A STUDY OF THE LIVESTOCK MANURE ISSUE AS IT RELATES TO THE MICHIGAN SWINE INDUSTRY

By

Kurt J. Norgaard

Plan B Paper

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Agricultural Economics
1991

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

Chapter 1

INTRODUCTION AND PROBLEM DEFINITION

1.1 MICHIGAN AGRICULTURE

1.1.1 Introduction

Michigan's diverse agricultural industry is vital to its employment and economic base. Michigan leads the nation in the production of five commercial crops and ranks fifth or higher in 22 commodities.[1] This industry with its many sectors ranks second only to the automotive industry in the number of people employed in the state.

Agriculture and agribusiness contributed more than 23 billion dollars gross revenue to Michigan's economy in 1988. Of this total, Michigan farmers are directly responsible for approximately $2.7 billion. Though this is only 11.7%, production agriculture provides the foundation and very necessary link in the food system. Nearly 50% of this large industry is related to livestock production and livestock by-products.[2]

1.1.2 Livestock Sector

Michigan's large animal livestock sector includes beef, dairy, and swine enterprises and is comprised of nearly three million animals. After including the seven million bird poultry industry, the livestock sector produces an estimated one billion dollar sales annually. Within this large industry, the swine sector is an important component. During 1988, in Michigan there were nearly two million hogs produced with annual cash receipts of $194 million.[3]

Associated with the production of animals is the by-product: manure. The amount of manure produced annually by these hogs is estimated at 2.6 million tons (10%-25% solids content).

In the past, livestock producers have been able to handle the animal manure according to their own prerogative. This autonomous practice is increasingly coming under question. The combination of larger, more intensive livestock farms with a growth in the rural population, has contributed to conflicts between livestock producers and their neighbors. Evidence of these conflicts is the number of complaints reported to the Michigan Department of Agriculture since August 1989, when a hotline was initiated. In the time period, from August till March 1990, approximately 260 complaints were filed and another 520 calls for information were made in regards to animal agriculture.[4]

1.2 STATEMENT OF THE PROBLEM

As the number of animals per farm have increased, the amount of manure on the individual farms has risen accordingly. With this greater volume of manure, there is a greater potential for pollution and a greater need to manage the manure in an appropriate manner.

This increased amount of manure with an increased rural population has resulted in an escalating number of conflicts between livestock producers and their neighbors. In attempts to resolve these conflicts, the need for generally accepted waste management practices has been revealed.

However, the definition of generally accepted waste management practices are complicated by several factors:

1) the livestock group is made up of several different species;
2) within each livestock species there are many different production systems and manure management practices;
3) within each livestock species there are different farm sizes and operations and different technology for the different sizes;
4) each livestock production site has unique characteristics.

There is a need for a definition of generally accepted waste management practices that individual livestock producers can follow that will: 1) be conducive to reducing the number of conflicts between livestock producers and their neighbors, 2) facilitate resolution of conflicts, 3) protect the natural resources and, 4) provide for profitable animal agricultural systems.

It is difficult to define management practices that are acceptable to all clientele groups. These groups include both livestock producers and rural residents. Each interest group needs to become sensitized to the perceived requirements of the other groups.

1.3 PURPOSE OF THE STUDY

The intent of this study is to describe, assess, and analyze livestock manure management issues with specific analytic attention addressed to the swine enterprise. Swine was selected because of its economic importance to the Michigan economy and recent litigation challenging the manure management practice of individual swine producers.

To address this problem, pertinent national and state laws, including recently published legislation and guidelines, will be reviewed in chapter 2. A literature review on research in the waste management area will be presented in chapter 3. Next, results from a manure management practices survey sent to Michigan swine producers will be summarized in chapter 4. To illustrate the economic impact of proposed waste management guidelines, three representative swine farms will be analyzed and the financial results presented in chapter 5. A discussion and recommendation will be presented in chapter 6.

REFERENCES

1. Michigan Department of Agriculture, "Michigan Agricultural Statistics 1989", July 1989, Michigan Agricultural Statistics Service, Lansing, Michigan, 4.

2.Ibid. pg. 11.

3.Ibid, pg. 48, 49.

4.Personal Correspondence with Christine Lietzau, Michigan Department of Agriculture, Environmental Division

Chapter 2

A SURVEY OF POLITICAL ACTIVITIES THAT AFFECT THE LIVESTOCK SECTOR IN MICHIGAN

2.1 INTRODUCTION

Webster's dictionary defines 'pollution' as: "to make physically impure or unclean"[1]. In the context of air and water, pollution could be defined as the addition of material that would alter the composition of the original gas or liquid. However, there is a question relating to the degree of alteration. When is the addition of material substantial enough to be labeled as pollution? A working definition of pollution might define pollution as the case when the addition of material has changed the original resource to such an extent that it can no longer be utilized as before.

To be discussed in this chapter are; air and water pollution standards and the Federal and State of Michigan regulations related to these standards. This structural discussion is followed by a brief review of recent political activity related to animal agriculture and stewardship of the natural resources.

2.2 POLLUTION DEFINITIONS AND REGULATIONS

2.2.1 Introduction

In the past few years, much of the conflict between the livestock producers and their neighbors has related to odor or some form of water pollution, ie. groundwater or surface water contamination. To define these issues more clearly, the laws associated with natural resources and the control of their use are reviewed here.

2.2.2 Air Pollution

Odors in the air are one of the most noticed forms of pollution. As defined by State of Michigan Air Pollution Act, (PA 348 of 1965) "air pollution can be either harmful to one's health or just a nuisance".[2] Gases associated with animal manure may consist of up to 40 odorous compounds in the air. Concentrations of these compounds coming from swine facilities under normal conditions are not considered hazardous to human health. Only under certain conditions, such as manure pit agitation, can dangerous gas concentrations develop.[3] Therefore, odors from swine facilities are normally a nuisance as contrasted with a human health hazard. However, odors are primarily a subjective response and the response level depends on the intensity, duration, and frequency of perception of the odor.[4]

2.2.3 Air Regulations

The State of Michigan Air Pollution Act (PA 348 of 1965) defines air pollution as

> "the presence in the outdoor atmosphere of air contaminants in quantities, of characteristics and under conditions and circumstances and of duration which are or can be injurious to human health or welfare, to animal life, to plant life, or to property or which interferes with the enjoyment of life and property in this state.... Air contaminants means a dust, fume, gas, mist, odor, smoke, vapor or any combination thereof".

This wording makes it possible to think that any odor of actual or potential danger or nuisance to humans could be air pollution. However, in this act there is also language describing what is not air pollution. This act states:

> "air pollution shall *not* be construed to mean those usual and ordinary animal odors associated with agricultural pursuits and located in a zoned agricultural area if the numbers of animals and methods of operations are in keeping

with *normal and traditional animal husbandry practices* for the area".[5] (Italics authors)

What is evident from this statement is that this law is dependent upon the definition of "normal and traditional animal husbandry practices".

2.2.4 Groundwater Pollution

Pollution of groundwater by nitrates is a natural event in humid climates due to percolation (the downward movement of water through the soil profile). Percolating surface water will leach or remove the soluble mineral from the soil into the groundwater. For Michigan's environment, where rain water percolates through the soil, a zero nitrate level for groundwater is not possible. Nitrates going into the groundwater can occur naturally in virgin woodland where man has not cultivated the soil.

The potential for the pollution of groundwater due to leaching is increased when excessive manure and/or commercial fertilizer is applied to the land. The nitrogen level in the soil could become so high that the plants can not consume enough nitrogen to prevent it from polluting groundwater. Nitrogen can also be leached through the soil if applied when plants are not growing. High levels of nitrate have been linked with methemoglobinemia (blue-baby syndrome) and adult gastric cancer after long term exposure. The national standard which defines when water is polluted by nitrogen is 10 parts of nitrogen per million parts of water.[6]

2.2.5 Surface Water Pollution

Surface water pollution can be more noticeable than groundwater contamination. If material similar to animal manure gets into surface water a number of things may occur. The decaying material will use the oxygen in the water, thereby reducing the level of oxygen. If the oxygen level drops low enough there may be fish kills. Also, the phosphorus in the manure can cause algae bloom and turn the water quite green, a further degradation of the water. Recreational usage of the water may be hindered by this coloration of the water.

2.2.6 Water Regulations

In 1929, the Michigan Water Resource Commission Act (PA 245) was enacted to "create a water resource commission to protect and conserve the water resources of this state".[7] This act makes surface and groundwater a natural resource and prohibits the pollution of these resources. This act was significantly affected in 1972 when the Federal Government enacted the Water Pollution Control Act (92-500) which requires a permit for the discharge of pollutant from any point source into the waters of the United States. This act cited concentrated animal feeding operations as a point source and agricultural manure was defined as a pollutant.

This federal water pollution control act was the first to define the terms "one thousand animal units" as an index of pollution potential. Included in this act is text that defines how many animals comprise one thousand animal units. Those farms with over one thousand animal units are required to file for a National Pollutant Discharge Elimination System Permit (NPDES). Also, those farms with over three hundred animal units who are discharging waste directly into surface waters, are required to obtain a permit.[8]

After enactment of the 1972 Federal Water Pollution Control Act, the Michigan Water Resource Commission Act was amended to define the concentrated animal feeding operation as a point source of pollution and animal manures as waste. Once defined as such, rule #2106 from the Michigan Water Resource Commission is relevant. This rule states: "A person discharging waste on the ground or into groundwaters shall apply to the commission for a state permit."[9] Although the wording of this state law suggests that all livestock operations need a state permit, only two Michigan livestock farms had permits as of October 1989. However, according to a Department of Natural Resources (DNR) employee in the land application unit, agricultural manures have been such a low priority that the DNR has seen no need to implement the permit process.[10]

2.3 MICHIGAN ENVIRONMENTAL PROTECTION ACT

Another act that is significant in the area of environmental law is the Michigan Environmental Protection Act (MEPA: PA 127 of 1970). This law defines natural resources as being within the public trust. This allows individuals to restrain those whose activities are proven to cause damage to the environment. Once proven that activities are causing damage those responsible are required to modify his or her behavior.[11]

2.4 RIGHT TO FARM ACT

In 1981, Act No. 93 of the Public Acts of 1981 was created to "provide for circumstances under which a farm shall not be found to be a public or private nuisance".[12] In this act the phrase "generally accepted agricultural and management practices" was used. This phrase refers to a set of definitions that are not precise in nature. As a result of these definitional problems, nuisance lawsuits have been contested over interpretation of these phrases and often leading to non-conclusive results. To address this problem the Animal Waste Resource Committee was organized.

2.5 ANIMAL WASTE RESOURCE COMMITTEE

2.5.1 Introduction

The Michigan Department of Agriculture, in September 1986, directed by Dr. Paul Kindinger "organized a multi-disciplinary evaluation team to investigate the livestock waste management problems in the state".[13] In November of that year, the name was changed to the Animal Waste Resource Committee. This committee included 250 persons with a wide variety of interests. Three subcommittees were established to address "Legislative Issues", "Management Practices" and "Information and Education".

The "Legislative" subcommittee was to develop amendatory language for the Michigan Right to Farm Act and other environmental laws and regulations. The "Management Practices" subcommittee was to develop a uniform set of design and management standards to use for "Proposed Michigan Standards." The "Information and Education" subcommittee was responsible for meeting discussion and review over a period ending in June 1987.

2.5.2 Legislative Subcommittee

The Legislative subcommittee proposed a policy to require a surface discharge permit if the farm surpassed a certain size requirement. To determine the size requirements, the Legislative subcommittee proposed using the one thousand animal units size definition as defined by federal law, Water Pollution Control Act (92-500).

Secondly, the Legislative subcommittee recommended changing the wording within two Michigan laws, the "Right to Farm Act" and the "Air Pollution Control Act". They proposed changing the wording "traditional animal practices" to "management practices as published by the Michigan Department of Agriculture". This would attempt to eliminate the guess work of what management practices the law is referencing. Then the Michigan Department of Agriculture had to define a set of management practices. This task was delegated to the Management subcommittee.

2.5.3 Management Subcommittee

This subcommittee proposed a set of management and design standards and specifications for livestock waste management. Included in these standards were specifications for animal manure storage facilities. The specifications or rules that are used in this study are listed here:

- Must have 180 day storage capacity of animal manures;

- All earthen storage basins must be lined;
  - three ft of clay
  - flexible membrane liner (FML)
  - flexible membrane liner with geotextile (FML w\ Geo)

- Manure storage tanks must be at least 2 ft above groundwater;
  - alternative building styles utilized

- Must control all runoff from open lots;
  - usage of grass waterways or storage facilities

- Monitor all animal manure holding facilities;
  - hydrogeological study prior to construction and monitoring afterwards

- Incorporate animal manures as soon as possible.
  - investigate injection and other incorporation methods.

There was also a number of technical standards included in this report from the Management subcommittee. These standards included concrete thicknesses for loading platforms, soil compaction requirements, and other technical details. The cost of implementing these technical standards are incorporated in the economic analysis that is presented in chapter 5.

2.5.4 Educational Subcommittee

This subcommittee was organized to develop a strategy to educate the general public of the findings of the committee. This subcommittee arranged to have 11 meetings scattered throughout the state organized through the Michigan State Cooperation Extension Services. These meetings were initiated in the winter of 1986-87. The responses of those attending these meetings were considered generally favorable, according to the evaluative surveys distributed after the meetings.

2.5.5 The Results

In August 1987, the Animal Waste Resource Committee published their work in a publication titled: "Preliminary Report of the Animal Waste Resource Committee to the Michigan Commission of Agriculture". This report, as just discussed and highlighted, presented proposed policy and standards for management of animal manure. Recommendations made in this report were the motivating factors to generate this analysis.

2.6 THE COMMITTEE OF ANIMAL AGRICULTURE

The response from the livestock industry to the "Preliminary Report" was generally unfavorable due to the strictness of the regulations. Shortly after the report was published, a number of farm interest groups joined together to form the "Committee of Animal Agriculture." This committee then entreated the Michigan Department of Agriculture to request that Michigan State University develop interim guidelines to replace the Animal Waste Resource Committee's publication. In June 1988, the Michigan Commission of Agriculture requested and Michigan State University agreed to develop interim guidelines. These interim guidelines are now presently being used to define "generally accepted and recommended good livestock waste management practices". These interim guidelines are reviewed annually by the Michigan Commission of Agriculture.

2.7 SUMMARY

In this chapter, several state and federal acts related to pollution and animal manure management in Michigan were reviewed. Definitional difficulty with the phrase "normal and traditional animal husbandry practices" was noted. In response to this problem, first the Michigan Department of Agriculture and then several livestock interest groups became involved. Their activities resulted in two publications entitled "Preliminary Report of the Animal Waste Resource Committee" and "Interim Generally Accepted and Recommended Good Livestock Waste Management Practices". The first publication has been superseded by the second and is no longer relevant. The second publication provides guidelines for generally accepted waste management practices. The analysis developed in chapter 5 provides for discarding the preliminary report in favor of another effort.

REFERENCES

1.Webster's Ninth New Collegiate Dictionary, 1985. Merriam-Webster Inc. Springfield, Massachusetts, 911.

2.Legislative Service Bureau, "State of Michigan Natural Resources Laws", 1983, Department of Natural Resources, 336.12.

3.Michael R. Overcash, Frank J. Humenik, and J. Ronald Miner, Livestock Waste Management Volume II. CRC Press Inc. 34.

4.Miner, J.Ronald, and Clyde L. Barth., "Controlling Odors From Swine Buildings", 1979, Cooperative Extension Bulletin E-1158, 1.

5.Legislative Service Bureau, 336.12.

6.United States Government, "Code of Federal Regulations", 1972, Environmental Protection Agency, Drinking Water Standard.

7.Michigan Compiled Laws, "The Michigan Water Resources Commission Act", 1983, Department of Natural Resources, 323.1.

8.United States Government, "Code of Federal Regulations", 1972, Environmental Protection Agency, 122.1.

9.Michigan Compiled Laws, 323.7.

10.Personal correspondence with Kurt Thelen, Department of Natural Resources.

11.Michigan Compiled Laws, 691.1201

12.Michigan Compiled Laws, 286.472.

13.Animal Waste Resource Committee, "Preliminary Report of the Animal Waste Resource Committee", August 1987, 4.

Chapter 3

LITERATURE REVIEW ON MANURE MANAGEMENT ANALYSIS

3.1 INTRODUCTION

The purpose of this chapter is to review economic studies related to animal manure management. Five studies are reviewed in the following sections. The collection of studies reviewed in this chapter is not exhaustive but does give an indication of economic work done on the topic of animal manure management.

3.2 "ALTERNATIVES FOR DAIRY MANURE MANAGEMENT"[1]

3.2.1 Introduction

In 1986, C. Edwin Young, Jeffrey R. Alwang, and Bradley M. Crowder studied "Alternatives for Dairy Manure Management" in Lancaster County, Pennsylvania. This area was chosen because it is a large watershed area for the Conestoga river. Recent studies had shown a significant trend toward decreasing water quality in the river. The author's objective of this study was to evaluate alternative dairy manure storage/application systems, including their effects on net farm returns and losses of nitrogen and phosphorus.

3.2.2 Method

In this study, the authors utilized a linear programming model at the farm level to model the operations of the farms and any changes due to attempts to minimize water pollution. Changes used to minimize water pollution were: 1) change cropping pattern; 2) change nutrient application rate; 3) reduce the number of animals; and 4) haul manure to a distant site.

In this study, 11 different styles of manure management were employed. These variations incorporated differences in solid versus liquid manure, daily haul versus storage, earthen basin versus steel tank, 6 versus 12 month storage and incorporation versus injection. Incorporation was defined as plowing in the manure at a later date while injection was defined as using knives to incorporate the manure immediately into the soil. This distinction was noted to determine if utilizing injectors made a difference in the net annual costs.

A simulation model called Chemicals, Runoff, and Erosion from Agricultural Management Systems (CREAMS) was used to generate estimates of soil loss coefficients and losses of nitrogen and phosphorus. The CREAMS model was adjusted to imitate the assumptions made and the resultant figures would give the differences in nutrient retention for the different manure handling and application styles.

The first run was operated with no constraints on nitrogen loss and was used as a base run. The results from this run were then compared to subsequent runs with varying constraints of nitrogen loss from the fields. These constraints were for a 10, 30 and 50% reduction of nitrogen. Animal to land densities were also analyzed by varying the number of animals on a fixed farm acreage.

Another option tested in the model was long distance hauling. In this option the manure was hauled away from the farm to enable the farm to meet restriction on per acre nitrogen losses. The shortest distance considered was 30 miles because anything less would not have been far enough to get the manure out of the watershed.

3.2.3 Conclusion

In modeling the farms, the dairy sales and crop production were included in this study. The objective function was to maximize net returns from milk production and crop sales. Cropping considerations were included because the possible changes in crop mixture to meet the nutrient loss constraints could change the net income of the farm.

The authors found clear differences in the income production potential of the storage/application systems evaluated. For the no nitrogen loss constraint, the six month earthen basin storage of slurry manure was the most profitable. Daily haul was second best and steel tank storage had such low net returns that it was dropped from the study.

Differences in the nutrient losses were dependant on the storage/application system used. Findings showed that the largest nutrient losses were with the daily haul system. The smallest nitrogen loss was for six month uncovered solid storage. Daily spreading had the largest phosphorus losses.

At larger farm acreage where animal to land densities were two or less, the slurry systems outperformed the solid storage. The greater retention of nitrogen of the slurry systems led to lower nitrogen fertilizer costs. Injection rather than incorporation also became more profitable at the larger farm size for the same reason.

When nitrogen loss constraints were incorporated into the model the net returns varied depending on the required nitrogen loss reduction. The 10% reduction changed the net income very little for all cases. However, the 50% reduction of nitrogen loss lowered the net returns up to 60%. This happened because the number of cows milked had to be dropped to meet the requirements. This 50% reduction of nitrogen also changed the ranking of the different types of systems. The 12 month slurry system became the most profitable.

When the activity of hauling manure was incorporated into the model, the net returns improved moderately for the condition where the 50% reduction of nitrogen was required. The hauling of the manure allowed the farms to keep more of their milking herd thus having a larger net return. The 12 month slurry system was still the most profitable.

The authors summarized this study by noting that the policy goals need to be clearly defined. The impacts of measure vary greatly depending on the content of the constraint measure.

3.3 "ECONOMIC IMPACT OF CONTROLLING SURFACE WATER RUNOFF FROM POINT SOURCES IN U.S. HOG PRODUCTION"[2]

3.3.1 Introduction

This study was done in 1973 by Roy N. Van Arsdall, Richard B. Smith and Thomas A. Stucker. After describing the U.S. hog industry, the authors described the importance of controlling runoff from open lots used in concentrated hog production. It was estimated that 22% or 112,000 producers in the 15 major hog producing states studied, had runoff problems requiring additional control. This study was to determine the possible impact that measures made to control runoff would have on the U.S. hog industry.

3.3.2 Method

In this study, two different technologies to control runoff from open lots were investigated. One style of technology entailed unrestricted space around the lot for runoff and the second restricted space. In the restricted case, the runoff control measures used more mechanical components and thus were more capital intensive.

The authors permitted the farms to have both paved and partially paved lots. Sizes of lots were 40 square feet per head for completely paved surface with 125 square feet for partially paved. Amount of runoff was determined by size of holding areas plus the annual precipitation levels. The authors used other studies to give annual costs of production per head. These additional costs for runoff control for individual farms were then aggregated across the 15 states to give an estimated impact. The results were given as total investment, increased annual production costs, and costs per hundred-weight of pig produced.

3.3.3 Conclusion

The authors estimated that the total increased investment would be $254 to $290 million for the 15 state region. Eighty percent of total new investment would fall on small farms, defined as those farms selling fewer that 500 hogs a year.

The estimated impact of the runoff control on increased net annual cost would be $0.25 per 100 pound for total hog output in the 15 state region. The long run impact of this increased net annual cost could possibly change the hog industry. Those farms producing a fewer number of pigs could possibly quit the hog business. Other possible impacts would be an increased use of tounconfinement in hog operations.

The authors also cited a study done in Illinois which seemed to support their claims. Using this Illinois study, the authors estimated that the producers could lose $400 million annually. This loss would also have a negative impact on agribusiness firms. Consumer prices would also respond by increasing during the transition period which could lead to an extra expense of $750 million. Thus the standard of having runoff control could have a long term rippling effect.

3.4 "ECONOMIC COMPARISONS OF ALTERNATIVE WASTE MANAGEMENT SYSTEMS ON TENNESSEE DAIRY FARMS"[3]

3.4.1 Introduction

A study in 1987 by Russel D. Morgan and Luther H. Keller made a "comparative economic evaluation of the various manure management systems most commonly found on Tennessee dairy farms". This study was done because of the heightened environmental awareness.

3.4.2 Method

To reach their objectives, the authors surveyed Tennessee dairy farmers to determine the various manure management systems used on farms in that state. The authors identified 13 different systems of manure management. The systems ranged from daily haul to concrete/steel storage tanks to earthen lagoons. The combination of 13 manure management systems with three different sizes (80, 160, and 320 cows) and 2 different confinement styles (partial/total) produces 78 different situations studied.

For economic comparisons between the different situations, the authors determined initial investment and net annual cost of operating for each system. The data used to calculate these comparative values were either synthesized, gathered from their survey, or borrowed from other studies. The authors also listed any other assumptions made in their study.

