital Recovery Cost	$	1,082,100
Annual Costs		
Transportation Costs	$	273,700
Labor & Maintenance Costs	$	453,500
AGBAGS	$	209,000
Chemical Costs	$	242,800
Bulking Agents/Wood Chips	$	68,900
Fuel Costs	$	78,200
Indirect Costs (Overhead, utilities, taxes, insurance, administration)	$	673,600
Sinking Fund	$	388,000
Total Annual Costs	$	2,387,700
Direct Annual Income		
Food Waste Tipping Fees	$	352,000
Compost Sales	$	562,700
Electricity Sales to Grid	$	402,400
Total Annual Income	$	1,317,100

TABLE C-11
CT CAFO MANURE MANAGEMENT STUDY
ECONOMIC MODEL 1 MILLION LAYER FACILITY
COMPOSTING AT FARM

Capital Costs		
Equipment Costs	$	1,608,600
Direct Installation Costs	$	633,100
Site Preparation, Buildings & Tanks Costs	$	10,138,800
Indirect Installation Costs (Land, Legal, Engineering, Permitting, Contir	$	5,199,800
Total Capital Cost	$	17,580,300
Annual Capital Recovery Cost @ 6.00% and 20 yrs	$	1,532,700
Annual Costs		
Transportation Costs	$	-
Labor & Maintenance Costs	$	314,300
Chemical Costs	$	-
Power	$	109,200
Bulking Agents/Wood Chips	$	-
Fuel Costs	$	25,200
Indirect Costs (Overhead, utilities, taxes, insurance, administration)	$	786,300
Sinking Fund	$	112,000
Total Annual Costs	$	1,347,000
Direct Annual Income		
Food Waste Tipping Fees	$	-
Compost Sales	$	226,300
Electricity Sales to Grid	$	-
Total Annual Income	$	226,300

APPENDIX D

APPENDIX D

AVAILABLE FEDERAL AND STATE FUNDING PROGRAMS

Potential federal and state funding sources for CAFO farmers in Connecticut are listed in Table D-1 (federal) and D-2 (state). Taken together, these sources provide a variety of support mechanisms. However, only a few programs are potentially oriented towards manure waste management projects. Those programs with such applicability are drawn out and discussed in Section 8 of the report.

TABLE D-1
POTENTIAL FEDERAL FUNDING SOURCES THROUGH UNITED STATES DEPARTMENT OF AGRICULTURE (USDA) NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

Program	Through	Description	Applicability	Funding in FY 2005
EQUIP and NRCS Technical Support	USDA NRCS	The program funds up to 75% cost sharing per farm, up to 500K funding per farm. NRCS staff provide technical assistance to farmers	In wide use in CT	$4.71 million
Conservation Reserve Program (CRP)	USDA FSA	Provides payments to farmers who set aside conservation lands	[pending]	[pending]
Agricultural Management Assistance (AMA)	USDA NRCS	Provides cost shared assistance for conservation practices. The focus is not necessarily environmental	In use in CT	$226 k
Farm and Ranch Lands Protection Program (FRPP)	USDA NRCS	Provides funds for purchase of development rights to farmland, preserving land for agricultural use	Highly used in CT	$2.94 million
Grassland Reserve Program (GRP)	USDA NRCS	Provides an opportunity to protect, restore and enhance grasslands through easements or rental agreements	In use in CT	$942 k
Wetlands Reserve Program (WRP)	USDA NRCS	Provides an opportunity to protect, restore and enhance wetlands	Has been used in previous years	Zero in FY 05
Wildlife Habitat Incentives Program (WHIP)	USDA NRCS	Provides technical and financial assistance to owners who want to improve habitat or restore natural ecosystems	Highly used in CT	$1.12 million

TABLE D-1 (CONTINUED)

Program	Through	Description	Applicability	Funding in FY 2005
Conservation Innovation Grants (CIG)	USDA NRCS National	Provides funds to stimulate innovative conservation techniques; a national program which provides EQIP funds through a competitive process	No proposals from CT awarded in FY 05	Zero in FY 05
Conservation Partnership Initiative (CPI)	USDA NRCS National	Provides technical and financial resources for conservation priorities; a national program which is considerably smaller than the CIG program	No proposals from CT awarded in FY 05	Zero in FY 05
Conservation Security Program	USDA NRCS National	Provides financial and technical assistance to promote conservation and improvement; based on specific watersheds; in CT, for FY 2006, the named watershed is in the Litchfield area	No proposals from CT awarded in FY 05	Zero in FY 05

State sources of funding are listed in D-2 below.

TABLE D-2

POTENTIAL STATE FUNDING SOURCES

Program	Through	Description	Applicability	Funding in FY 2005
Connecticut Environmental Assistance Program (EAP)	CT DOAG	Provides reimbursement to any farmer for part of qualifying costs in order to maintain compliance with DEP-approved agricultural waste management plan. Provides funding that can assist farmers in meeting the match requirements of federal EQIP funding	Highly applicable in CT	$500k
Connecticut Farmland Preservation Program (FPP)	CT DOAG	Farmers provide development rights to the state in return for compensation. Farms remain in private ownership. Has preserved 30,157 acres in CT as of July 2005	Highly Applicable in CT	$8 m in FY 05-06 and $10m in FY 06-07
Connecticut Farm Reinvestment (Enhancement) Grant Program (FEP)	CT DOAG	Provides matching grants to help preserve the state's agricultural base and improve farm production. Can be applicable to expansion of facilities or diversification and expansion into new production areas and related site improvements	Highly applicable in CT	$500k

CONNECTICUT DEPARTMENT ENVIRONMENTAL PROTECTION

Wright-Pierce