Noting that the value of the nutrients in the manure effected the net cost, the authors varied both the nutrient loss rate during storage and the value of the nutrients to examine the resultant changes. The authors also varied the labor cost, recognizing that a dairy enterprise is quite labor intensive and labor costs might be a determining factor in selection of the most economic systems.

To facilitate the economic engineering of this project the authors developed 7 different budgets. These budgets were categorized as either 1) technical, 2) technical and economical, and 3) economical. The technical budgets described technology used for 1) collection, and 2) storage and application of manure. The technical and economic budgets included 1) annual labor and energy cost, 2) nutrient mineralization and 3) annual valuation budget. Along with the capital recovery and insurance/repairs/housing costs, these budgets were combined to give an initial investment budget and the net annual cost budget for each of the 78 systems studied.

3.4.3 Conclusion

The initial investments for the different alternatives ranged from $22,000 to $258,000. Investment per cow was consistently higher for every system for the small farm as compared to the larger farm. For the farms using the six months manure storage in an earthen pit, the increased investment per cow for the small farm was $381. For the larger farm, the increased investment was $166 or less than half as much. The difference when the farms were using daily haul was a $289 difference or a 400% increased investment per cow for the small farm as compared to the larger farm. Because of economies of size for the capital expenditures, this caused the small farm (80 cows) to have a higher investment per cow as compared to the large farm (320 cows). Initial investment ranged from $283 per cow to $1,536 per cow for the small farm (80 cows) and $94 to $809 per cow for the large farm (320 cows).

Net annual cost was computed as the difference between total annualized cost of the manure management system less the value of the fertilizer nutrient retained. For example the cost per day for daily haul of solid manure dropped from $54 per cow to $19 per cow, a 65% drop after the nutrient value was added. In all cases, the three month storage had lower net annual cost than the 6 month case.

Cost sensitivity in nutrient loss during storage were evaluated for alternative levels of nutrient loss. For the small farm, the net annual costs varied by as much as $1,200 per cow per year. The net annual cost for the six month earthen pit for the small farm was 21% higher at high levels as compared to low levels of nutrient loss. For the large farm, the maximum deviation was for the single stage lagoon and was $4,763. This largest change in net annual cost was 117% when comparing low nutrient loss rates to high loss rates.

When the nutrient prices rather than amount of the nutrients were changed, this led to a change of $1,400 for the small farm and $4,000 for the large farm. Those systems that retained larger portions of nutrients were those impacted most positively. When raising the manurial nutrient value by 50% the net annual cost for those large systems using concrete above ground tanks dropped by 25%.

The labor costs priced at $5.00 per hour were varied by as much as 40%. The largest change in net annual cost for this varying of labor cost was a 23% change for the larger farm.

Two conclusions from this dairy herd manure management study were: 1) significant economies of herd size are evident on U.S. dairy farms, and 2) increased regulation would result in increases in total costs for the dairy industry.

3.5 "ECONOMIC IMPACTS OF APPLYING SELECTED POLLUTION CONTROL MEASURES ON MICHIGAN DAIRY FARMS"[4]

3.5.1 Introduction

The purpose of a 1973 study by D.L Good, C.R. Hoglund, L.J.Connor, and J.B. Johnson was to "determine the economic impact on Michigan dairy farmers of complying with selected pollution control measures." The authors surveyed producers to get an accurate picture of the present state of technology on Michigan dairy farms.

3.5.2 Method

To meet their objectives, the authors assumed four different housing systems with their respective manure handling systems. Those systems employed were stanchion, open lot, cold covered, and warm enclosed housing systems. Two herd sizes (40 and 60 for stanchion, 80 and 160 for other systems) for each manure/housing system were assumed in order to model the dairy farms in Michigan.

The selected pollution control measures used were: 1) mandatory control of surface runoff from the production site; 2) prohibition of winter spreading of dairy manures; and 3) mandatory subsurface disposal of dairy manures.

For the economic analysis, the authors used whole farm budgeting. Owned land and sufficient cropping activities to raise feed for the cattle was assumed. The expenses of raising the feed were drawn from enterprise budgets in other studies.

3.5.3 Conclusion

To control and distribute surface runoff, only one irrigation system was analyzed. For the smaller sized farm (80 cows), the investment per cow was $48.43, while the investment per cow for the larger sized farm (160 cows) was $34.53. Net annual cost per cow was also lower for the larger sized farm.

When winter disposal was prohibited, storage length required was six months. With solid manure systems, the required additional investment was $212 per cow for the 40 cow farm and $108 per cow investment for the 160 cow farm. Net yearly changes in cost were also greater for the small farm. For farms with liquid manure systems, it was assumed that the farms already had three months storage, therefore an additional three months were needed. This additional storage could be added to present underground storage or additional outside storage could be developed. The added investments were much greater for adding to the present underground storage. For the two farms considered, the 80 cow farm's investment per cow was $175 or 13% greater than for the 160 cow farm.

For subsurface disposal of manure, only those farms using liquid manure were analyzed. Additional costs were $3.47 per cow for the 80 cow farm and $2.72 for the 160 cow farm. No added value of the nutrients saved by subsurface spreading were noted.

The authors stated that the combined economic impact of these three different measures would be most severe on the farms with stanchion housing. Returns to labor and management would be reduced about 15% for the two different sized farms using stanchions. For those farms not using stanchions, the impact on returns to labor were stated as being 6.3% and 10.7%.

3.6 "ECONOMIC EVALUATION OF SWINE MANURE UTILIZATION IN A SUSTAINABLE AGRICULTURAL PRODUCTION SYSTEM"[5]

3.6.1 Introduction

The purpose of this study by Vern Pierce, Jim Kliebenstein, Mike Duffy, and Per Olav Skjolberg was to measure the economic impact of rearranging times of hauling manure to use it more efficiently for crop needs. This changing of manure spreading times could conflict with crop production labor and additional labor would possibly be needed. The additional cost of labor would be contrasted with the added value of nutrients for crop use.

3.6.2 Method

Three different manure application alternatives were considered in this study. The first applied half of the manure in the spring before planting and the second half of the annual manure total in the fall after crop harvest. This alternative required a six month manure storage. The other two alternatives spread the manure once a year thus requiring twelve month storage. The difference between alternatives two and three was in the timing of the application. Alternative two applied manure in the fall and alternative three in the winter. The distinction is needed because for alternative three, there is no competing requirement for crop labor. However, the timing of the spreading of manure is critical for the amount of nitrogen losses after application.

Three sizes of manure tankers and thus differing prices were used to contrast labor costs and capital investments. The nutrients in the manure were valued at commercial costs of nitrogen, phosphorus and potassium.

Linear programming is used as the optimization model to maximize the net income for the possible alternatives constrained by various restrictions listed by the author. An example of a restraint is the number of hours worked by the operator in one year cannot exceed 2600 hours. This is important because if changes in manure management required more hours than 2600, additional labor would have to be hired.

3.6.3 Conclusion

With the three different sized manure tankers and the three alternatives, nine different scenarios were analyzed. In comparison for size, even though the smaller tankers took more time, for each case the net income was higher for farms using the small tanker as opposed to the large tanker.

The only other variations used in the model were the amount of labor hired and commercial fertilizer bought. These values depended on when the manure was actually spread.

The conclusions reported by the authors included that effective use of hog manure in crop production requires increased management. With this increased time needed it is profitable to hire the additional labor to apply the manure at the split spring/fall spreading to enable the crops to get the most nutrients from the manure. This will raise the overall farm profit of the farm.

3.7 SUMMARY

In this chapter five different studies were reviewed. While some studies concentrated on the nutrient loss, others focused on the reduction of pollution. Several studies focused mainly on the impact to the individual farm while another study attempted to aggregate to the entire livestock industry.

In all cases the adverse economic impact was almost always greater on the smaller farmer. Also, never did the added changes have a positive net impact on the farmer's income. These findings need to be considered when attempts are made to regulate the methods that livestock operators can use in animal manure management systems.

REFERENCES

1.C. Edwin Young, Jeffrey R. Alwang, and Bradley M. Crowder, "Alternatives for Dairy Manure Management", 1986, Natural Resource Economics Division, Economic Research Service.

2.Roy N. Van Arsdall, Richard B. Smith, and Thomas A. Stucker, "Economic Impact of Controlling Surface Water Runoff from Point Sources in U.S. Hog Production", 1973, Economic Research Service.

3.D. L. Good, C. R. Hoglund, L. J. Connor, and J. B. Johnson, "Economic Impacts of Applying Selected Pollution Control Measures on Michigan Dairy Farms", 1973, Agricultural Experiment Station, Michigan State University.

4.Russel D. Morgan and Luther H. Keller, "Economic Comparisons of Alternative Waste Management Systems on Tennessee Dairy Farms", 1987, Agricultural Experiment Station, University of Tennessee.

5.Vern Pierce, Jim Kliebenstein, Mike Duffy, and Per Olav Skjolberg, "Economic Evaluation of Swine Manure Utilization in a Sustainable Agricultural Production System", 1990, Department of Economics, Iowa State University.

Chapter 4

ANALYSIS OF MICHIGAN PORK PRODUCERS ASSOCIATION SURVEY

4.1 INTRODUCTION

Due to an increasing public focus and media attention on animal manure issues, Michigan Pork Producers Association (MPPA), an organization of Michigan swine producers initiated a study of manure management practices. Mr. Sam Hines, the executive director of MPPA in conjunction with Dr's Purkheiser, Person and Schwab, professors at Michigan State University, developed a three page questionnaire to "determine waste management practices currently being employed, the incidence of problems associated with these practices and if a descriptive profile could be established for waste management problem situations".[1] A copy of the questionnaire is in the appendix, Table (A1).

The results from this survey are included in this report, because it provides an examination of what technology is presently on swine farms in Michigan. Knowing the existing level of technology on farms provides a means of assessing the magnitude of change that would be required to meet the proposed manure management guidelines for the research that is presented in chapter 5.

In December 1986, questionnaires were sent to approximately 5,800 swine producers on the MPPA mailing list. Of those sent, 493 usable surveys were obtained, from the 11%

returned, representing 63 out of 83 counties in Michigan. The distribution of the responses throughout Michigan is pictured in Figure 4.1. To give a measure of the extent of the survey responses, the percent of annual pigs farrowed on farms returning useable questionnaires was determined to be approximately 32% of pigs farrowed in Michigan in 1986.

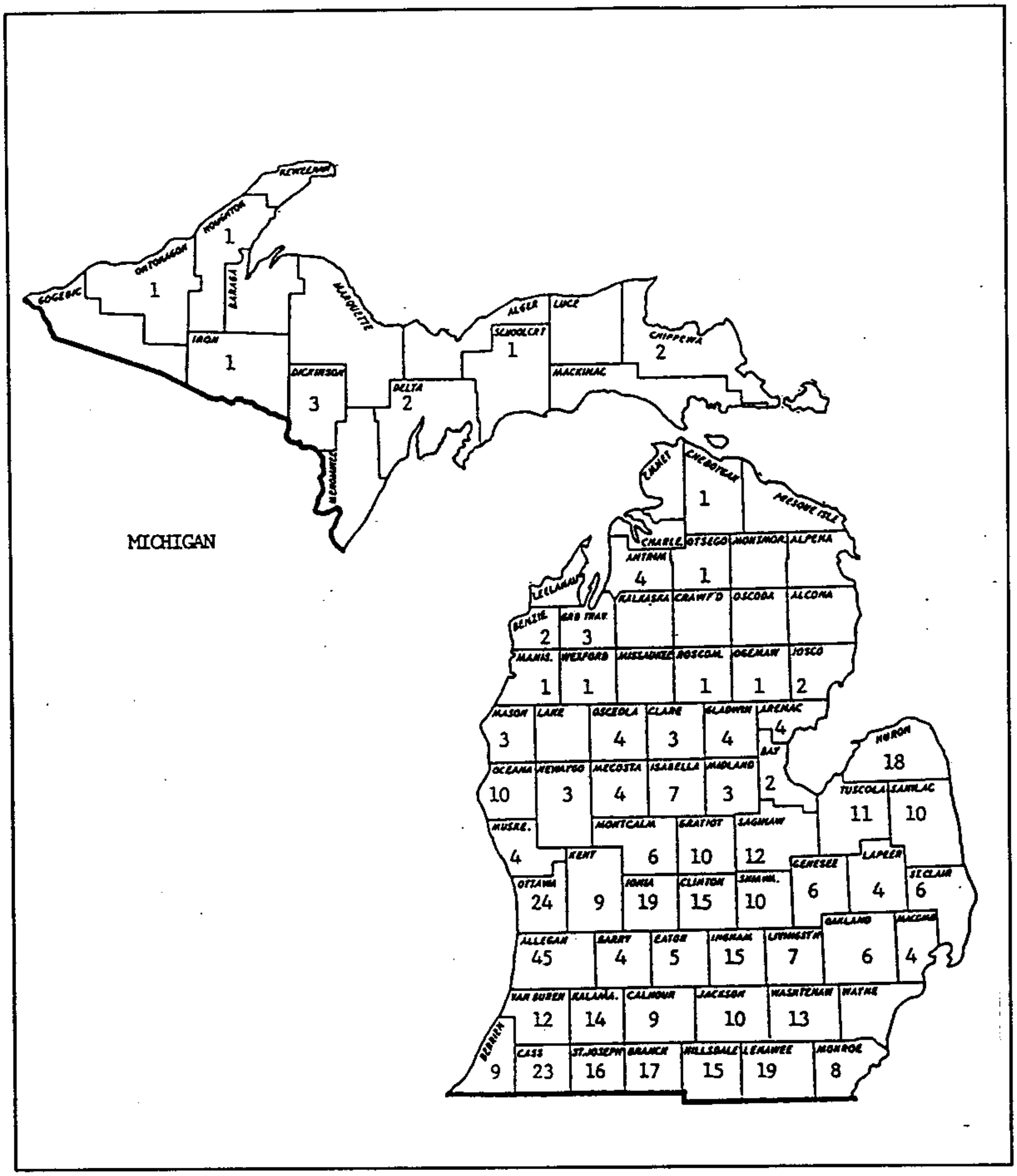

Figure 4.1 Distribution of Responses
Source: MPPA Waste Management Survey 1986

4.2 RESULTS AND DISCUSSION

4.2.1 Ownership

Family ownership and operation of swine facilities was the dominant style of business control. Approximately 96.1% of the respondents were either owners or owner operators as seen in Figure 4.2. Approximately 96% were either sole proprietorships, family partnerships or family corporations.

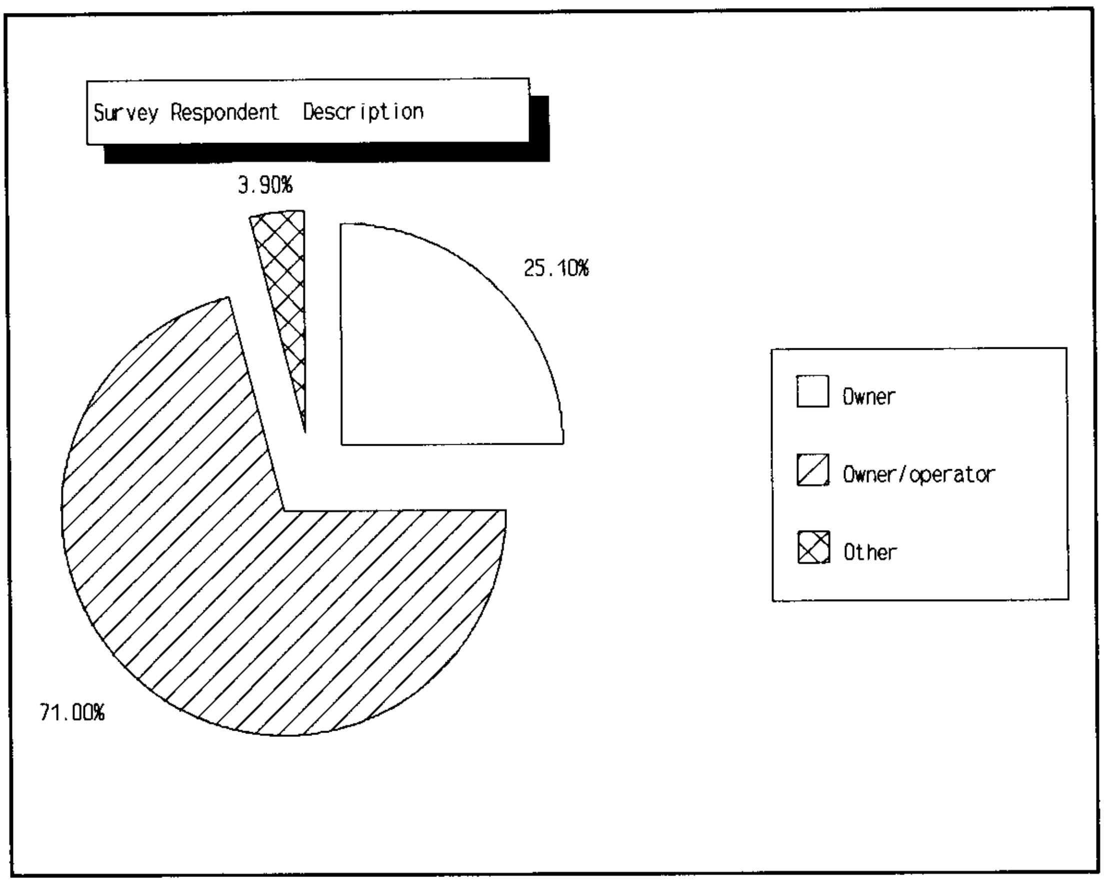

Figure 4.2 Description of Ownership Styles for Respondents to MPPA Survey
Source: MPPA Waste Management Survey 1986

4.2.2 Production Type

The different types and sizes of swine facilities are shown in Table 4.1. Pigs raised in confinement make up the largest segment of production and these farms were also larger in average size.

Table 4.1 Type and Average Size of Swine Enterprise in MPPA Survey.

	No. of Farms	Ave. No. Pigs Produced/Yr/Farm
FARROW-to-FINISH		
Pasture Farrowing & Pasture Finishing	45	840
Pasture Farrowing & Confinement Finishing	38	968
Confinement Farrow-Finish	283	1,214
FARROW-to-FEEDERS		
Pasture Farrowing	14	178
Confinement	150	1,211
FINISH ONLY		
Pasture	11	287
Confinement	117	922

4.2.3 Other Livestock

Respondents were also questioned if there were other kinds of livestock on the farm. Figure 4.3 shows that 61.2% of the farms surveyed had either beef, dairy, or poultry also being raised on the farm.

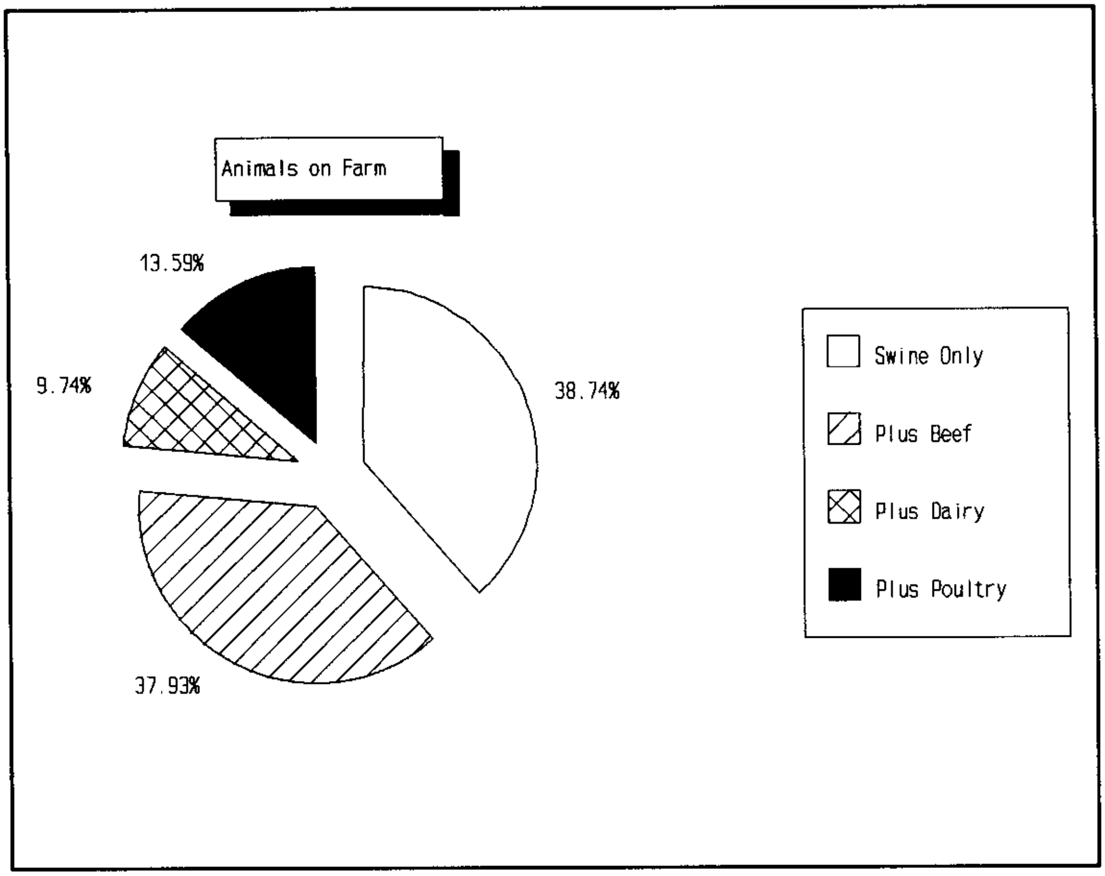

Figure 4.3 Livestock Enterprises on the Farms Surveyed
Source: MPPA Waste Management Survey 1986

4.2.4 Land Area Owned and Rented

Over 68% of the respondents answered that they owned more than 80 acres. For proper land application of manure, not only is the number of acres owned important, but also the availability of land on which to apply manure. The average number of tillable acres owned was 212 acres, plus an average of 140 acres rented. Also, 44% of those who responded said they did have other land either rented or owned which they could use for manure application. With a limited land base, the arrangement of crops and the amount of the nutrients in the manure are important for application rates for the manure. Because the survey did not include the questions on cropping systems, assumptions on typical arrangements of crops are made. Using data from another source[2], the average mixture of crops for this size farm would be would be: 199 acres corn, 51 acres wheat, 73 acres soybeans and 18 acres idle. With this crop arrangement, the average farm in this survey would have enough acres in which to distribute manure according to manure application levels recommended by Midwest Planning Service "Livestock Waste Facilities Handbook".

4.3 MANURE HANDLING SYSTEMS

The manure handling systems were put into three classifications: liquid, solid without bedding and solid with bedding. Table 4.2 displays the percentage of respondents that reported use of each system, and the percentage of those using 75% or more of that manure handling system.

Table 4.2 Type and Number of Manure Handling Systems for Farms in MPPA Survey

Manure Handling Systems	No. (%) Farms Reporting Some Use of system		No. (%) Farms Using This System For 75% or More of Manure	
Liquid	285	(57.8%)	180	(36.5%)
Solid Without Bedding	128	(26.0%)	11	(2.2%)
Solid With Bedding	399	(80.9%)	164	(33.3%)

Of those surveyed, 42% reported that they did not use liquid manure at all and relied entirely on a system of solid manure handling.

4.3.1 Solid Manure: Storage

When handling manure as a solid the frequency of scraping the facilities is of importance. The more frequently scraped the more likely a reduced odor within the facility. Table 4.3 displays the scraping intervals in the various types of facilities. A fairly large number of producers do not scrape every day.

Table 4.3 Frequency of Scraping Solid Manure Systems

Facility Phase	No. Responses	Scraping Interval: Daily	Every 2nd day	3 to 7 days	8 to 30 days	More Than 30 Days
Gestation	218	17.0%	7.3%	41.7%	28.0%	6.0%
Nursery	169	36.1%	14.2%	33.7%	13.6%	2.4%
Finishing	247	14.2%	9.7%	40.5%	28.7%	6.9%

4.3.2 Solid Manure: Application

The amount of time that passes before solid manure is incorporated into the soil is illustrated in Figure 4.4. The length of time that the manure is left on the surface is significant for the amount of nitrogen lost from the manure and how much odor is released.

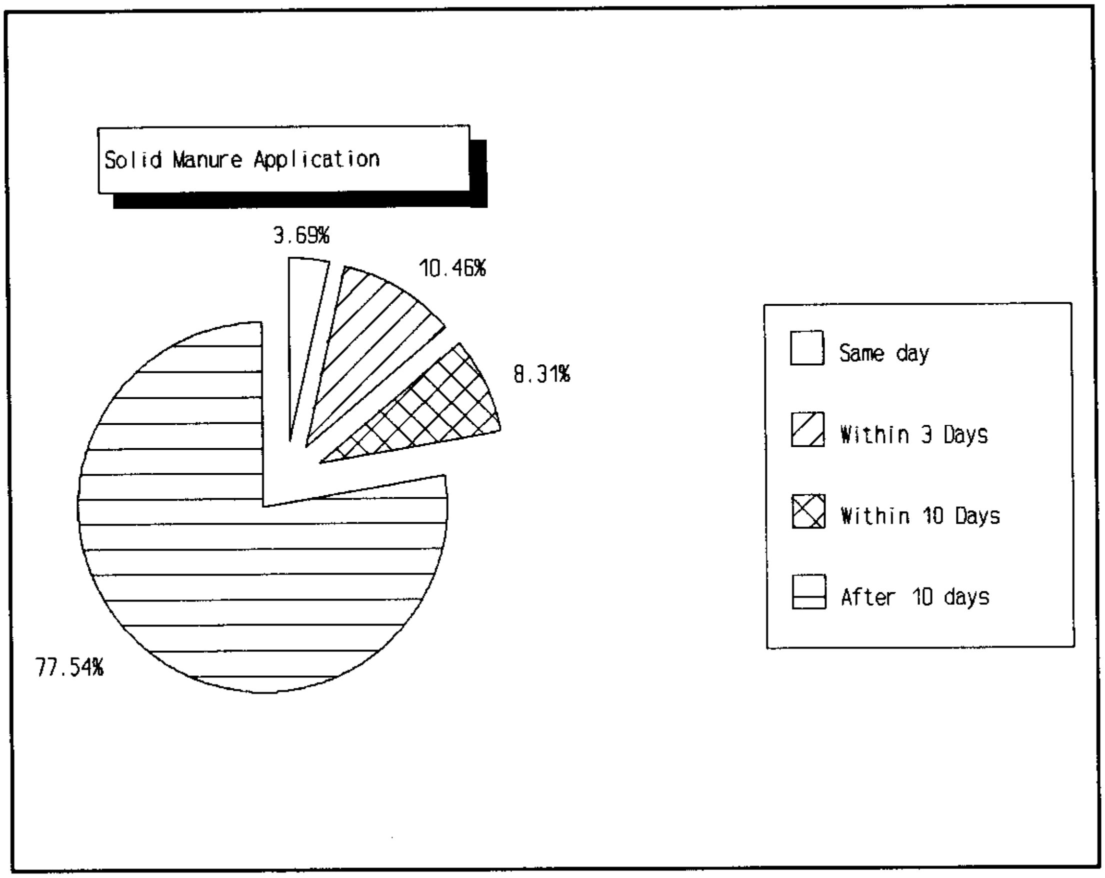

Figure 4.4 Solid Swine Manure Application/Incorporation System
Source: MPPA Waste Management Survey 1986

Recommendations from the proposed guidelines are that manure should be incorporated as soon as possible. As can be seen by Figure 4.4, 77.4% of the farmers presently do not incorporate within 10 days.

4.3.3 <u>Liquid Manure: Storage</u>

For liquid manure, the storage facilities come in various types and sizes. These facilities can be put under the building or outside of the building. Outside storage facilities can be either above or below the ground surface. Table 4.4 is a complete list of those who responded to having liquid manure storage.

Table 4.4 Days Storage Capacity for Liquid Manure Systems

Storage Facility	Number of Responses	Days Storage Capacity: 30 or less*	31 to 90 days	90 to 180 days	Over 180 days
Pit Under:					
Farrowing	161	33.5	31.1	28.6	6.8
Hot Nursery	81	38.3	27.2	29.6	4.9
Nursery	135	31.9	34.1	30.4	3.7
Grower I	79	32.9	30.4	31.6	5.1
Grower II	54	31.5	22.2	35.2	11.1
Finisher	172	25.6	22.1	41.8	10.5
Gestation	80	30.0	31.3	27.5	11.3
Breeding	59	35.6	25.4	28.8	10.2
Outside:					
Underground					
Tank w/cover	74	33.8	27.0	28.4	10.8
Tank w/o cover	12	41.7	16.7	33.3	8.3
Above Ground					
Tank w/cover	3	0.0	100.0	0.0	0.0
Tank w/o cover	11	18.2	0.0	72.7	9.1
Earth Storage	52	1.9	11.5	32.7	53.9
Treatment Lagoon	7	0.0	0.0	42.9	57.1

Referring again back to the proposed guidelines, it states that the recommended storage capacity for manure storage be 180 days or greater. As can be seen in Table 4.4, for each type of storage a fairly large segment of Michigan swine producers at the present time do not have that length of capacity. It can also be seen in Table 4.4 that the days storage capacity on the average are greater for the earthen storage than for other types of facilities. This could indicate an economies of size factor for earthen storages and if proposed standards required greater capacities this could lead to a greater use of earthen storages.

4.3.4 Liquid Manure: Application

Again, as it was for solid manure, the method of manure application is important for odor control and potential surface and groundwater pollution. Figure 4.5 represents the responses of those who use different application methods. As can be observed, less than 10% of the farmers responding actually incorporate the manure into the soil within three days. Proposed standards would require a change in management practices that allowed for quicker incorporation.

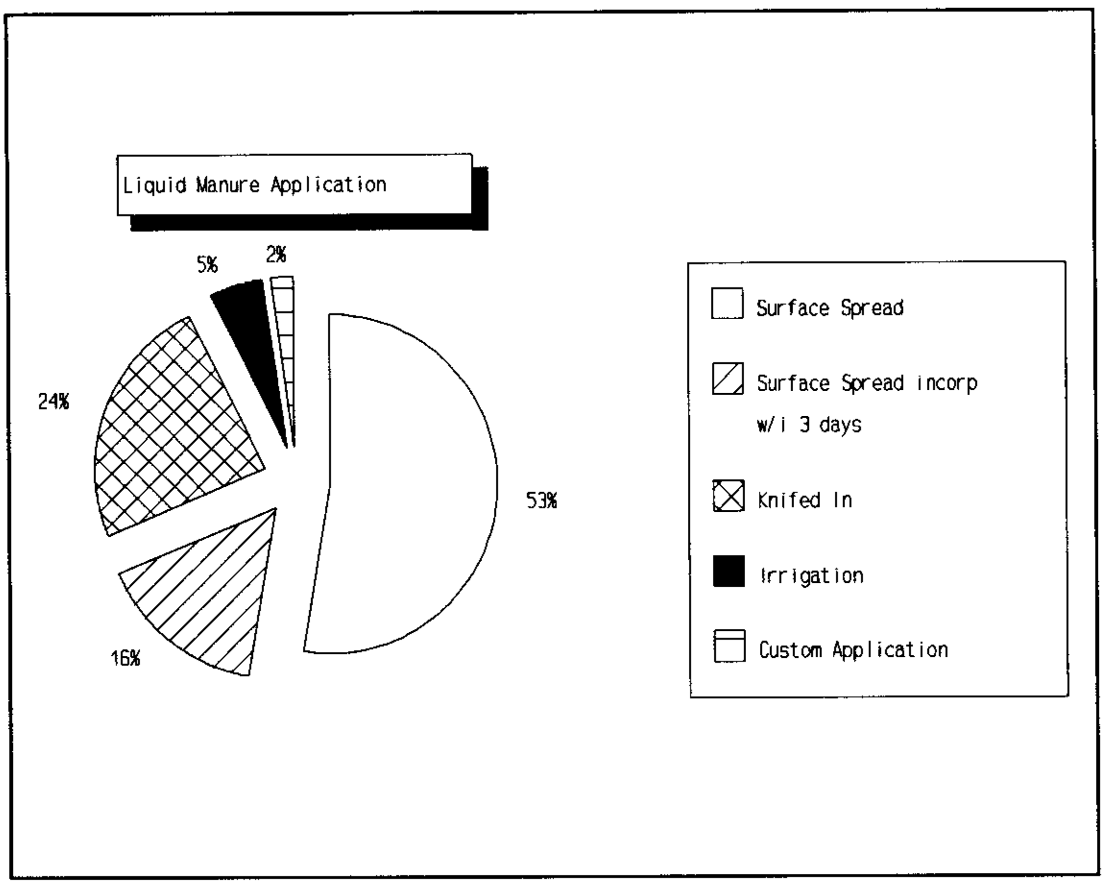

Figure 4.5 Liquid Swine Manure Application/Incorporation Systems
Source: MPPA Waste Management Survey 1986

4.4 MISCELLANEOUS QUESTIONS

4.4.1 Soil Test and Manure Analysis

Producers use of soil test and/or manure analysis was determined. Of those who had responded, 37% said that they had employed the tests. The proper use of soil and manure tests would give the producer sufficient information to disperse the correct amount of manure to the land. The correct amount of applied manure would yield proper nutrient loading without over loading.

4.4.2 Drinking Water Test

The level of concern with the safety of the farmer's drinking water was also determined. When asked about testing of their drinking water, 45% responded that they had tested their water for pollutants. No questions were asked about the actual test results measuring the quality of the water.

4.4.3 Proximity to Neighbors and Surface Water

The proximity of swine farms to their neighbors and to surface water was also asked in the questionnaire. From Figure 4.6, it can be observed that only approximately 13% of the livestock operations have no neighbors within 1/4 mile from their operation.

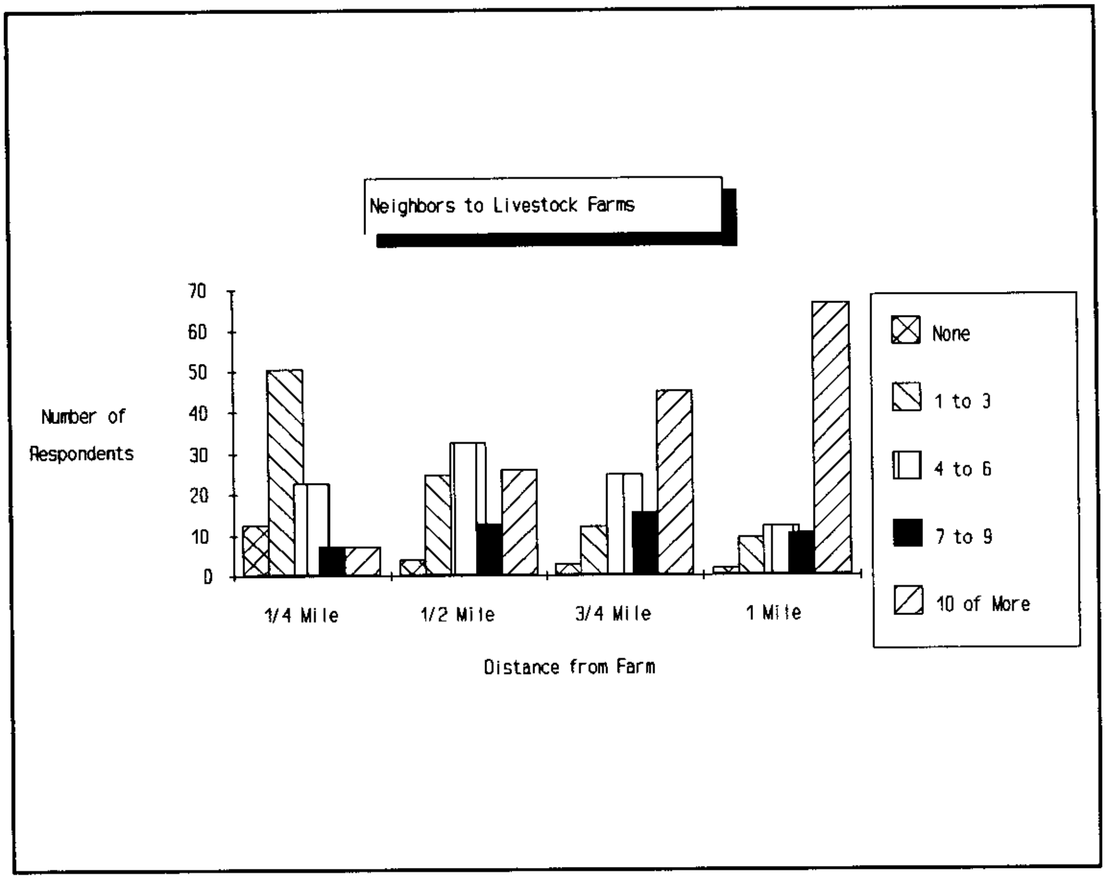

Figure 4.6 Proximity of Neighbors to Swine Farm
Source: MPPA Waste Management Survey 1986

For the four distances described, there is a large increase in the number of neighbors as the distance reaches one mile. This large number of neighbors is one indication of the earlier stated trend of an increased rural population.

The distance from farm to surface water could be an indicator of a potential problem if there are large manure spills. As can be seen in Figure 4.7, nearly 74% of the farms are located within one half mile of some form of surface water.

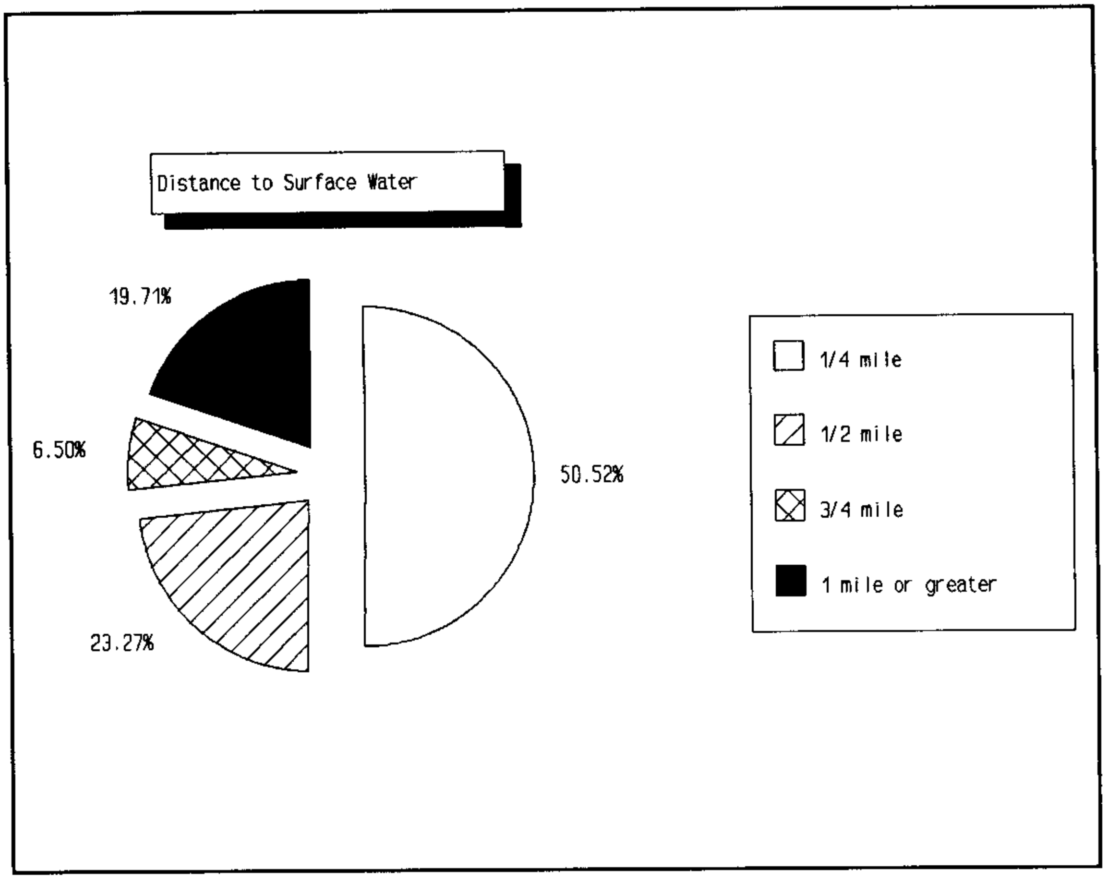

Figure 4.7 Proximity of Surface Water to Swine Farm
Source: MPPA Waste Management Survey 1986

4.5 PROBLEM FARMER PROFILE

To find a descriptive profile of waste management problem situations, a number of questions were asked in regards to complaints. Of those who responded, nearly 20% reported that they experienced some form of complaint. Of the complaints, 70% of them stated odor as part of the problem. Complaints other than odor are illustrated in Figure 4.8.

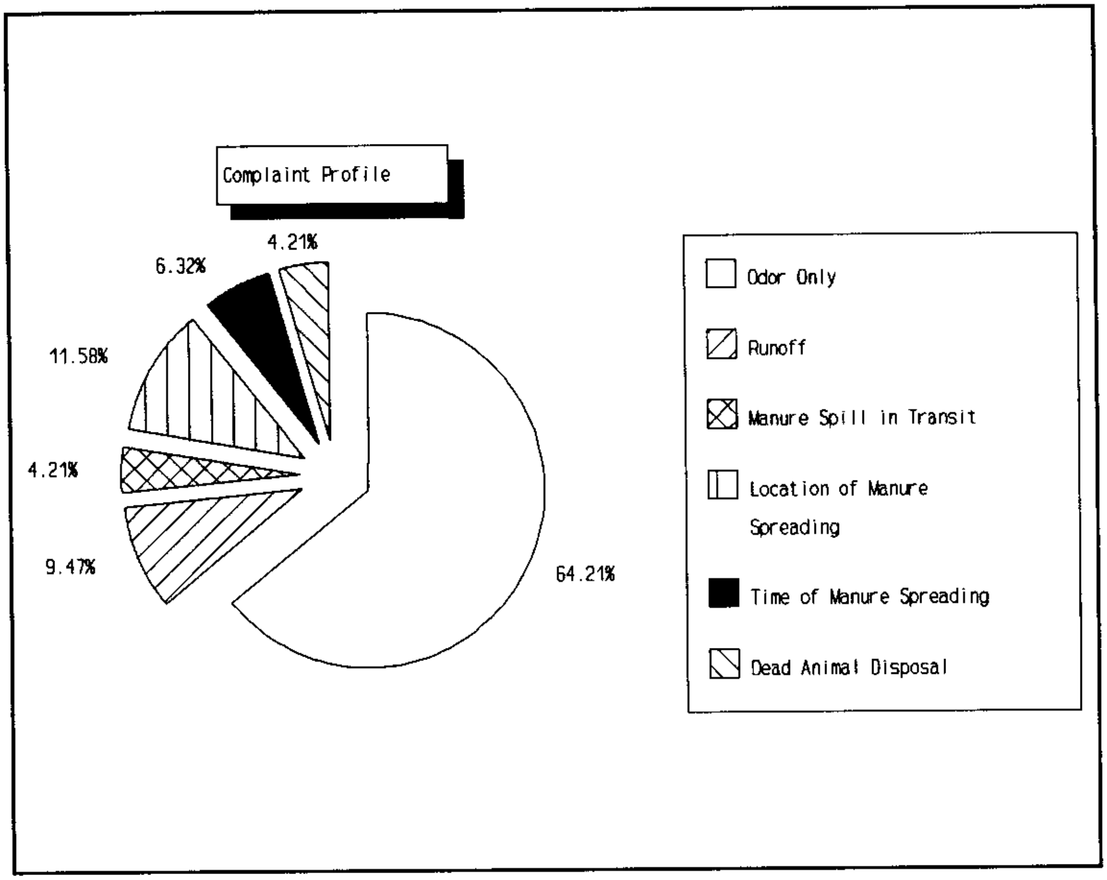

Figure 4.8 Nature of Complaints about Swine Farms
Source: MPPA Waste Management Survey 1986

There did not seem to be any typical descriptive profile, however there are some distinguishing characteristics. A proportionally higher rate of complaints were directed to confinement farrow-to-finish operations. Also, if a liquid manure system was used for 50% or more of the total annual manure, there was a trend of higher rate of complaints. The percent of operators using 50% liquid manure increased from 45% to 61.2% when looking at only those farms that registered complaints. For solid manure, the response was just the opposite, the number of those using solid manure for more than 50% dropping from 39% to 25.5%.

Size and location did not seem to be a determining factor, because complaints were registered in 38 different counties. Also, there was no significant relationship in the number of neighbors to the number of complaints. In regards to farm size, the distribution of the different sized farms for those who registered complaints were not significantly different than for the entire sample.

4.6 SUMMARY

These data are a good indicator of the varying waste management practices being used by swine producers in Michigan. This information is useful when attempting to define generally accepted manure management practices and determining what impact future legislation could have on swine producers in Michigan. In chapter 5, these findings are then contrasted to the proposed standards defined in chapter 2 and the economic impacts in complying to these standards are then projected for three representative swine farms.

REFERENCES

1.Hines, S., K. Norgaard, H. Person, and G. Schwab. 1987. "Description of MPPA management practices survey". Michigan State University, East Lansing, MI 48823.

2.Schwab, Gerald D., "Business Analysis Summary for Swine Farms", 1985, Agricultural Economics Report #485, 9.

Chapter 5

AN ANALYSIS OF THREE REPRESENTATIVE SWINE FARMS

5.1 INTRODUCTION

One purpose of this study is to evaluate the economic impact of proposed "manure management standards" upon Michigan swine producers. These proposed standards were originally published in 1987 in a publication entitled "Preliminary Report of the Animal Waste Resource Committee".[1]

Three different sized swine farms were defined as representative of the Michigan swine production industry. Description of each farm size and associated manure management system is contained in the following section. The issue then is to determine the physical structural changes needed by these farms to comply with the proposed standards and then evaluate the impact upon each farm's cost competitiveness. Using capital budgeting analysis, net annualized cost for each system is determined.

5.2 BACKGROUND

To define the three representative farms, descriptive data from the Michigan Pork Producers Association's 1986 survey and expert opinion were used to describe the three farms and their respective manure management systems. Once these parameters were specified, a software package "Pig Plan" was used to determine facility requirements and amount of manure produced annually by the pigs.[2] The details of the three representative farms are listed below.

Table 5.1 Description of Three Representative Farms

	Small Farm	Medium Farm	Large Farm
Number of Sows (1)	60	197	394
Pigs Produced Per Year	1194	3979	7959
Breeding and Gestation (2)	Open Lots	Open Lots	Confinement Facilities
Confinement Facilities	Farrowing, Nursery, Grower-Finishing 15 Fa. Crates/Room 1 Farrowing Room	Farrowing, Nursery, Grower-Finishing 10 Fa. Crates/Room 5 Farrowing Rooms	Farrowing, Nursery, Grower-Finishing 20 Fa. Crates/Room 5 Farrowing Rooms
Manure Storage	120 Day Underneath Building	120 Day Underneath Building	120 Day Underneath Building

Footnote (1) These numbers were obtained from the software package "Pig Plan".
Footnote (2) This is significant because of the need to control runoff from these lots.

The number of sows chosen to represent the different sized farms are reflective of the output from the software package "Pigplan". Pig production is calculated from the software when the number of farrowing crates and rooms are given as an input. Other assumptions needed to run the program are indicated in the input sheet of the program "Pigplan" and were also obtained using expert opinion. The complete input and output forms from "Pigplan" are given in the appendix, Tables (A2-A7). The number of farrowing crates and rooms used for the different sized farms are given in Table 5.1.

5.3 PROPOSED STANDARDS

After specifying the three representative farms, their manure management practices were contrasted with the proposed standards. Those standards that would have the greatest impact on Michigan swine farms are listed below:

STORAGE
Must have 180 day storage capacity of animal manures;
- All earthen storage basins must be lined;
- Manure storage tanks must be at least 2 feet above groundwater;
- Hydrogeological study done before construction;

Monitor all animal manure holding facilities;

RUNOFF
Must control all runoff from open lots;

APPLICATION
Incorporate animal manure as soon as possible;

Certain changes were needed on the three representative swine farms in order to conform to the proposed standards. The required changes, outlined in Table 5.2, are based upon knowledge of current practices gleaned from the MPPA survey.

Table 5.2 Manure Management Changes Needed On Three Representative Swine Farms to Conform to Proposed Standards

Proposed Standards	Changes Needed		
	Small Farm	Medium Farm	Large Farm
180 Day Storage	60 Days Additional Storage	60 Days Additional Storage	60 Days Additional Storage
All Earthen Storage Basins (ESB) Must Be Lined:	Three Different Alternatives: - Clay - FML (1) - FML with Geo (2)	Three Different Alternatives: - Clay - FML - FML with Geo	Three Different Alternatives: - Clay - FML - FML with Geo
Manure storage Facilities Must Be At Least 2 ft Above Groundwater	Alternative Construction Methods: - Cut Only - Cut and Fill - Above Ground	Alternative Construction Methods: - Cut Only - Cut and Fill - Above Ground	Alternative Construction Methods: - Cut Only - Cut and Fill - Above Ground
Must Control All Runoff From Open Lots	Alternative Methods: - Grass Waterway - Combined Storage - Separate Storage	Alternative Methods: - Grass Waterway - Combined Storage - Separate Storage	Not Applicable: No Open Lots on Farm
Monitor All Animal Manure Holding Facilities	Costs of a Hydrogeological Study	Costs of a Hydrogeological Study	Costs of a Hydrogeological Study
Incorporate Animal Manures As Soon As Possible	Alternative Incorporation Methods: - Injection - Disk In	Alternative Incorporation Methods - Injection - Disk In	Alternative Incorporation Methods: - Injection - Disk In

Footnote (1) FML = Flexible membrane lining
Footnote (2) Geo = Geotextile

5.4 METHODOLOGY

To estimate the financial impact of the changes, this study is divided into three parts. The first part investigates changes needed for open lot runoff control. The second, analyzes the costs of increasing the manure storage capacity of the swine farms from 4 months to 6 months. The third part addresses the change from surface application of manure to two alternatives methods of incorporation.

Capital budgeting analysis techniques were used to compare the different alternatives. The steps for using capital budgeting were taken from "Managing the Farm Business" by Harsh, Connor, and Schwab.[3]

The first step in capital budgeting analysis is to identify the different investment alternatives. As already stated, three representative swine farms and their respective styles of manure facilities were identified. By contrasting these benchmark farms with the proposed standards, the changes needed were determined as presented in Table 5.2.

The second step in capital budgeting is to estimate the amount of capital required for each investment alternative. Steve Ferns, an agricultural engineer, determined construction costs of the manure storage facilities.[4] PigPlan was used to determine swine animal flows and size of facilities needed. Using standard construction costs gathered from commercial construction firms, the different construction costs for the various structures were derived. Material costs and such matters as soil boring costs were obtained by contacting local contractors for the respective prices. The different costs and their respective sources are located in appendix, Table (A8).

The third step is to identify any changes in cash flow. Extra monitoring costs and various changes in cash flow were included at the proper time and manner. Again, local contractors and businesses contributed to our knowledge base. These changes in cash flows were then projected over a 10 year period.

Next, a method to determine cost of capital is required. It was assumed that the farmer could borrow from the Farm Credit System at the market rate. Noting the type of property, the Farm Credit System submitted the rate of 11.4% as an average rate for a seven year loan.

The time value of money was recognized with use of the present value calculation. The discount rate used the market return on a U.S. Treasury bond as the farmer's opportunity cost for money. Using this as the discount rate can be debated, however if it tends to error, it errors on the conservative side. Higher rates could be obtained but with higher risk. The after-tax discount rate is determined by multiplying the discount rate with one minus the tax rate. This after-tax discount rate equals 5.76%. A summary of the assumptions used and sources of those assumptions are listed in Table 5.3.

Table 5.3 Summary of Assumed Economic Factors

Input	Cost or Value of Input	Source
Discount Rate	8.0%	U.S. Treasury Bond
Tax Rate	28.0%	Farmers Tax Guide 1990
Interest Rate	11.4%	Farm Credit System
Depreciation Rate	10 Year MACRS(1)	Farmers Tax Guide 1990

Footnote (1) MACRS = Modified Accelerated Cost Recovery System

Table 5.4 is an example of the cost summary tables used in this analysis. Refer to the appendix for the actual tables used. These tables are organized to determine standardized annual cost and total discounted cost.

Once the capital requirements are determined for a specific project, yearly payments on an equal payment amortization plan are determined and the principle portion is noted. In table 5.4, $1,000 is used for the initial outstanding balance to make for a simpler example.

Secondly, yearly depreciation according to the 10 year MACRS declining balance method is determined. In the first year the 1/2 year convention is used.

Next, multiplying the tax rate to the amount of depreciation for that year, gives the tax savings due to depreciation. This amount is then subtracted from the principle portion of the payment to give the post tax cost.

Interest cost, yearly repairs and yearly operations costs are then summed to obtain the pretax cash cost. The after-tax cash cost is determined by multiplying the pretax cash cost with one minus the tax rate. Summing the after-tax cash cost with the post tax cost provides the total yearly after-tax cost. Multiplying this figure with the discount factor determines the yearly discounted cost. Summing the yearly discounted cost over 10 years yields the total discounted cost. The annual standardized costs are the annuities that would yield the total discounted cost over a ten year period at the after-tax discount rate. This procedure was performed for all alternatives.

Table 5.4 Cost Summary Table Used to Determine Discounted Cost

Titles	*Cost Summary Table for Storage Facilities All Size Farms*										
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Totals
Outstanding Balance	$1,000	$899	$787	$661	$522	$366	$193	$0	$0	$0	
Payments (1)	$215	$215	$215	$215	$215	$215	$215	$0	$0	$0	$1,505
Principle	$101	$112	$125	$140	$155	$173	$193	$0	$0	$0	$1,000
Depreciation (2)	$75	$139	$118	$100	$87	$87	$87	$87	$87	$87	$954
Tx Savings due to Dep	$21	$39	$33	$28	$24	$24	$24	$24	$24	$24	$267
Post Tax Cost	$80	$74	$92	$112	$131	$149	$169	($24)	($24)	($24)	$733
Interest Cost	$114	$102	$90	$75	$59	$42	$22	$0	$0	$0	$505
Repairs (3)	$216	$316	$370	$409	$442	$469	$493	$515	$535	$553	$4,317
Operations Cost (4)	$450	$450	$450	$450	$450	$450	$450	$450	$450	$450	$4,500
Pretax Cash Cost	$780	$869	$909	$935	$951	$961	$965	$965	$985	$1,003	$9,322
Aftertax Cash Cost	$562	$626	$655	$673	$685	$692	$695	$695	$709	$722	$6,712
Aftertax Cost	$642	$699	$747	$785	$816	$841	$864	$670	$685	$698	$7,445
Discount Factor (5)	0.94554	0.89404	0.84535	0.79931	0.75578	0.71461	0.67569	0.63889	0.6041	0.5712	
Discounted Cost	$607	$625	$632	$627	$617	$601	$583	$428	$414	$398	$5,531

Annual standardized cost $743

Footnote (1) Payments are based on a 7 year loan at 11.4% interest.
Footnote (2) Depreciation rate is determined by using MACRS method using 10 year property and 1/2 year convention.
Footnote (3) Annual repairs are est. using "A Standard Model for Repair Costs of Agricultural Machinery" (see Rotz)
Footnote (4) Operations cost is yearly expense of monitoring site, manure tests,and misc. costs.
Footnote (5) The discount factor is based on the average yearly after tax return on a U.S. treasury bond.

5.5 OPEN LOT RUNOFF CONTROL

For the small and medium sized swine farms, breeding and gestation are done in open lots. According to the proposed standards, any runoff from these lots must be controlled. A diversion ditch to deter clean water from flowing onto the lot and a channel to direct the flow of water was used in all cases. Secondly, a concrete settling basin used to collect the solids in the runoff was also included. For runoff control on these lots, three alternatives were investigated and are described in Table 5.5.

Table 5.5 Open Lot Runoff Control: Three Alternatives for Small and Medium-Sized Farms

Title	Description
Grass Waterway	Settled effluent from the settling basin is directed into a grass infiltration area to filter nutrients from the runoff. New facilities needed include a diversion ditch, channel, a settling basin and infiltration area.
Combined Storage	Settled effluent from the settling basin is directed into a concrete settling basin to separate the solids and the liquids and then directed into the storage basin already built to hold the manure for the livestock in confinement. This basin is enlarged to store both the additional solids from the runoff and the manure from the confinement building. New facilities needed include a diversion ditch, channel, settling basin, pipe, pump and storage expansion.
Separate Storage	Settled effluent from the settling basin is directed into a separate storage built for runoff storage. New facilities needed include a diversion ditch, channel, settling basin, pipe and runoff storage.

Tables (A9-A11) in the appendix, summarize the components and investment costs of the open lot runoff control system.

The first alternative evaluated was a grass waterway to capture the nutrients. The nutrients are caught in the grass/soil and not allowed to run into surface water. Annual maintenance of harvesting the grass then removes the nutrients from the area. This grass waterway alternative uses the least amount of new capital for facilities, but requires more land. This alternative might not be possible in all situations due to the unique requirements needed for the sloped grass waterway. A land base for the grass waterway must be available and the slope necessary for the water to run. This slope may be built if conditions are appropriate or already exist.

The other two alternatives involved storing the runoff in either: 1) a storage tank separate from the confinement storage (Separate Storage); or 2) run into tank built to handle runoff from the open lots (6 months capacity) and 2 months capacity for the livestock in confinement (Combined Storage). To be consistent, only the additional cost of extra capacity for runoff storage in the combined storage alternative was compared to the entire cost of the structure for runoff storage in the separate storage alternative. The calculations for the storage cost are presented in Table (A11) of the appendix.

Figure 5.1 gives the different amounts of initial investment required for the three runoff control alternatives. The level of investment is higher for the medium farm as opposed to the small farm for all three runoff control alternatives. The combined storage alternative utilizes a system that already exists although the capacity is expanded. Therefore, the additional needed capacity is much less expensive than the separate storage. When comparing systems that store the runoff for the medium sized farms, the combined storage is the least expensive alternative.

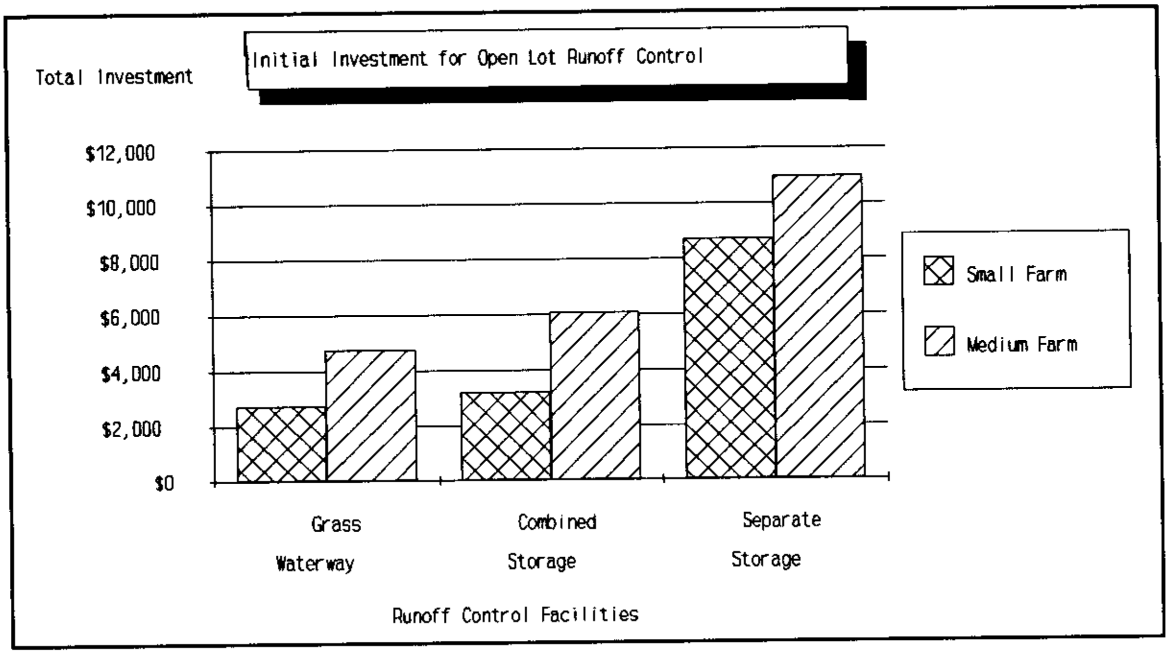

Figure 5.1 Initial Investment for Open Lot Runoff Control

Using the cost summary table, Table (A12) in the appendix, annual after-tax cost was calculated. The open lot runoff control summary table, Table (A13) in the appendix, was developed using the annual after-tax costs determined. The annual standardized costs per pig were determined and are graphically shown in Figure 5.2. The additional cost allocated to each production unit was determined by dividing annual costs by number of hogs produced, the complete table is shown in the appendix, Table (A13). Annual expenditures per pig were over twice as large for the small farm compared to the medium farm. The fact that the settling basin was not size neutral led to this difference in annual expenditures per pig.

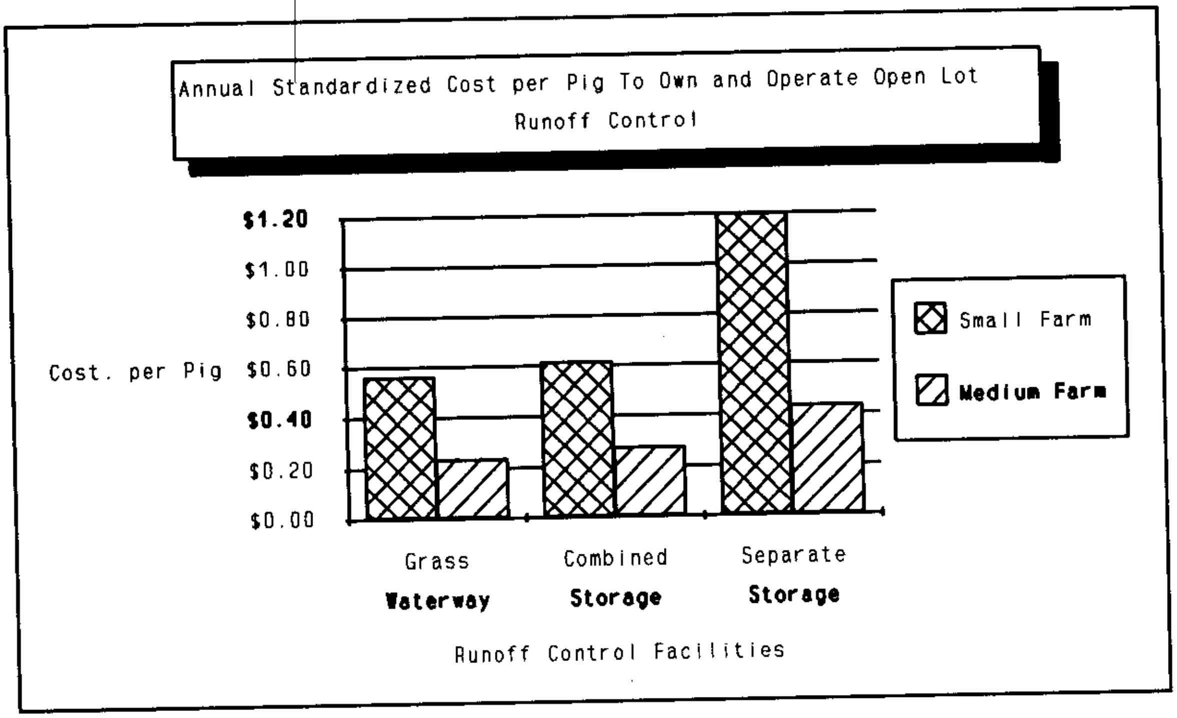

Figure 5.2 Annual Standardized Cost per Pig to Own and Operate Open Lot Runoff Control

Using the cost summary table, located in the appendix, Table (A12), total discounted costs were calculated for a 10 year period. This table reflects the sum of a discounted stream of after-tax cash expenditures for 10 years as a result of investing in runoff control facilities.

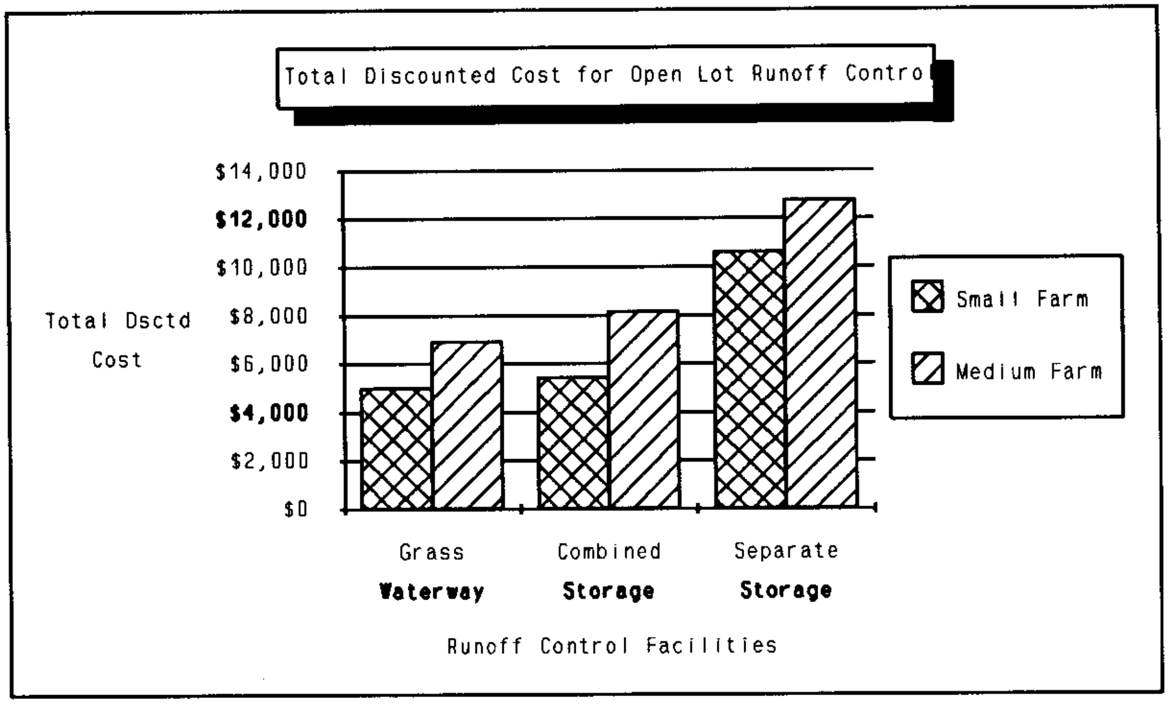

Figure 5.3 Total Discounted Cost for Open Lot Runoff Control

The relative order of magnitude of the different alternatives do not differ when comparing total discounted cost to initial investment. This is because the cash stream of the three options are quite similar. A summary of the different results are found in the appendix, Table (A13).

With many of the smaller and medium sized farms using open lots in their management scheme the costs of open lot control would mostly affect these sizes of operations. This would make it relatively more expensive to use this option. The long range impact of such guidelines could lead to a switching of open lots to other forms of manure management systems.

5.6 INCREASING MANURE STORAGE CAPACITY

5.6.1 Introduction

The proposed requirement for a farm's manure storage capacity, was six months storage. For the three representative farms, the original storage capacity was assumed to be four months, two months short of the required six.

Several different styles of storage were examined for various reasons. The additional variables included: (1) the cost of a hydrogeological study for costs associated with monitoring costs; (2) various construction methods for the earthen storage basins (ESB) for groundwater limitations; (3) various linings for the ESB for prevention of leaching; and (4) adding covers to the ESB for odor control. The different alternatives are described in Table 5.6.

Table 5.6 Manure Storage Basins and Alternatives Reviewed

Description	Base(1)	Hydro Study	Groundwater Limitations	Cover
Earthen Storage Basin (ESB)	X	X	X	X
ESB w/ 1 ft clay liner	X	X	X	X
ESB w/ 3 ft clay liner	X	X	X	X
ESB w/ Flexible Membrane liner (FML)	X	X	X	X
ESB w/ FML and Geotextile (FML w/ Geo)	X	X	X	X
ADL Precast Concrete Tank (Tank A)	X	X		
Butler Livestock Liqui-stor (Tank B)	X	X		
Rochester Silo Slurry Vat (Tank C)	X	X	X	

(1) The base alternative refers to the simplest alternative before any of the other variables are included.

5.6.2 Methodology

In order to determine the costs of the various alternatives the costs associated with building the base case were determined first. After calculating the costs for the simplest alternative, the additional costs for groundwater limitations, cover and hydrogeological study were added on.

Alternative construction styles for earthen storage basins were identified and investment costs estimated to determine the impact that a high groundwater level would have on a storage structure. With high groundwater, constructing the structures above ground could be done to follow the standard of "not building within two feet of groundwater levels". Three different styles were reviewed: (1) cut only (top is flush with ground); (2) cut and fill (soil dug out is used for dikes, ESB is partially above old ground level); and (3) groundwater limitations (no digging is done, dikes are used for walls of ESB).

Several different alternative types of earthen and flexible membrane linings were estimated for the earthen storage basins. The proposed standards address the need for a nonporous lining and gives several alternatives. Liners used were: (1) one ft clay liner; (2) three ft clay liner; (3) flexible membrane liner (FML); and (4) FML with geotextile (GEO). The cost of building ESB with the various liners are contrasted to several different styles of manure storage tanks. These tanks were as follows: Tank A: ADL Precast Concrete Tank; Tank B: Butler Livestock Liqui-stor; Tank C: Rochester Silo Slurry Vat.

Covers for the earthen storage basins, although not listed as a proposed standard, are also included in this study. The cost of covers are included because covers are an alternative in possibly reducing odor and ammonia emission from the storage facilities.

To aid in the cost estimation of these storage facilities, several work sheets and summary tables were used and are presented in the appendix (A14-A34). Cost estimates were taken from the work that Steve Ferns conducted.[5]

First developed were seven engineering cost work sheets, Tables (A14-A20) in the appendix. Listed on these sheets are the relevant sections of information that constitute the variety, construction styles and covers of the various storage basins studied. The initial investments derived from these work sheets, are presented on three summary tables; (A22-A24), one for each size farm. These initial investments calculations were placed into an operating cost summary table, Table (A21), to develop annual standardized costs and total discounted costs. The annual standardized costs are the annuities that would yield the total discounted costs over a 10 year period at the after-tax discount rate. These calculations were then added to the summary tables, Tables (A22-A24). Also calculated on the summary tables are the initial investment and annual standardized cost on a per pig basis.

To determine the impacts of a hydrogeological study, similar work sheets and tables (A25-A34) were also generated. According to a Department of Natural Resources employee in the Water Division, the initial hydrogeological study would cost $10,000 and would include the cost of drilling three separate wells needed for monitoring the site. In addition, there are also annual costs of monitoring these wells.[6] The initial cost of a hydrogeological study and the yearly expenditures for monitoring of the three wells are added to the base case. The figures in this section were generated from the tables located in the appendix.

5.6.3 Results-Manure Storage Alternatives

The initial investments for the various facilities are shown in Figure 5.4. All three different sized farms are listed on each figure to aid in the ability to compare across sizes. Also, various styles of linings for the earthen storage basin are shown.

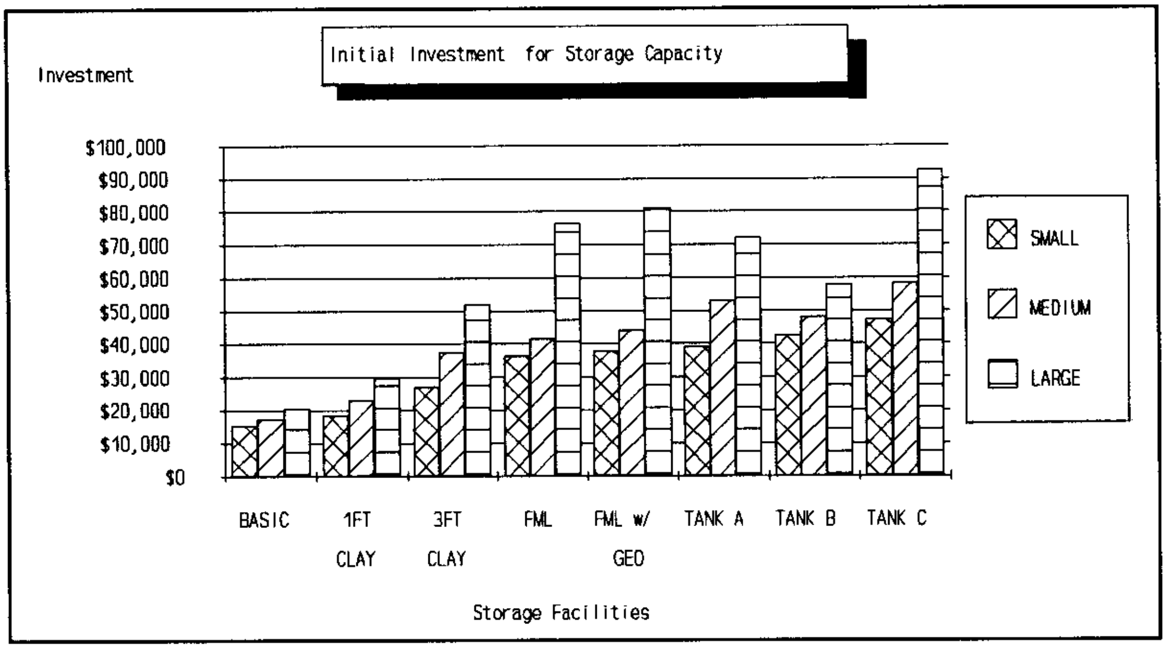

Figure 5.4 Initial Investment for Manure Storage

The type of lining used is an important factor on the amount of the initial investment of manure storage basin. When using the higher priced liners, the manure storage tanks become cost competitive to the earthen storage basins. These cost data illustrate the financial concern about adequate manure storage systems to meet the proposed standards.

5.6.4 <u>Manure Storage Alternatives + Hydrogeological Study</u>

In Figure 5.5, the initial investments for the various storage facilities are presented with the cost of a hydrogeological study and the respective annual monitoring costs included. The cost of this hydrogeological study is the same for all three different sized farms.

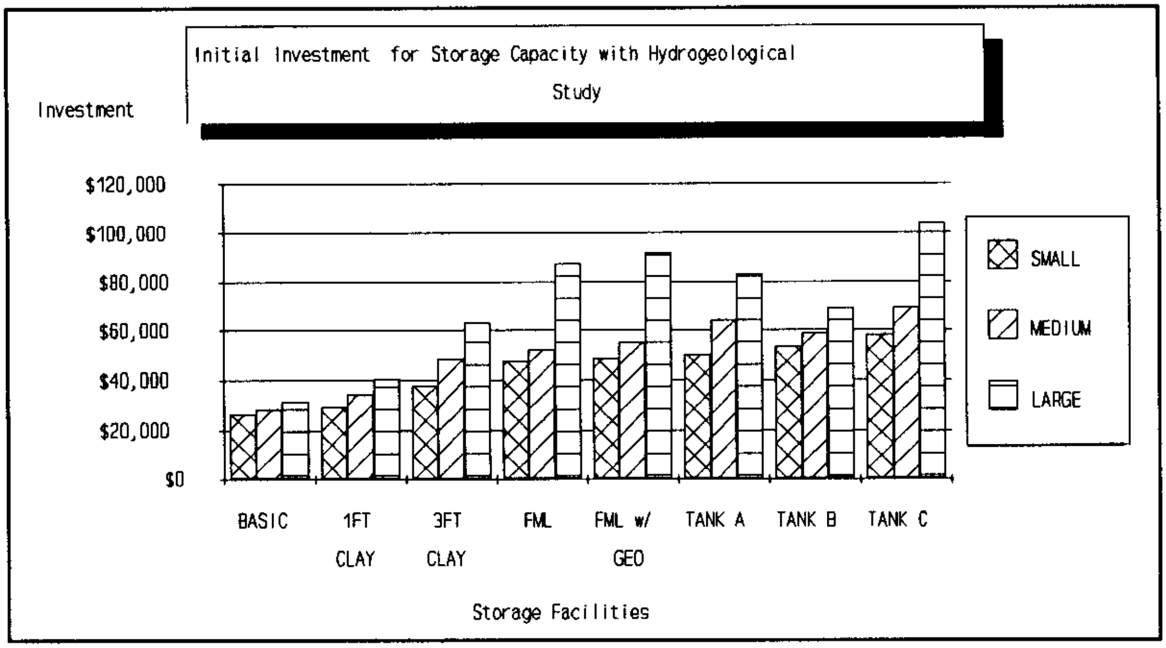

Figure 5.5 Initial Investment for Manure Storage with Hydrogeological Study

The significance of this initial investment cost, common to all sizes can be seen in Figure 5.6. Shown in the figure is the initial investment costs for each size farm, divided by the number of pigs produced per year by the respective farm. For the small farm this means that the total investment is divided by 1194, versus the medium farm by 3979 and the large farm by 7959. The $10,000 hydrogeological study impacts the small farm, producing 1194 pigs per year, much greater per pig than the large farm producing 7959 pigs per year, $8.37/pig vs. $2.51/pig.

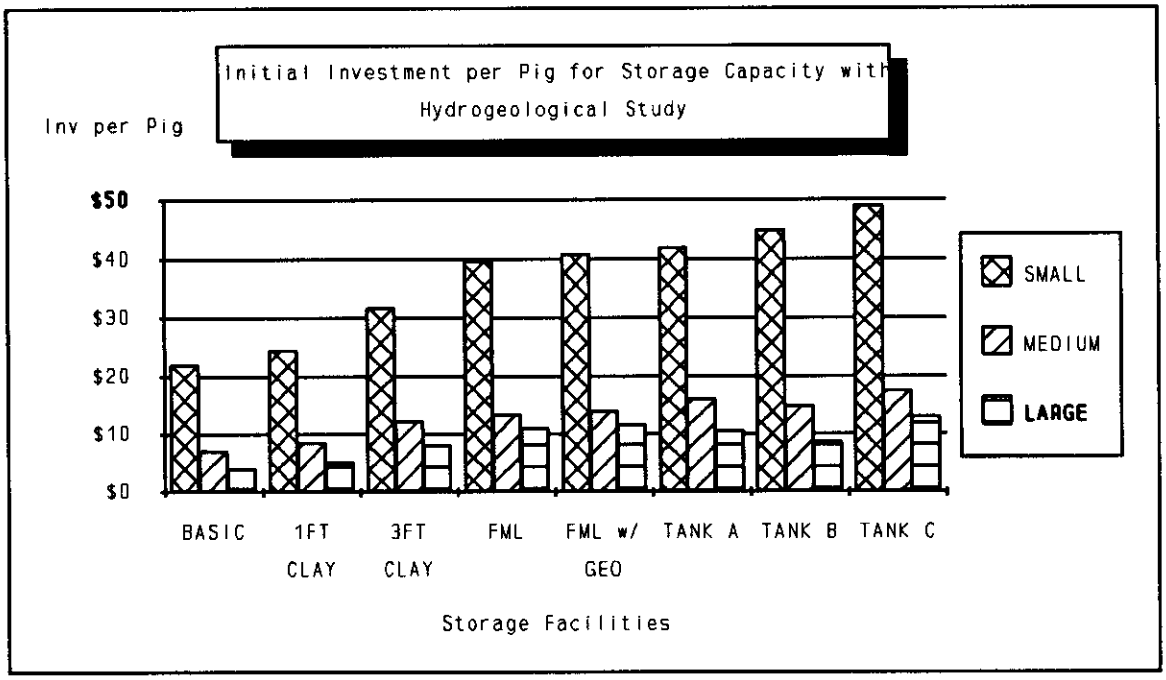

Figure 5.6 Initial Investment per Pig Produced for Manure Storage with Hydrogeological Study

In Figure 5.7 the initial investment of the manure storage without the hydrogeological study is presented. When this is framed, the differences in investment per pig for the different sized farm diminishes as compared to investments per pig for storage with hydrogeological study.

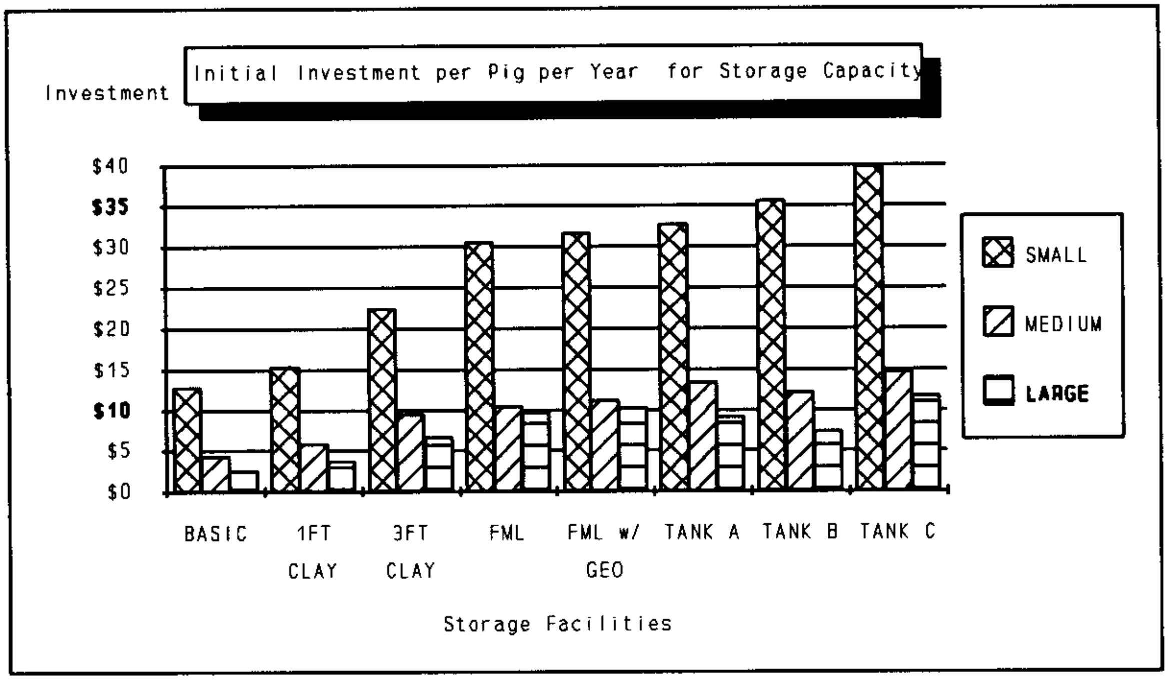

Figure 5.7 Initial Investment per Pig Produced for Manure Storage without Hydrogeological study

Dividing the annual standardized cost by the number of pigs raised, the annual cost per pig is determined. It can be observed in Figure 5.8, that the annual cost per pig for the storage facilities is over 300% greater for the small farm in relation to the large farm. These data provide evidence that the proposed storage standards for manure storage are not size neutral and have large economies of size in operation.

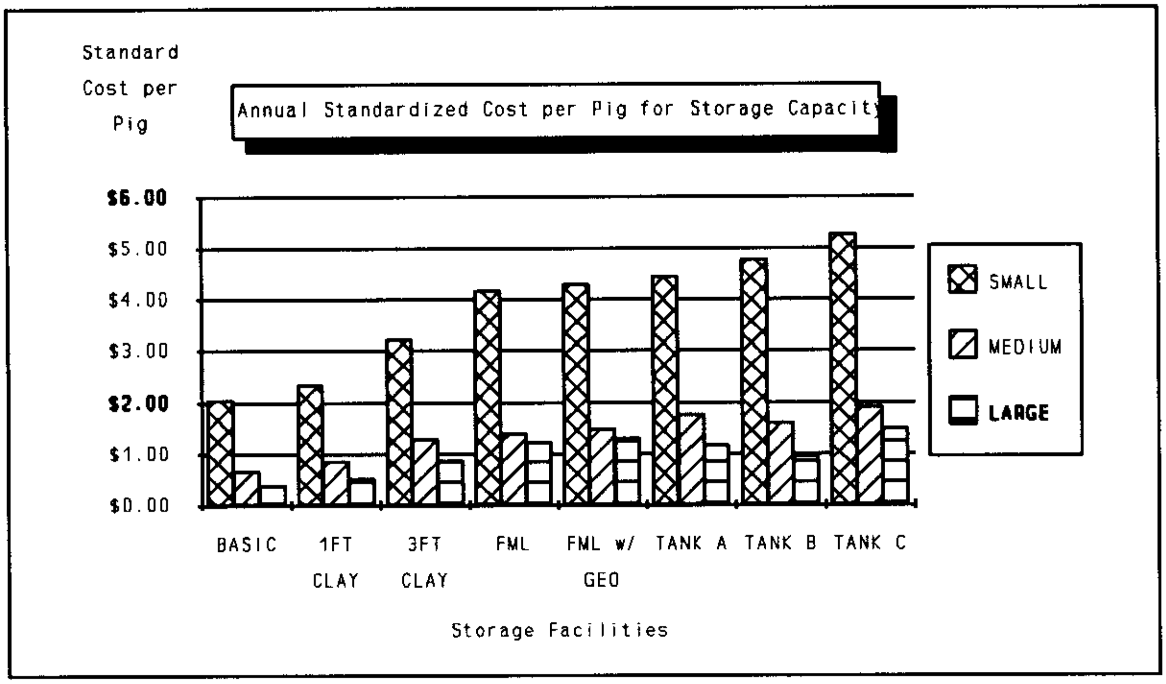

Figure 5.8 Annual Standardized Cost per Pig for Manure Storage Capacity

5.6.5 Manure Storage Alternatives + Groundwater Level Restrictions

For groundwater level restrictions, construction costs for three different methods of building earthen storage basins were estimated. In Figure 5.9, the average investment costs of the different construction styles were contrasted. These costs were averaged to portray only the added costs of the differing styles. The increase in initial costs were approximately $2,000 for the small farm, $3,000 for the medium farm and $4,000 for the large farm.

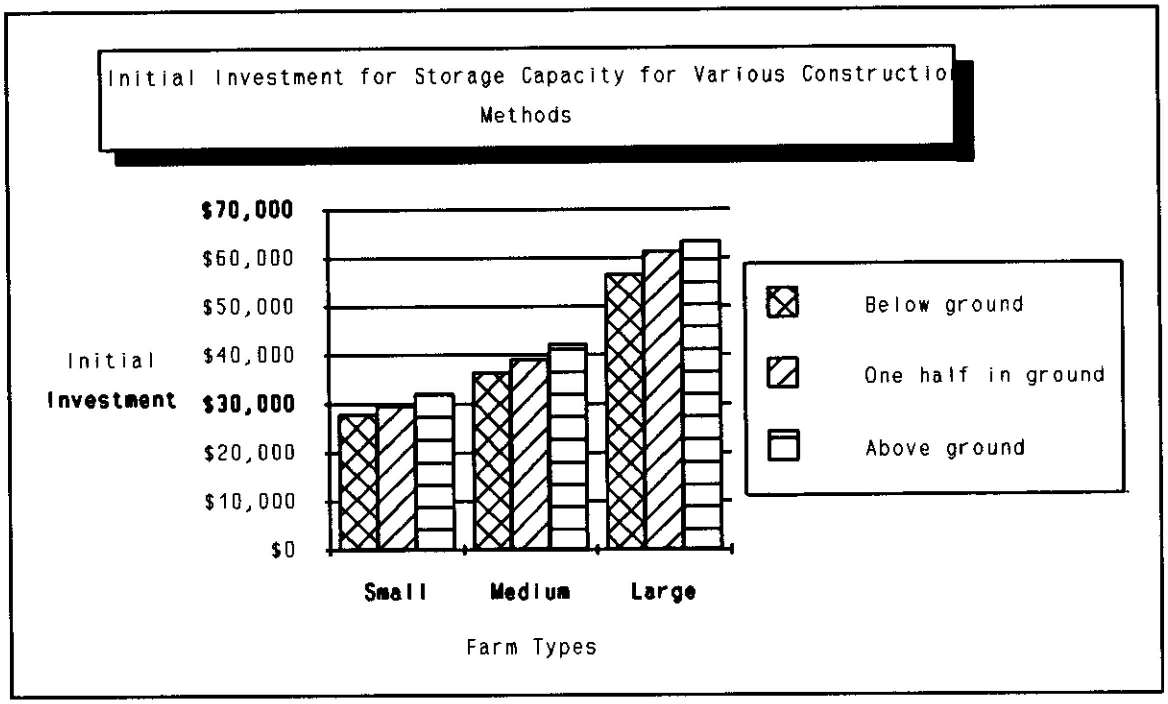

Figure 5.9 Initial Investment for Manure Storage Groundwater Control

In Figure 5.10 the investment per pig for manure storage groundwater control is presented. The additional cost to the small farm to incorporate the different construction methods is substantially more than for the medium and large sized farms. For the small farm, the increased cost per pig to change to above ground storage is $3.51. The cost to the medium and large sized farms are $1.45 and $.85. The table in which these figures are determined are in the appendix, Tables (A22-A24).

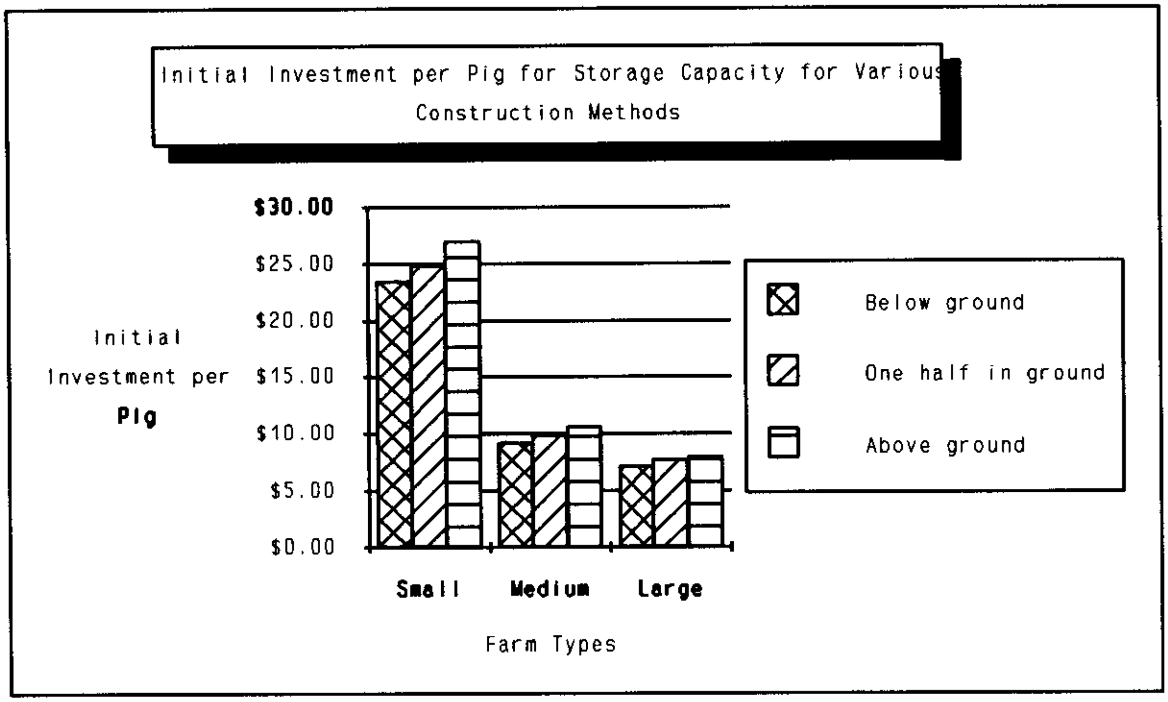

Figure 5.10 Initial Investment per Pig for Manure Storage Groundwater Control

5.6.6 Manure Storage Alternatives + Adding Covers

Adding covers to the manure storage structures increase the initial investment by a large margin. Covers were constructed of the same material as the flexible membrane liner. Cost of the covers per square foot were greater than for the liners because of the added cost for flotation devices. This use of a cover to cut down on odor emitted, can be an expensive strategy as seen in Figure 5.11. Covering the additional storage increased investment cost by 50% for the small farm, 75% for the medium farm, and over 100% for the large farm.

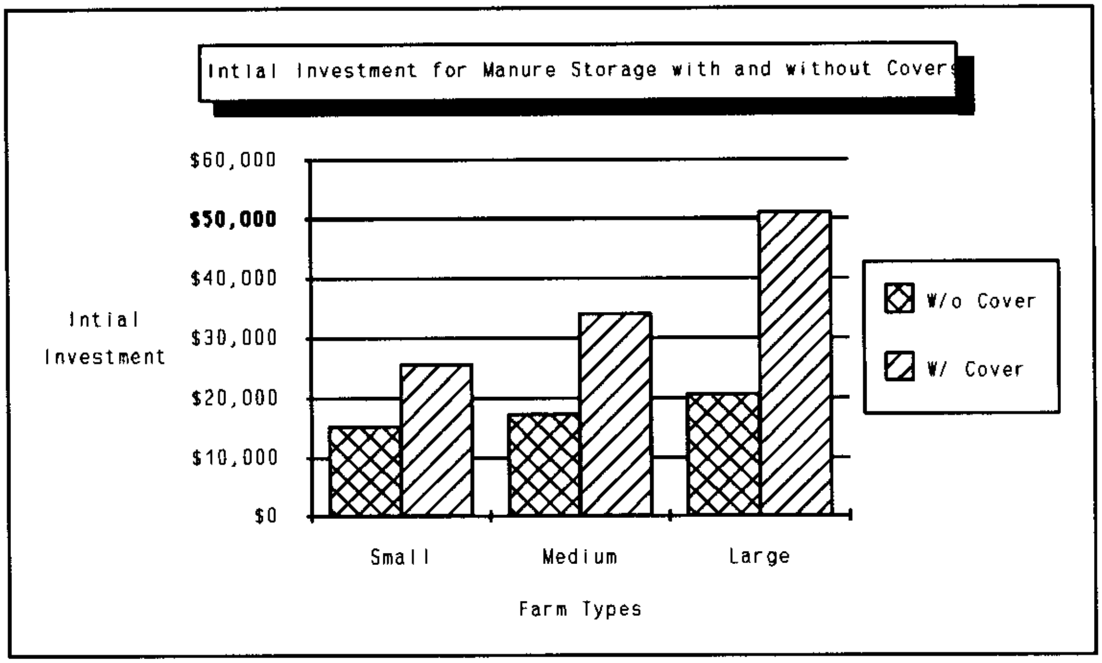

Figure 5.11 Initial Investment for Manure Storage with and without Cover

In viewing the many different styles of manure storage, it is seen that the 'extra' options can greatly increase the cost of a certain type of facility. Because many of these 'extra' options are not size neutral, the result is that they are a greater expense on the production units on the small farm as opposed to other sizes. The initial investments are higher as well as the total discounted cost. In Figure 5.12, the intial investment per pig for manure storage with and without cover is presented.

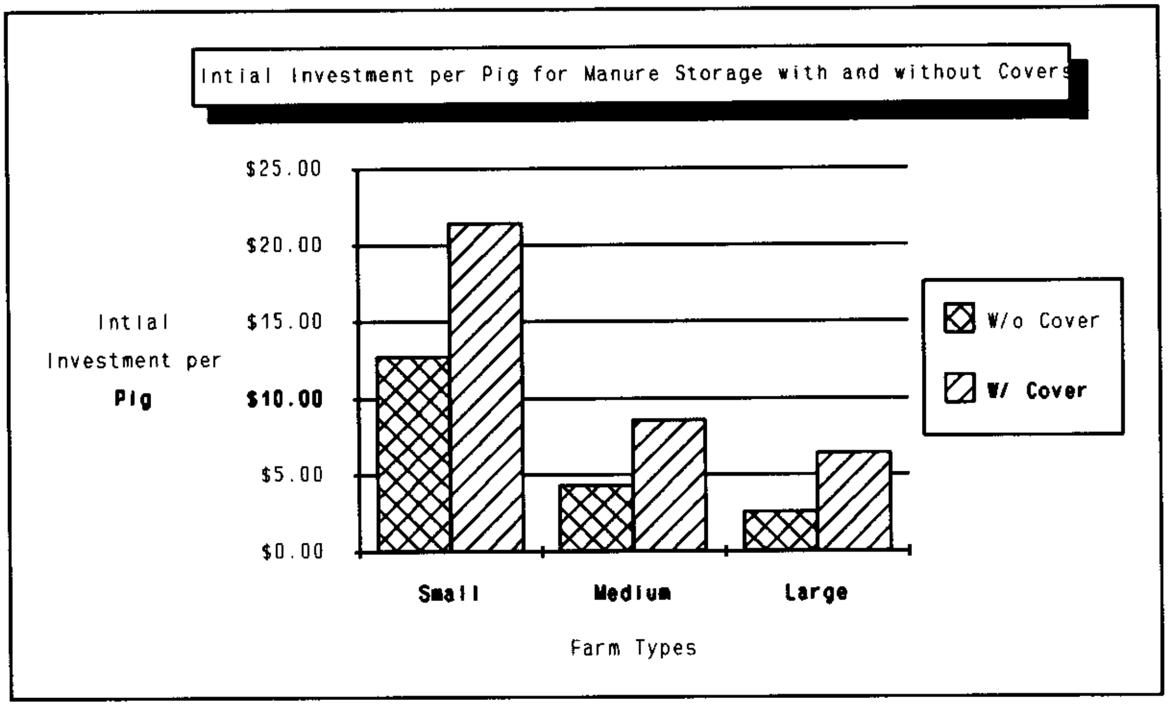

Figure 5.12 Initial Investment per Pig for Manure Storage with and without Cover

5.7 INCORPORATION AS ALTERNATIVE TO SURFACE APPLICATION

With the proposed standard stating: "incorporate as soon as possible" two methods of incorporation are evaluated. The first alternative consists of incorporating the manure within 24 hours after the manure is applied on the surface by use of a tillage implement such as a disk. For the second alternative, the manure is injected into the soil rather than surface applied. A brief description of these alternatives are listed in Table 5.7.

Table 5.7 Manure Application Alternatives

Title	**Description**
Benchmark Practice	Manure from storage facilities is spread on the surface of the ground. No immediate incorporation is used.
Alternative One Surface Application with Incorporation within 24 hours	Manure from storage facilities is spread on the surface of the ground. Incorporation of manure into soil with disc within 24 hours is assumed. No new investment costs but increased labor, energy and machinery costs.
Alternative Two Injection of Manure	Manure from storage facilities is injected into the soil by the use of injectors on the manure tanker. Cost of buying capability to inject is included in this alternative. Also included is the extra energy expense for pulling injectors.

The benefits of incorporating include increased nutrients saved and the possibility of reduced air and water pollution. In this study, with both alternatives using incorporation, the value of the nitrogen saved is contrasted to the extra expenses of incorporation. There are extra expenses because in the benchmark practice there is no tilling of the soil so there is less energy required than for the cases of incorporation. The tables that display the calculations are found in the appendix Tables (A35-A36). The external benefits of possible reduced odor and runoff were not given an economic value and internalized to the farm.

When manure is surface applied without incorporation into the soil within 24 hours, the loss of nitrogen is approximately 20%. Incorporation within 24 hours reduces nitrogen loss from 20% to 10% and use of injection reduces nitrogen loss by 15% to 5%.

In alternative 1, to incorporate the manure within 24 hours, the additional cost is the variable expense of using the disk. Land area required for the spreading of the manure was determined using a software package, Manure Application Economics (MAE).[7] Expenses charged for disking per acre was $1.71 and was derived by using extension bulletins.[8] These calculations are shown in the appendix Table (A35).

In the 2nd alternative using injection, the additional expenses are the initial investment of buying injectors, and extra fuel costs of pulling the manure tank with injectors. Again the MAE program is used for calculating land area and also for added energy costs, see appendix Table (A36). Figure 5.13 graphically demonstrate the different total discounted cost of the two alternatives.

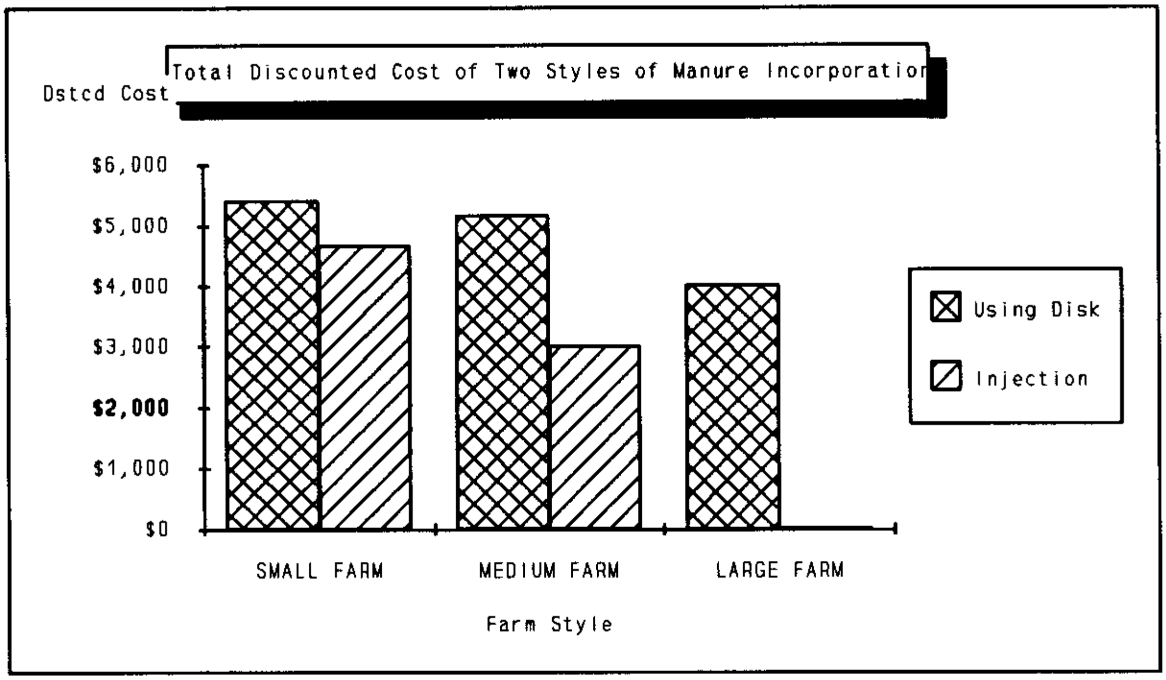

Figure 5.13 Total Discounted Cost of Two Styles of Manure Incorporation

From Figure 5.13 it can be seen that there are positive total discounted costs for all cases using disk. This means that the increased expenses are greater than the value of nutrients saved. Thus from our findings, the value of the nitrogen saved does not warrant the use of incorporation using the disk. Situations that could change these values is not valuing the cost of disking so high. An example would be if disking is already being used for crop production. By lowering the cost of disking to incorporate manure, this would reduce the cost of incorporation, hence possibly a positive total discounted cost.

For the injection alternative, only the small farm and medium farm have a positve total discounted cost. The additional nitrogen saved by incorporation is more than the added cost of using injection for the large farm.

In Figure 5.14, the annual standardized cost is expressed as dollars per year per pig. This illustrates the costs borne by the production unit.

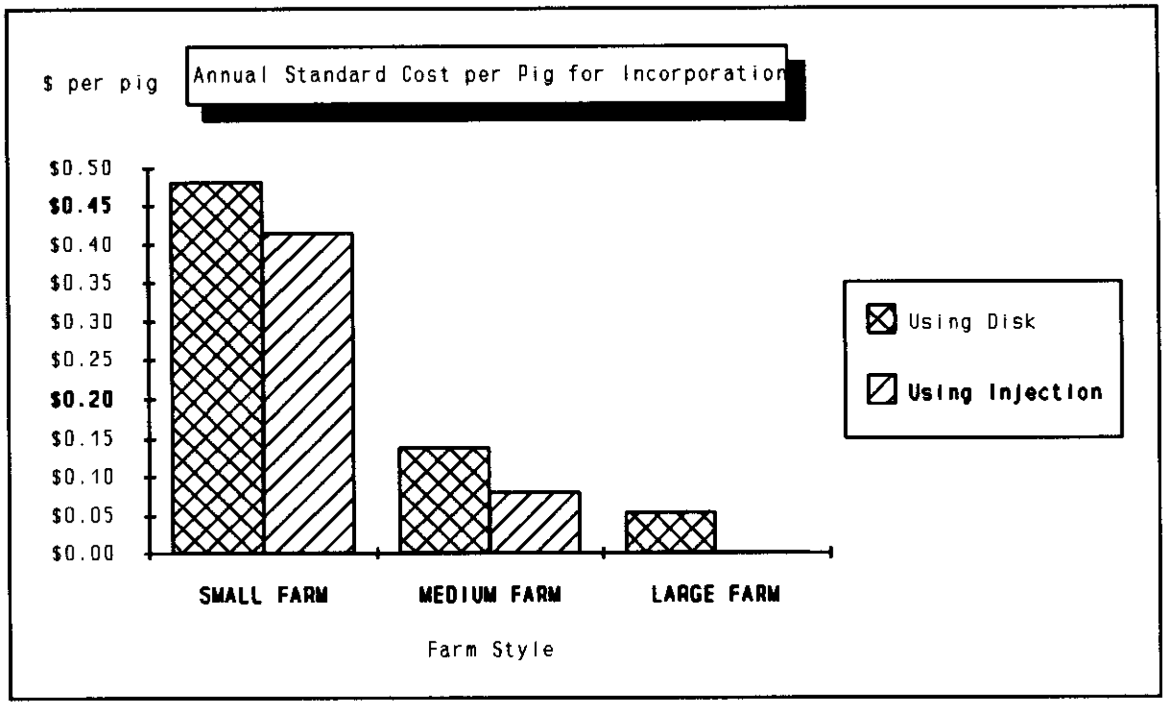

Figure 5.14 Annual Standardized Cost per Pig Produced for Incorporation

5.8 RESULTS AND IMPLICATIONS

In this chapter, three different sized farms were developed to represent the swine production farms in Michigan. By use of a survey and expert opinion, the different farms were described as to their manure management styles. These farms were then contrasted to the proposed standards that were taken from the Animal Waste Committee report. The changes needed in the farm's manure management were noted and divided into different sections.

Costs to control runoff from open lots was the first area studied. It was found that by expanding the capacity of the storage slated to be built for manure from confinement facilities, the investment cost was approximately the same as the costs of the grass waterway alternative. Building a separate storage was significantly more, approximately double that of the other systems. Increased total costs per pig ranged from $.56 to $1.20 for the small farm and $.23 to $.43 for the medium farm. The large farm was not included because operations of this size do not usually utilize outdoor lots.

Implications from this include: required runoff control could force a change in the manure management styles used on these sized farms. Rather than investing in control facilities pig producers may either build confinement facilities or leave the pig business. Because a large number of swine producers in Michigan utilize open lots, this would impact a large number of producers.

The amount of manure storage capacity was considered next. It was assumed that these farms needed an additional 2 months storage. The additional investment costs for the different types of facilities were calculated. Annual Standardized costs were divided by the number of livestock produced per year to obtain a annual cost per pig. It was found that due to economies of size, the impact on the smaller farms was greater. Even though this small farm needed smaller facilities, the cost per pig was much higher than for the medium sized or the large farm. Additional variables such as nonporous liners, hydrogeological studies and covers added relatively larger costs to the small farm.

The storage alternative chosen determines the impact on the different sized farms. Due to the large initial investment and the disproportional cost on the smaller producer it is possible that the structure of the Michigan swine industry could change. The number of small farms would decrease in relation to the larger farms due to the comparative advantage of the larger farms.

The third part of this chapter analyzed two alternatives to surface application of the manure. Incorporation within 24 hours and injection were both calculated to determine the economic impact to the farm. Additional expenses were contrasted to the value of the nitrogen saved by use of incorporation. It was found that the net costs were positive as the additional costs were greater than the value of nitrogen saved for all cases except for the large farm using injectors. This demonstrates that the cost to incorporate all manure would be disproportionally higher for the small and medium sized farms. With a positive cost, education and desire to use the nutrients may not be sufficient to switch application practices from surface spreading to incorporation.

5.9 SUMMARY

Manure management systems for three representative swine farms were analyzed with respect to the economics of runoff control, storage time and incorporation of manure. Runoff control is only a concern to those who have outside facilities. For those with open lots, the facilities to contain and control runoff may be relatively small if the physical conditions around the lot are compatible. If not, large investments on runoff control facilities could be significant enough to cause farms using open lots to change their management practices.

Alternative manure storage facilities were identified and analyzed. All systems included were capable of six months storage capacity for the respective farm size. A number of materials and building styles were analyzed to give the corresponding investment cost and expenses. It was found that by lining the earthen storage basins, this could make the earthen storage basin more costly than other styles, depending on the lining material. When covers for the earthen storage basin were considered the costs went up significantly. Another thing to note is, by adding the hydrogeological study this nearly doubled the cost of the manure facility. The desire for an adequately monitored facility comes at a steep price.

The third area is in the application of the manure. Incorporation seems to be a good idea with saving of valuable nutrients and reduced chances of pollution. However unless this reduction in pollution is valued for the environment, the cost to incorporate outweighs the benefits for the average sized farm.

REFERENCES

1.Animal Waste Resource Committee, " Preliminary Report of the Animal Waste Resource Committee", August 1987.

2.Howard Person, "Pigplan - software for estimating space requirements for swine", 1985, Michigan State University.

3.Stephen B. Harsh, Larry J. Connor, Gerald D. Schwab, "Managing the Farm Business", 1981, Prentice-Hall, Inc. Page 244.

4.Steve Ferns, "Livestock Waste System Cost Estimates", Unpublished article.

5.Steve Ferns, Ibid.

6.Personal Correspondence with Bill Iverson, Department of Natural Resources, Water Division.

7.Stuart Crane, "Manure Application Economics" Software package.

8.Gerald Schwab and Kurt Norgaard, "Custom Work Rates in Michigan", Cooperative Extension Service, 1988.

Chapter 6

DISCUSSION AND RECOMMENDATIONS

6.1 SUMMARY

The Michigan livestock industry is an important component of the Michigan economy. As this industry has grown and become more intensive, a growing number of conflicts between livestock producers and their neighbors have been reported to the Michigan Department of Agriculture. In response to this problem situation the objectives for this paper were "to describe, assess, and analyze livestock manure management issues with specific analytic attention addressed to swine production facilities".

Laws regarding natural resources and livestock agriculture were reviewed in chapter 2. Included was information on recent legislative work related to air and water pollution. One of the pre-legislative efforts included the Animal Waste Committee's report that included a number of proposed manure management standards. These standards were used in this study as a benchmark for analysis of economic impact upon three representative size Michigan swine farms.

In chapter three, several papers on the topic of animal manure management were reviewed. Findings of economies of size were found regularly in the papers. It was also found that the authors used several different methods to examine this topic.

Results of a survey of hog farmers were given in Chapter 4 to furnish a profile of Michigan hog producers. Descriptions on size, management practices and facilities used were given in the various tables. A profile of those farms that had complaints directed towards their operations was also given.

In chapter 5, three model swine farms were defined to represent different sized farms in Michigan's swine industry. This chapter discloses the changes and costs that would occur on farms if the proposed standards were imposed. Analytical results were presented as tables and figures. Implications from these findings were also given.

6.2 CONCLUSION

With the increasing numbers of conflicts and also a growing public concern for natural resources, livestock producers are going to have to reevaluate their management of animal manures. This byproduct of animal production can be a valuable input to crop production. However, manure also has the potential to negatively effect others in the rural area.

Past protocol has been that the livestock producers have handled the manure according to their own prerogative. Any individual who disagrees with this practice may contest the action in court. As livestock production has intensified and rural population increased, conflicts have arisen. The increased number of conflicts have brought this problem to public attention.

A set of standards were proposed by the Michigan Department of Agriculture to address the manure management problem. This paper attempted to clarify the cost of compliance that would have occurred on three representative Michigan swine farms. By choosing several different sized farms and management styles this gave a broader perspective, thus incorporating more of the possible situations presently on Michigan swine farms. It was concluded from chapter 5 that the costs for compliance to the regulations can be quite significant. Economies of size are in effect and could possibly change the structure of the Michigan hog industry.

These proposed standards did not receive approval and a second set of interim guidelines were created. These guidelines incorporated some of the proposed standards as guidelines, although many of proposed standards were left out.

Originally it was suggested in chapter one, that there existed the need for a definition of generally accepted waste management practices that individual livestock producers can follow that will: 1) be conducive to reducing the number of conflicts between livestock producers and their neighbors, 2) protect the natural resources and, 3) provide for profitable animal agricultural systems. Whether these guidelines fit the bill is at this point unknown.

6.4 FUTURE RESEARCH

The total cost of compliance for three representative sized Michigan swine farms was modeled and determined. Now the other side of the coin is needed and the magnitude of the benefits need to be determined. It would make sense that such a set of standards would be imposed only if the marginal benefits are higher than the marginal costs. Such benefits need to be identified and quantified. A suggestive list could include: 1) the neighbor's well-being is raised, 2) the quality of surface and ground water increased, 3) air quality is improved, and 4) health care costs could be reduced. These benefits would not only be difficult to measure but also some of the cause and effects need to be established. Contingent valuation technique could contribute to quantifying people's perception of their willingness to pay for such benefits.

This research is needed to determine the impact of livestock farms in their neighborhood. Secondly, if animal manures are a problem and there does need to be changes, are new management standards the most efficient way to address the situation?

The Coase theorem states that as long as property rights are clearly defined and enforced, bargaining between the parties can achieve the efficient pattern of resource use.[1] In this case, it needs to be made clear who owns the rural air and waters. If it is the farmers, the need for compensation to induce change in farmer's behavior should be determined. If it is the neighbors, than it is the neighbors who need to be compensated if the air or water quality is reduced. Difficulty arises because of the large numbers of both producers and neighbors thus the process of achieving agreement is greatly hindered.

Other methods besides more rigid standards in reducing conflicts are needed to be researched. No matter what the outcome, if there are additional costs to the livestock producers in this state, it will lead to higher input prices thus higher production costs. This will put Michigan livestock producers at a disadvantage relative to other states that do not have such costs. If livestock production is important to Michigan, the farmers could be reimbursed for the amount of the cost making them more competitive with other states.

With animal agricultural so important to this state, the need for an equitable painless as possible, cure would be the best for all of those concerned.

REFERENCES

1.Edgar K. Browning and Jacquelene M. Browning, Microeconomic Theory and Applications, Little Brown and Co. pg 552.

APPENDIX

Table A1 Michigan Pork Producers Association (MPPA) Questionnaire

MPPA MANAGEMENT PRACTICES SURVEY

(Please leave any question not applying to your operation blank and proceed to the next question.)

1. In what county is your operation located? ______

2. Your interest or position in the swine operation is best described as: *(Please mark one.)*

A. Owner [✓] C. Manager [ ] E. Investor [ ]
B. Owner-Operator [ ] D. Employee [ ] F. None of the above [ ]

Please describe: ______

3. The type of ownership (or interest) you have in the swine operation is best described as: *(Please mark one.)*

A. Sole-proprietorship [✓]
B. Family Partnership [ ]
C. Partnership with someone outside the family [ ]
D. Family Corporation [ ]
E. Corporation with someone outside the family [ ]
F. Investor [ ]

4. How many tillable acres do you own on which manure could be applied? 100

5. How many tillable acres do you rent on which manure could be applied? 150

6. Do you have access to acreage that you neither own or rent on which manure could be applied?

A. Yes [✓] B. No [ ]

7. If you answered yes to question 6, are you currently applying manure to land you neither own or rent?

A. Yes [✓] B. No [ ]

8. If you answered yes to question 7, are you currently, or would you consider, selling the manure to the landowner or are you applying the manure at no charge in order to have a place to dispose of it?

A. Currently selling the manure [ ]
B. Not currently selling but am considering selling [ ]
C. Am applying at no charge and plan to continue [✓]

9. The total number of hogs produced *annually* in your operation with each housing production system is:

A. Farrow to Finish sold annually:
1) Farrowed in pasture (No.) ______ Acres Used ______
2) Finished in pasture (No.) ______ Acres Used ______
3) Farrowed in pasture but finished in confinement (No.) ______
4) Farrow to finish in confinement (No.) 3,000

B. Farrow to Feeder Pigs (Sold as feeders annually):
1) Farrowed and raised in pasture (No.) ______ Acres Used ______
2) Farrowed and raised in confinement (No.) 6,000

C. Finishing Feeder Pigs (Purchased feeder pigs finished annually):
1) Finished in pasture (No.) ______ Acres Used ______
2) Finished in confinement (No.) ______

10. How many animals of other species are maintained by your operation annually?

A. Beef (No.) 0 B. Dairy (No.) 0 C. Poultry (No.) 0 D. Other (No.) 0

11. If breeding and gestation are maintained on dirt and/or pasture lots the numbers of animals maintained are:

A. Breeding Lots
1) Acres Used ______ 2) No. of animals maintained ______

B. Gestation Lots
1) Acres Used ______ 2) No. of animals maintained ______

12. **What percentage of your total annual manure production is handled in the following form:**
(A + B + C = 100%)
A. Liquid (%) 95% B. Solid without bedding (%) ______ C. Solid with bedding (%) 5%

13. **How many days of liquid manure storage capacity do you have within each of the following buildings** (If you have no inside storage, skip to question 14):
A. Farrowing (Days of Storage) 270
B. Hot Nursery (Days of Storage) 150
C. Nursery (Days of Storage) 42
D. Grower I (Days of Storage) ______
E. Grower II (Days of Storage) 120
F. Finishing (Days of Storage) 120
G. Gestation (Days of Storage) 300
H. Breeding (Days of Storage) 300

14. **How many days of liquid manure storage capacity do you have outside the buildings with each of the following types of storage** (If you have no outside storage skip to question 15):
A. Underground storage tank with cover (No. of Days) 120, Without cover (No. of Days) 0
B. Above ground storage tank with cover (No. of Days) 0, Without cover (No. of Days) 0
C. Earth storage basin (No. of Days) 0 How often is this facility pumped annually? 0
D. Treatment Lagoon (No. of Days) 0 (If you utilize a treatment lagoon, please describe the system.)
______
E. Please describe any other liquid manure storage facility used in your operation. ______
______
______

15. **What percentage of the total annual swine manure is handled in solid form (%)?** 5%

16. **How often is solid manure scraped and cleaned from concrete feeding floors in each of the following facilities?**
A. Gestation—Every ______ days.
B. Nursery—Every ______ days.
C. Finishing—Every ______ days.
D. Feeding floors are utilized but are never scraped. *(Please check)* ☑

17. **How soon after application is solid manure tilled into the soil?** *(Please mark one)*
A. At the close of each day ☐
B. Within three days ☐
C. Within ten days ☐
D. After more than 10 days ☑
E. Does not apply ☐

18. **Please give percentage of liquid manure applied by the following methods:**
A. Surface spread (%) 25
B. Surface spread and tilled into the soil within three days (%) ______
C. Knifed in at the time of application (%) 50
D. Irrigated during the growing season (%) ______
E. Irrigated before the growing season (%) ______
F. Irrigated after the growing season (%) 25
G. What percentage of liquid manure is custom applied? (%) ______

19. **Do you use soil tests and/or manure analysis to determine how much manure to apply to your land?**
A. Yes ☐ B. No ☑

20. **Have you ever had your drinking water tested for the presence of pollutants?**
A. Yes ☑ B. No ☐

21. **What changes in production do you plan within the next ten years?** *(Please mark one.)*
A. Expand more than 25% ☑
B. Expand less than 25% ☐
C. Stay at same level ☐
D. Decrease ☐
E. Discontinue raising hogs ☐
F. Discontinue farming ☐

22. **How close is the nearest residence, other than your personal residence, to your production facility?** 100 yds.

23. **How many residences are located within the following distances to your production facility?**
A. Within ¼ mile (No.) 4
B. Within ½ mile (No.) 10
C. Within ¾ mile (No.) 36
D. Within 1 mile (No.) 65

24. How far is your production facility from the nearest village limits? [illegible] ___

25. Is your farm located in a zoned area? (If no, skip to question 28.)

A. Yes [ ] B. No [✓]

26. If your farm is located in a zoned area, is it zoned agricultural?

A. Yes [ ] B. No [ ]

27. If your farm is located in a zoned area, how far is it from the nearest non-agriculturally zoned area? ___

28. How far is your production facility from the nearest lake, stream or drainage ditch? 1/4 mile

29. Is a majority of your farm operation in Public Act 116? (Farm Land Preservation Act.)

A. Yes [✓] B. No [ ]

30. Are your swine facilities located on land that is in Public Act 116?

A. Yes [✓] B. No [ ]

31. Have there been any complaints about your operation in the past five years? (Either formal complaints to regulatory agencies or informal complaints by neighbors or other parties.)

A. Yes [✓] B. No [ ]

32. If you answered yes to question 31, indicate the nature of the complaint. *(Please mark all that apply.)*

A. Odor [✓]
B. Runoff [ ]
C. Manure spillage in transit [ ]
D. Location of manure spreading [ ]
E. Time of manure spreading (Holidays, weekends, etc.) [ ]
F. Dead Animal Disposal [ ]

33. Did you have any outside assistance with the design of your manure storage and handling systems?

A. Yes [✓] B. No [ ]

34. If you answered yes to question 33, from whom did you receive assistance? Contractor

___

35. Did you receive any cost sharing assistance with the construction of your manure storage and handling systems?

A. Yes [ ] B. No [✓]

36. If you answered yes to question 35, from what agency did you receive funding? ___

___

37. What management practices are you currently using to control odors and runoff? ___

Incorporation when ever possible

___

___

38. Which of the following describes your relationship with MPPA? *(Place a check mark to identify your status.)*

A. Producer Member [✓]
B. Associate Member [ ]
C. Not presently a member but have been in the past [ ]
D. Never have been a member [ ]

39. Within which of the following farm and commodity organizations do you currently hold membership? *(Please mark all that apply.)*

A. Grange [ ]
B. Farm Bureau [✓]
C. National Farmers Organization [ ]
D. Cattlemen's Associations [ ]
E. Milk Producers [ ]
F. Others [ ]

Please list ___

___

Table A2 "Pigplan" Input Form for Small Farm

Number of pigs produced per year	1193
Number of groups of sows to be used	19
Number of sows in herd	59
Farrowing and breeding interval in days	7
Actual idle time (room empty) in days	2.2
Early farrowing allowance in days	8
Number of farrowing groups per year	46.54
Ages of pigs at weaning minimum	27
Ages of pigs at weaning maximum	35
Number of sow groups in breeding unit at one time	4
Number of groups of pigs in nursery at one time	5
Maximum age of pigs leaving nursery	67
Extra days available	.2
Number of groups in grower 1 at one time	6
Maximum age of pigs leaving grower 1	113
Extra days available	.1
Number of groups in grower 2 at one time	5
Maximum age of pigs leaving grower 2	151
Extra days available	.2
Number of groups of pigs in finishing at one time	7
Maximum average age of pigs to market	204
Extra days available	6.9
Number of sows to have available for breeding	4
Number of working boars needed for the above number of sows ..	2

Space Requirements:

Building	Ave. Wt. in Lbs.	Number of Pigs	Sq.Ft. per Pig	Pigs per Pen	Area per Pen	Number of Pens	Pen Area
Gilt Pool	200-250	5	24.0	7	168	1	168
Brd. Boars	300-500	2	56.0	1	56	2	112
Sows	300-500	16	30.0	6	180	3	540
Gestation	300-500	33	16.0	6	96	6	576
Farrowing	300-500	3	62.0	1	One Farrowing Room		186
1 Nur. Rm.	55	32	2.5	12	30	4	120
Grower 1	129	162	5.0	25	125	7	875
Grower 2	184	135	6.0	25	150	6	900
Finishing	227	189	8.0	25	200	8	1600

Cost index: Farrow to finish = 118380 Feeder pig = 87600

Table A3 "Pigplan" Output Form for Small Farm

Manure and Nutrient Production:

Type	Time Mo.	Cu. Ft. Storage	Volume in Gallons	Avail. N lb/yr	P205 lb/yr	K20 lb/yr
Gilt Pool	6	180	1346	70	72	59
Breeding	6	810	6058	315	327	266
Gestation	6	1188	8886	462	479	390
Farrowing	6	1782	13329	693	719	586
Nursery	6	864	6462	336	348	284
Grower 1	6	4082	30536	1587	1648	1343
Grower 2	6	3402	25446	1323	1374	1119
Finishing	6	8164	61072	3175	3297	2687
Feeder pig total		8906	66619	3464	3597	2931
Farrow-finish total		20473	153139	7963	8269	6738

Table A4 "Pigplan" Input Form for Medium Farm

Number of pigs produced per year	3979
Number of groups of sows to be used	19
Number of sows in herd	197
Farrowing and breeding interval in days	7
Actual idle time (room empty) in days	2.2
Early farrowing allowance in days	8
Number of farrowing groups per year	46.54
Ages of pigs at weaning minimum	27
Ages of pigs at weaning maximum	35
Number of sow groups in breeding unit at one time	4
Number of groups of pigs in nursery at one time	5
Maximum age of pigs leaving nursery	67
Extra days available	.2
Number of groups in grower 1 at one time	6
Maximum age of pigs leaving grower 1	113
Extra days available	.1
Number of groups in grower 2 at one time	5
Maximum age of pigs leaving grower 2	151
Extra days available	.2
Number of groups of pigs in finishing at one time	7
Maximum average age of pigs to market	204
Extra days available	6.9
Number of sows to have available for breeding	12
Number of working boars needed for the above number of sows ..	5

Space Requirements:

Building	Ave. Wt. in Lbs.	Number of Pigs	Sq.Ft. per Pig	Pigs per Pen	Area per Pen	Number of Pens	Pen Area
Gilt Pool	200-250	15	24.0	7	168	2	336
Brd. Boars	300-500	5	56.0	1	56	5	280
Sows	300-500	48	30.0	6	180	8	1440
Gestation	300-500	110	16.0	6	96	19	1824
Farrowing	300-500	10	62.0	1	One Farrowing Room		620
1 Nur. Rm.	55	108	2.5	12	30	10	300
Grower 1	129	540	5.0	25	125	22	2750
Grower 2	184	450	6.0	25	150	18	2700
Finishing	227	630	8.0	25	200	25	5000
Cost index:		Farrow to finish =	392750		Feeder pig =		290150

Table A5 "Pigplan" Output Form for Medium Farm

Manure and Nutrient Production:

Type	Time Mo.	Cu. Ft. Storage	Volume in Gallons	Avail. N lb/yr	P205 lb/yr	K20 lb/yr
Gilt Pool	6	540	4039	210	218	177
Breeding	6	2385	17839	927	963	784
Gestation	6	3960	29620	1540	1599	1303
Farrowing	6	5940	44431	2310	2399	1954
Nursery	6	2916	21811	1134	1177	959
Grower 1	6	13608	101787	5292	5496	4478
Grower 2	6	11340	84823	4410	4580	3732
Finishing	6	27216	203575	10585	10993	8957
Feeder pig total		29349	219530	11415	11854	9659
Farrow-finish total		67905	507929	26412	27428	22348

Table A6 "Pigplan" Input Form for Large Farm

Number of pigs produced per year	7958
Number of groups of sows to be used	19
Number of sows in herd	394
Farrowing and breeding interval in days	7
Actual idle time (room empty) in days	2.2
Early farrowing allowance in days	8
Number of farrowing groups per year	46.54
Ages of pigs at weaning minimum	27
Ages of pigs at weaning maximum	35
Number of sow groups in breeding unit at one time	4
Number of groups of pigs in nursery at one time	5
Maximum age of pigs leaving nursery	67
Extra days available	.2
Number of groups in grower 1 at one time	6
Maximum age of pigs leaving grower 1	113
Extra days available	.1
Number of groups in grower 2 at one time	5
Maximum age of pigs leaving grower 2	151
Extra days available	.2
Number of groups of pigs in finishing at one time	7
Maximum average age of pigs to market	204
Extra days available	6.9
Number of sows to have available for breeding	24
Number of working boars needed for the above number of sows	10

Space Requirements:

Building	Ave. Wt. in Lbs.	Number of Pigs	Sq.Ft. per Pig	Pigs per Pen	Area per Pen	Number of Pens	Pen Area
Gilt Pool	200-250	30	24.0	7	168	4	672
Brd. Boars	300-500	10	56.0	1	56	10	560
Sows	300-500	96	30.0	6	180	16	2880
Gestation	300-500	220	16.0	6	96	37	3552
Farrowing	300-500	20	62.0	1	One Farrowing Room		1240
1 Nur. Rm.	55	216	2.5	12	30	19	570
Grower 1	129	1080	5.0	25	125	43	5375
Grower 2	184	900	6.0	25	150	36	5400
Finishing	227	1260	8.0	25	200	51	10200

Cost index: Farrow to finish = 785500 Feeder pig = 580300

Table A7 "Pigplan" Output Form for Large Farm

Manure and Nutrient Production:

Type	Time Mo.	Cu. Ft. Storage	Volume in Gallons	Avail. N lb/yr	P205 lb/yr	K20 lb/yr
Gilt Pool	6	1080	8078	420	436	355
Breeding	6	4770	35679	1855	1926	1569
Gestation	6	7920	59241	3080	3199	2606
Farrowing	6	11880	88862	4620	4798	3909
Nursery	6	5832	43623	2268	2355	1919
Grower 1	6	27216	203575	10585	10993	8957
Grower 2	6	22680	169646	8821	9160	7464
Finishing	6	54432	407151	21171	21986	17914
Feeder pig total		58698	439061	22831	23709	19318
Farrow-finish total		135810	******	52824	54856	44697

Table A8 Selected Costs for Manure Management Systems

	Values	Sources
OPEN LOT		
Diversion Cost	$1.63/ft	Department of Natural Resources
Channel Cost	$1.50/ft	Department of Natural Resources
Grass Waterway Cost	$5.00/ft	Department of Natural Resources
Settling Basin Cost	$1,910	"Livestock Waste Facilities Handbook"
MANURE STORAGE		
Hydrogeological Study	$10,000	Department of Natural Resources
Surveying Cost	$200	Local Firms
Soil Boring Cost	$2,000	Local Firms
Manure Analysis	$300	Dr. Lee Jacobs
Earthwork Costs	Varies	Steve Fern's Unpublished Article
Materials Cost	Varies	Steve Fern's Unpublished Article
INCORPORATION		
Nitrogen Prices	$.22/lb	Ag Econ Report #524
Fuel Costs	$1.00	Ag Econ Report #524
Investment Costs	Varies	Local Firms
Extra Energy Costs	Varies	"Manure Application Economics" Software
CAPITAL BUDGETING		
Interest Cost	11.4%	Production Credit Association
Tax Rate	28.0%	Farmers Tax Guide 1989
Labor Costs	$5.00/hr	Ag Econ Report #524
Discount Rate	8.0%	U.S. Treasury Bond
Repair Expenses	Varies	MI Ag Experiment Station Journal Article #11833

Table A9 Open Lot Runoff Control - Small Farm - Engineering Cost Worksheet

	OPEN LOT RUNOFF CONTROL - SMALL FARM Engineering Cost Worksheet				
	Description	Cost	Grass waterway	Combined storage	Separate storage
Diversion (1)	124 ft	$1.63 / ft	$202	$202	$202
Channel (2)	140 ft	$1.50 / ft	$210	$210	$210
Settling Basin (3)			$1,910	$1,910	$1,910
Manure Pipe (4)	25/50 ft			$325	$550
Grass Strip (5)	30 ft	$5.00 / ft	$165		
Subtotal			$2,487	$2,647	$2,872
Engineering (6)			$249	$265	$287
TOTALS			$2,735	$2,911	$3,159
Storage (7)			N/A	$295	$5,560
TOTALS After Storage			$2,735	$3,206	$8,719

Footnote (1) Diversion describes a ditch that is built to divert clean surface water around the lot.
Footnote (2) Channel is the facilty that catches and carries the runoff into the settling basin.
Footnote (3) Settling basin is constructed of cement and removes the solids from the runoff.
Footnote (4) Manure pipe is the pipe that carries the runoff from the settling basin to the storage facility.
Footnote (5) Grass strip is the infiltration area where the runoff is ran, the grass utilizes the nutrients from the runoff.
Footnote (6) Engineeering is the cost added to the project for egineering work. Value assigned is 10% of total job.
Footnote (7) Storage is the cost for storage of the liquid runoff for 6 months. See "Open Lot Runoff Control Storage Facilities" for details. Grass waterway does not utilize any storage.

Table A10 Open Lot Runoff Control - Medium Farm - Engineering Cost Worksheet

	OPEN LOT RUNOFF CONTROL - MEDIUM FARM Engineering Cost Worksheet				
	Description	Cost	Grass waterway	Combined storage	Separate storage
Diversion (1)	300 ft	$1.63 / ft	$489	$489	$489
Channel (2)	317 ft	$1.50 / ft	$476	$476	$476
Settling Basin (3)			$2,726	$2,726	$2,726
Manure Pipe (4)	25/50 ft			$325	$550
Grass Strip (5)	115 ft	$5.00 / ft	$633		
Subtotal			$4,323	$4,016	$4,241
Engineering (6)			$432	$402	$424
TOTALS			$4,755	$4,417	$4,665
Storage (7)			N/A	$1,658	$6,314
TOTALS After Storage			$4,755	$6,075	$10,978

Footnote (1) Diversion describes a ditch that is built to divert clean surface water around the lot.
Footnote (2) Channel is the facilty that catches and carries the runoff into the settling basin.
Footnote (3) Settling basin is constructed of cement and removes the solids from the runoff.
Footnote (4) Manure pipe is the pipe that carries the runoff from the settling basin to the storage facility.
Footnote (5) Grass strip is the infiltration area where the runoff is ran, the grass utilizes the nutrients from the runoff.
Footnote (6) Engineeering is the cost added to the project for egineering work. Value assigned is 10% of total job.
Footnote (7) Storage is the cost for storage of the liquid runoff for 6 months. See "Open Lot Runoff Control Storage Facilities" for details. Grass waterway does not utilize any storage.

Table A11 Open Lot Runoff Control - Storage Facilities

	OPEN LOT RUNOFF CONTROL - STORAGE FACILITIES Earthen Storage Basin					
	Small Farm			Medium Farm		
	confinement only	combined	Separate	confinement only	combined	Separate
General (1)	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030
Site Preparation	$211	$224	$149	$347	$425	$189
Earthwork	$929	$1,074	$371	$2,047	$3,011	$716
Structures (2)	$155	$155	$155	$155	$310	$155
Utilities(3)	$7,810	$7,810	$0	$7,810	$7,810	$0
Landscaping	$2,468	$2,578	$2,168	$3,058	$3,368	$2,468
Subtotal	$13,603	$13,871	$4,873	$15,447	$16,954	$5,558
Engineering + Surv (4)	$1,560	$1,587	$687	$1,745	$1,895	$756
Total (no cover)	$15,163	$15,458	$5,560	$17,192	$18,849	$6,314

DIFFERENCE (5)	$295	$1,658

Footnote (1) Included in the heading "General" is a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost to install a concrete pad that is used for a pumping stand.
Footnote (3) Utilities is the intial cost of the manure pump and hook up
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200
Footnote (5) Difference is the value used for comparing storage costs for combined.
This value is found by (combined - confinement only)

Table A12 Illustrative Cost Summary Methodology for Open Lot Runoff Control

	Cost Summary Table										
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Totals
Outstanding Balance	$2,735	$2,459	$2,151	$1,809	$1,427	$1,002	$528	$0	$0	$0	
Payments (1)	$588	$588	$588	$588	$588	$588	$588	$0	$0	$0	$4,116
Principle	$276	$308	$343	$382	$425	$474	$528	$0	$0	$0	$2,735
Depreciation (2)	$205	$380	$323	$274	$238	$238	$238	$238	$238	$238	$2,609
Tx Svngs due to Dep	$57	$106	$90	$77	$67	$67	$67	$67	$67	$67	$731
Post Tax Cost	$219	$201	$252	$305	$359	$407	$461	($67)	($67)	($67)	$2,004
Interest Cost	$312	$280	$245	$206	$163	$114	$60	$0	$0	$0	$1,381
Repairs (3)	$27	$27	$27	$27	$27	$27	$27	$27	$27	$27	$274
Operations Cost (4)	$450	$450	$450	$450	$450	$450	$450	$450	$450	$450	$4,500
Pretax Cash Cost	$789	$758	$723	$684	$640	$592	$538	$477	$477	$477	$6,154
Aftertax Cash Cost	$568	$546	$520	$492	$461	$426	$387	$344	$344	$344	$4,431
Aftertax Cost	$787	$747	$773	$797	$819	$833	$848	$277	$277	$277	$6,435
Discount Factor (5)	0.9455	0.8940	0.8453	0.7993	0.7558	0.7146	0.6757	0.6389	0.6041	0.5712	
Discounted Cost	$744	$668	$653	$637	$619	$595	$573	$177	$167	$158	$4,992

Annual standardized cost $671

Footnote (1) Payments are based on a 7 year loan at 11.4% interest

Footnote (2) Depreciation rate is determined by using MACRS method using 10 year property and 1/2 year convention.

Footnote (3) Annual repairs are estimated as 1% of original intial investment.

Footnote (4) Operations cost is yearly expense of manure tests,and misc. costs.

Footnote (5) The discount factor is equivalant to the after-tax return on a U.S. T. bond.

Table A13 Open Lot Runoff Control - Summary Table

FACILITY TYPE	OPEN LOT RUNOFF CONTROL - SUMMARY TABLE				
	Investment Cost	An. Standardized Cost	Total Dsctd Cost	$/Pig for Inv.	$/Pig An. Cost
Small Farm					
Grass Waterway(1)	$2,735	$671	$4,993	$2.29	$0.56
Combined Storage(2)	$3,206	$730	$5,437	$2.69	$0.61
Separate Storage(3)	$8,719	$1,429	$10,638	$7.30	$1.20
Medium Farm					
Grass Waterway(1)	$4,755	$927	$6,898	$1.20	$0.23
Combined Storage(2)	$6,075	$1,094	$8,143	$1.53	$0.27
Separate Storage(3)	$10,978	$1,715	$12,770	$2.76	$0.43

Footnote (1) This option uses a grass waterway rather than a storage facility for the runoff from the lot.
Footnote (2) This option utilizes the same storage system as the confinement system. Cost to storage is additional capacity needed.
Footnote (3) This option utilizes a separate storage system for the runoff. The storage facility is an ESB with no cover and no liner.

Table A14 Manure Storage - Engineering Cost Worksheet - Earthen Storage Basin - No Liner

ENGINEERING COST WORKSHEET

Earthen Storage Basin

	cut only			bal cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030
Site Preperation	$211	$347	$511	$221	$393	$612	$267	$419	$612
Earthwork	$929	$2,047	$4,220	$903	$1,804	$3,411	$2,180	$2,666	$4,629
Structure (2)	$155	$155	$310	$155	$155	$310	$155	$155	$310
Utilities(3)	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810
Landscape	$2,468	$3,058	$3,628	$2,516	$3,214	$3,908	$2,708	$3,298	$3,908
Subtotal	$13,603	$15,447	$18,509	$13,635	$15,406	$18,081	$15,150	$16,378	$19,299
Engineering + Surv(4)	$1,560	$1,745	$2,051	$1,564	$1,741	$2,008	$1,715	$1,838	$2,130
Total (no cover)	$15,163	$17,192	$20,560	$15,199	$17,147	$20,089	$16,865	$18,216	$21,429
Cover	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710
Subtotal	$23,057	$30,807	$46,219	$23,089	$30,766	$45,791	$24,604	$31,738	$47,009
Engineering + Surv(4)	$2,506	$3,281	$4,822	$2,509	$3,277	$4,779	$2,660	$3,374	$4,901
Total (w/ cover)	$25,563	$34,088	$51,041	$25,598	$34,043	$50,570	$27,264	$35,112	$51,910

Footnote (1) Included in the heading "General" is a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost to install a concrete pad that is used for a pumping stand.
Footnote (3) Utilities is the intial cost of the manure pump and hook up
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200

Table A15 Manure Storage - Engineering Cost Worksheet - Earthen Storage Basin - One Ft Liner

ENGINEERING COST WORKSHEET

Earthen Storage Basin (1 foot clay liner)

	cut only			bal cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030
Site Preperation	$211	$347	$511	$221	$393	$612	$267	$419	$612
Earthwork	$3,622	$7,208	$12,760	$3,671	$7,030	$11,969	$5,989	$9,051	$12,962
Structure (2)	$155	$155	$310	$155	$155	$310	$155	$155	$310
Utilities(3)	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810
Landscape	$2,468	$3,058	$3,628	$2,516	$3,214	$3,908	$2,708	$3,298	$3,908
Subtotal	$16,296	$20,608	$27,049	$16,403	$20,632	$26,639	$18,959	$22,763	$27,632
Engineering + Surv(4)	$1,830	$2,261	$2,905	$1,840	$2,263	$2,864	$2,096	$2,476	$2,963
Total (no cover)	$18,126	$22,869	$29,954	$18,243	$22,895	$29,503	$21,055	$25,239	$30,595
Cover	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710
Subtotal	$25,750	$35,968	$54,759	$25,857	$35,992	$54,349	$28,413	$38,123	$55,342
Engineering + Surv(4)	$2,775	$3,797	$5,676	$2,786	$3,799	$5,635	$3,041	$4,012	$5,734
Total (w/ cover)	$28,525	$39,765	$60,435	$28,643	$39,791	$59,984	$31,454	$42,135	$61,076

Footnote (1) Included in the heading "General" is a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost to install a concrete pad that is used for a pumping stand.
Footnote (3) Utilities is the intial cost of the manure pump and hook up
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200

Table A16 Manure Storage - Engineering Cost Worksheet - Earthen Storage Basin - Three Ft Liner

ENGINEERING COST WORKSHEET

Earthen Storage Basin (3 foot clay liner)

	cut only			bal cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030
Site Preperation	$211	$347	$511	$221	$393	$612	$267	$419	$612
Earthwork	$4,670	$8,699	$15,111	$11,550	$20,285	$32,561	$17,137	$26,129	$37,651
Structure (2)	$155	$155	$310	$155	$155	$310	$155	$155	$310
Utilities(3)	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810
Landscape	$2,468	$3,058	$3,628	$2,516	$3,214	$3,908	$2,708	$3,298	$3,908
Subtotal	$17,344	$22,099	$29,400	$24,282	$33,887	$47,231	$30,107	$39,841	$52,321
Engineering + Surv(4	$1,934	$2,410	$3,140	$2,628	$3,589	$4,923	$3,211	$4,184	$5,432
Total (no cover)	$19,278	$24,509	$32,540	$26,910	$37,476	$52,154	$33,318	$44,025	$57,753
Cover	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710
Subtotal	$26,798	$37,459	$57,110	$33,736	$49,247	$74,941	$39,561	$55,201	$80,031
Engineering + Surv(4	$2,880	$3,946	$5,911	$3,574	$5,125	$7,694	$4,156	$5,720	$8,203
Total (w/ cover)	$29,678	$41,405	$63,021	$37,310	$54,372	$82,635	$43,717	$60,921	$88,234

Footnote (1) Included in the heading "General" is a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost to install a concrete pad that is used for a pumping stand.
Footnote (3) Utilities is the intial cost of the manure pump and hook up
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200

Table A17 Manure Storage - Engineering Cost Worksheet - Earthen Storage Basin - Flexible Membrane Liner

	ENGINEERING COST WORKSHEET Earthen Storage Basin (Flexible Membrane Liner (FML))								
	cut only			bal cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030
Site Preperation	$342	$451	$651	$309	$470	$738	$309	$532	$748
Earthwork	$2,699	$3,627	$5,479	$3,393	$4,432	$9,810	$3,393	$7,749	$10,527
Structure (2)	$155	$155	$310	$155	$155	$310	$155	$155	$310
Utilities(3)	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810
Landscape	$2,988	$3,398	$4,008	$2,868	$3,458	$4,224	$2,868	$3,638	$4,248
Subtotal	$32,326	$36,638	$64,642	$32,867	$37,522	$69,276	$32,867	$41,081	$70,027
Engineering + Surv(4)	$3,433	$3,864	$6,664	$3,487	$3,952	$7,128	$3,487	$4,308	$7,203
Total (no cover)	$35,759	$40,502	$71,306	$36,354	$41,474	$76,404	$36,354	$45,389	$77,230
Cover	$1,191	$2,296	$3,980	$1,191	$2,296	$3,980	$1,191	$2,296	$3,980
Subtotal	$33,517	$38,934	$68,622	$34,058	$39,818	$73,256	$34,058	$43,377	$74,007
Engineering + Surv(4)	$3,552	$4,093	$7,062	$3,606	$4,182	$7,526	$3,606	$4,538	$7,601
Total (w/ cover)	$37,069	$43,027	$75,684	$37,664	$44,000	$80,782	$37,664	$47,915	$81.608

Footnote (1) Included in the heading "General" is a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost to install a concrete pad that is used for a pumping stand.
Footnote (3) Utilities is the intial cost of the manure pump and hook up
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200

Table A18 Manure Storage - Engineering Cost Worksheet - Earthen Storage Basin - Flexible Membrane Liner w/ Geotextile

ENGINEERING COST WORKSHEET

Earthen Storage Basin (FML w/ Geotextile)

	cut only			bal cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030
Site Preperation	$211	$347	$511	$221	$393	$612	$267	$419	$612
Earthwork	$929	$2,047	$4,220	$903	$1,804	$3,411	$2,180	$2,666	$4,629
Structure (2)	$155	$155	$310	$155	$155	$310	$155	$155	$310
Utilities(3)	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810
Landscape	$2,468	$3,058	$3,628	$2,516	$3,214	$3,908	$2,708	$3,298	$3,908
Subtotal	$31,505	$44,307	$71,644	$31,537	$44,266	$71,216	$33,052	$45,238	$72,434
Engineering + Surv(4)	$3,351	$4,631	$7,364	$3,354	$4,627	$7,322	$3,505	$4,724	$7,443
Total (no cover)	$34,856	$48,938	$79,008	$34,891	$48,893	$78,538	$36,557	$49,962	$79,877
Cover	$1,191	$2,296	$3,980	$1,191	$2,296	$3,980	$1,191	$2,296	$3,980
Subtotal	$32,696	$46,603	$75,624	$32,728	$46,562	$75,196	$34,243	$47,534	$76,414
Engineering + Surv(4)	$3,470	$4,860	$7,762	$3,473	$4,856	$7,720	$3,624	$4,953	$7,841
Total (w/ cover)	$36,166	$51,463	$83,386	$36,201	$51,418	$82,916	$37,867	$52,487	$84,255

Footnote (1) Included in the heading "General" is a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost to install a concrete pad that is used for a pumping stand.
Footnote (3) Utilities is the intial cost of the manure pump and hook up
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200

Table A19 Manure Storage - Engineering Cost Worksheet - ADL Precast and Butler Liqui-stor

ENGINEERING COST WORKSHEET Manure Storage Tanks ADL Precast and Butler Livestock Liqui-stor	Tank A			Tank B		
	small	medium	large	small	medium	large
General (1)	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030
Site Preperation	$65	$125	$192	$39	$39	$72
Earthwork	$7,875	$13,156	$17,349	$472	$472	$769
Structure (2)	$17,043	$24,447	$37,206	$35,614	$40,614	$49,243
Utilities(3)	$7,094	$7,094	$7,094	$0	$0	$0
Landscape	$1,196	$1,246	$1,296	$285	$335	$385
Subtotal	$35,303	$48,098	$65,167	$38,440	$43,490	$52,499
Engineering + Surv(4)	$3,730	$5,010	$6,717	$4,044	$4,549	$5,450
Total (no cover)	$39,033	$53,108	$71,884	$42,484	$48,039	$57,949

Footnote (1) Included in the heading "General" is a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost of the facility. Tank A refers to ADL precast concrete tanks, Tank B refers to Butler Livestock Liqui-stor
Footnote (3) Utilities is the intial cost of the manure pump and risers.
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200.

Table A20 Manure Storage - Engineering Cost Worksheet - Rochester Silo Slurry

	ENGINEERING COST WORKSHEET								
	Manure Storage Tanks - Rochester Silo Slurry Vat								
	cut only			cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030
Site Preperation	$66	$66	$117	$85	$91	$158	$100	$114	$199
Earthwork	$3,669	$3,669	$6,649	$5,541	$6,979	$12,826	$9,137	$13,965	$28,244
Structure (2)	$26,937	$31,959	$49,885	$24,312	$29,536	$47,623	$23,392	$28,325	$44,983
Utilities(3)	$6,734	$6,734	$6,734	$7,094	$7,094	$7,094	$7,094	$7,094	$7,094
Landscape	$568	$618	$668	$1,196	$1,325	$1,453	$1,196	$1,325	$1,453
Subtotal	$40,004	$45,076	$66,083	$40,258	$47,055	$71,184	$42,949	$52,853	$84,003
Engineering + Surv(4)	$4,200	$4,708	$6,808	$4,226	$4,906	$7,318	$4,495	$5,485	$8,600
Total (no cover)	$44,204	$49,784	$72,891	$44,484	$51,961	$78,502	$47,444	$58,338	$92,603

Footnote (1) Included in the heading "General" is a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost of the Rochester Silo Slurry Vat.
Footnote (3) Utilities is the intial cost of the manure pump and risers.
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200.

Table A21 Illustrative Cost Summary Methodology for Manure Storage Analysis

Titles	*Cost Summary Table for Storage Facilities All Size Farms* Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Totals
Outstanding Balance	$1,000	$899	$787	$661	$522	$366	$193	$0	$0	$0	
Payments (1)	$215	$215	$215	$215	$215	$215	$215	$0	$0	$0	$1,505
Principle	$101	$112	$125	$140	$155	$173	$193	$0	$0	$0	$1,000
Depreciation (2)	$75	$139	$118	$100	$87	$87	$87	$87	$87	$87	$954
Tx Savings due to Dep	$21	$39	$33	$28	$24	$24	$24	$24	$24	$24	$267
Post Tax Cost	$80	$74	$92	$112	$131	$149	$169	($24)	($24)	($24)	$733
Interest Cost	$114	$102	$90	$75	$59	$42	$22	$0	$0	$0	$505
Repairs (3)	$216	$316	$370	$409	$442	$469	$493	$515	$535	$553	$4,317
Operations Cost (4)	$450	$450	$450	$450	$450	$450	$450	$450	$450	$450	$4,500
Pretax Cash Cost	$780	$869	$909	$935	$951	$961	$965	$965	$985	$1,003	$9,322
Aftertax Cash Cost	$562	$626	$655	$673	$685	$692	$695	$695	$709	$722	$6,712
Aftertax Cost	$642	$699	$747	$785	$816	$841	$864	$670	$685	$698	$7,445
Discount Factor (5)	0.94554	0.89404	0.84535	0.79931	0.75578	0.71461	0.67569	0.63889	0.6041	0.5712	
Discounted Cost	$607	$625	$632	$627	$617	$601	$583	$428	$414	$398	$5,531

Annual standardized cost $743

Footnote (1) Payments are based on a 7 year loan at 11.4% interest.
Footnote (2) Depreciation rate is determined by using MACRS method using 10 year property and 1/2 year convention.
Footnote (3) Annual repairs are est. using "A Standard Model for Repair Costs of Agricultural Machinery" (see Rotz)
Footnote (4) Operations cost is yearly expense of monitoring site, manure tests,and misc. costs.
Footnote (5) The discount factor is based on the average yearly after tax return on a U.S. treasury bond.

Table A22 Manure Storage - Small Farm - Summary Table

FACILITY TYPE	SMALL FARM: WASTE STORAGE FACILITY				
	Investment Cost	An. Standardized Cost	Total Dsctd Cost	$/Pig for Inv.	$/Pig Annual Cost
Basic Earth Storage Basin					
cut only (1)	$15,163	$2,436	$18,135	$12.70	$2.04
cut and fill (2)	$15,199	$2,440	$18,166	$12.73	$2.04
fill only (3)	$16,865	$2,639	$19,649	$14.12	$2.21
With Cover					
cut only	$25,563	$3,679	$27,389	$21.41	$3.08
cut and fill	$25,598	$3,683	$27,420	$21.44	$3.08
fill only	$27,264	$3,882	$28,903	$22.83	$3.25
ESB w/ 1ft Clay Liner					
cut only	$18,126	$2,790	$20,771	$15.18	$2.34
cut and fill	$18,243	$2,804	$20,875	$15.28	$2.35
fill only	$21,055	$3,140	$23,377	$17.63	$2.63
With Cover					
cut only	$28,525	$4,033	$30,025	$23.89	$3.38
cut and fill	$28,643	$4,047	$30,129	$23.99	$3.39
fill only	$31,454	$4,383	$32,631	$26.34	$3.67
ESB w/ 3ft Clay Liner					
cut only	$19,278	$2,928	$21,796	$16.15	$2.45
cut and fill	$26,910	$3,840	$28,588	$22.54	$3.22
fill only	$33,318	$4,606	$34,289	$27.90	$3.86
With Cover					
cut only	$29,678	$4,171	$31,050	$24.86	$3.49
cut and fill	$37,310	$5,083	$37,842	$31.25	$4.26
fill only	$43,717	$5,849	$43,543	$36.61	$4.90
Flexible Membrane Liner					
cut only	$35,759	$4,898	$36,461	$29.95	$4.10
cut and fill	$36,354	$4,969	$36,991	$30.45	$4.16
fill only	$36,354	$4,969	$36,991	$30.45	$4.16
With Cover					
cut only	$34,856	$4,790	$35,658	$29.19	$4.01
cut and fill	$34,891	$4,794	$35,689	$29.22	$4.02
fill only	$36,557	$4,993	$37,172	$30.62	$4.18
F M L. w/ Geotextile					
cut only	$37,069	$5,054	$37,627	$31.05	$4.23
cut and fill	$37,664	$5,125	$38,157	$31.54	$4.29
fill only	$37,664	$5,125	$38,157	$31.54	$4.29
With Cover					
cut only	$36,166	$4,946	$36,824	$30.29	$4.14
cut and fill	$36,201	$4,951	$36,855	$30.32	$4.15
fill only	$37,867	$5,150	$38,338	$31.71	$4.31
Tank A	$39,033	$5,289	$39,375	$32.69	$4.43
Tank B	$42,484	$5,702	$42,446	$35.58	$4.78
Tank C					
Below ground	$44,204	$5,907	$43,977	$37.02	$4.95
One half in ground	$44,484	$5,941	$44,226	$37.26	$4.98
Above ground	$47,444	$6,295	$46,860	$39.74	$5.27
Average costs differences					
Below ground	$28,018	$7,359	$37,693	$23.47	$6.16
One half in ground	$29,701	$7,607	$39,071	$24.88	$6.37
Above ground	$32,212	$7,977	$41,128	$26.98	$6.68

Footnote (1): Cut only refers to type of excavation where the basin is completely below previous ground level.
Footnote (2): Cut and fill refers to type of excavation where the basin is 1/2 below previous ground level.
Footnote (3): Fill only refers to type of excavation where the basin is completely above previous ground level.

Table A23 Manure Storage - Medium Farm - Summary Table

FACILITY TYPE	MEDIUM FARM: WASTE STORAGE FACILITY				
	Investment Cost	An.Standardized Cost	Total Dsctd Cost	$/Pig for Inv.	$/Pig Annual Cost
Basic Earth Storage Basin					
cut only (1)	$17,192	$2,678	$19,940	$4.32	$0.67
cut and fill (2)	$17,147	$2,673	$19,900	$4.31	$0.67
fill only (3)	$18,216	$2,801	$20,851	$4.58	$0.70
With Cover					
cut only	$34,088	$4,698	$34,975	$8.57	$1.18
cut and fill	$34,043	$4,693	$34,934	$8.56	$1.18
fill only	$35,112	$4,820	$35,886	$8.82	$1.21
ESB w/ 1ft Clay Liner					
cut only	$22,869	$3,357	$24,991	$5.75	$0.84
cut and fill	$22,895	$3,360	$25,015	$5.75	$0.84
fill only	$25,239	$3,640	$27,101	$6.34	$0.91
With Cover					
cut only	$39,765	$5,377	$40,026	$9.99	$1.35
cut and fill	$39,791	$5,380	$40,050	$10.00	$1.35
fill only	$42,135	$5,660	$42,136	$10.59	$1.42
ESB w/ 3ft Clay Liner					
cut only	$24,509	$3,553	$26,451	$6.16	$0.89
cut and fill	$37,476	$5,103	$37,989	$9.42	$1.28
fill only	$44,025	$5,886	$43,817	$11.06	$1.48
With Cover					
cut only	$41,405	$5,573	$41,486	$10.41	$1.40
cut and fill	$54,372	$7,123	$53,024	$13.66	$1.79
fill only	$60,921	$7,905	$58,852	$15.31	$1.99
Flexible Membrane Liner					
cut only	$40,502	$5,465	$40,682	$10.18	$1.37
cut and fill	$41,474	$5,581	$41,548	$10.42	$1.40
fill only	$45,389	$6,049	$45,031	$11.41	$1.52
With Cover					
cut only	$48,938	$6,473	$48,189	$12.30	$1.63
cut and fill	$48,893	$6,468	$48,149	$12.29	$1.63
fill only	$49,962	$6,595	$49,100	$12.56	$1.66
F M L. w/ Geotextile					
cut only	$43,027	$5,767	$42,930	$10.81	$1.45
cut and fill	$44,000	$5,883	$43,795	$11.06	$1.48
fill only	$47,915	$6,351	$47,279	$12.04	$1.60
With Cover					
cut only	$51,463	$6,775	$50,436	$12.93	$1.70
cut and fill	$51,418	$6,770	$50,396	$12.92	$1.70
fill only	$52,487	$6,897	$51,348	$13.19	$1.73
Tank A	$53,108	$6,972	$51,900	$13.35	$1.75
Tank B	$48,039	$6,366	$47,389	$12.07	$1.60
Tank C					
Below ground	$49,784	$6,574	$48,942	$12.51	$1.65
One half in ground	$51,961	$6,834	$50,879	$13.06	$1.72
Above ground	$58,338	$7,597	$56,554	$14.66	$1.91
Average costs differences					
Below ground	$36,376	$8,591	$44,538	$9.14	$2.16
One half in ground	$39,151	$9,001	$46,811	$9.84	$2.26
Above ground	$42,140	$9,442	$49,259	$10.59	$2.37

Footnote (1): Cut only refers to type of excavation where the basin is completely below previous ground level.
Footnote (2): Cut and fill refers to type of excavation where the basin is 1/2 below previous ground level.
Footnote (3): Fill only refers to type of excavation where the basin is completely above previous ground level.

Table A24 Manure Storage - Large Farm - Summary Table

FACILITY TYPE	LARGE FARM: WASTE STORAGE FACILITY				
	Investment Cost	An. Standardized Cost	Total Dsctd Cost	$/Pig for Inv.	/Pig Annual Cost
Basic Earth Storage Basin					
cut only (1)	$20,560	$3,081	$22,937	$2.58	$0.39
cut and fill (2)	$20,089	$3,025	$22,518	$2.52	$0.38
fill only (3)	$21,429	$3,185	$23,710	$2.69	$0.40
With Cover					
cut only	$51,041	$6,724	$50,060	$6.41	$0.84
cut and fill	$50,570	$6,668	$49,642	$6.35	$0.84
fill only	$51,910	$6,828	$50,834	$6.52	$0.86
ESB w/ 1ft Clay Liner					
cut only	$29,954	$4,204	$31,296	$3.76	$0.53
cut and fill	$29,503	$4,150	$30,895	$3.71	$0.52
fill only	$30,595	$4,281	$31,867	$3.84	$0.54
With Cover					
cut only	$60,435	$7,847	$58,420	$7.59	$0.99
cut and fill	$59,984	$7,793	$58,018	$7.54	$0.98
fill only	$61,076	$7,924	$58,990	$7.67	$1.00
ESB w/ 3ft Clay Liner					
cut only	$32,540	$4,513	$33,597	$4.09	$0.57
cut and fill	$52,154	$6,858	$51,051	$6.55	$0.86
fill only	$57,753	$7,527	$56,033	$7.26	$0.95
With Cover					
cut only	$63,021	$8,156	$60,721	$7.92	$1.02
cut and fill	$82,635	$10,501	$78,175	$10.38	$1.32
fill only	$88,234	$11,170	$83,157	$11.09	$1.40
Flexible Membrane Liner					
cut only	$71,306	$9,147	$68,094	$8.96	$1.15
cut and fill	$76,404	$9,756	$72,630	$9.60	$1.23
fill only	$77,230	$9,855	$73,365	$9.70	$1.24
With Cover					
cut only	$79,008	$10,067	$74,947	$9.93	$1.26
cut and fill	$78,538	$10,011	$74,528	$9.87	$1.26
fill only	$79,877	$10,171	$75,721	$10.04	$1.28
F M L. w/ Geotextile					
cut only	$75,684	$9,670	$71,989	$9.51	$1.21
cut and fill	$80,782	$10,279	$76,525	$10.15	$1.29
fill only	$81,608	$10,378	$77,260	$10.25	$1.30
With Cover					
cut only	$83,386	$10,591	$78,843	$10.48	$1.33
cut and fill	$82,916	$10,535	$78,424	$10.42	$1.32
fill only	$84,255	$10,695	$79,617	$10.59	$1.34
Tank A	$71,884	$9,216	$68,608	$9.03	$1.16
Tank B	$57,949	$7,550	$56,208	$7.28	$0.95
Tank C					
Below ground	$72,891	$9,336	$69,504	$9.16	$1.17
One half in ground	$78,502	$10,007	$74,497	$9.86	$1.26
Above ground	$92,603	$11,693	$87,045	$11.64	$1.47
Average costs differences					
Below ground	$56,694	$11,588	$61,179	$7.12	$1.46
One half in ground	$61,357	$12,276	$64,998	$7.71	$1.54
Above ground	$63,397	$12,577	$66,668	$7.97	$1.58

Footnote (1): Cut only refers to type of excavation where the basin is completely below previous ground level.
Footnote (2): Cut and fill refers to type of excavation where the basin is 1/2 below previous ground level.
Footnote (3): Fill only refers to type of excavation where the basin is completely above previous ground level.

Table A25 Manure Storage w/ Hydrogeological Study - Engineering Cost Worksheet - Earthen Storage Basin - No Liner

ENGINEERING COST WORKSHEET w/ Hydrogeological Study Earthen Storage Basin (No Liner)	cut only			bal cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030
Site Preparation	$211	$347	$511	$221	$393	$612	$267	$419	$612
Earthwork	$929	$2,047	$4,220	$903	$1,804	$3,411	$2,180	$2,666	$4,629
Structures (2)	$155	$155	$310	$155	$155	$310	$155	$155	$310
Utilities(3)	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810
Landscaping	$2,468	$3,058	$3,628	$2,516	$3,214	$3,908	$2,708	$3,298	$3,908
Subtotal	$23,603	$25,447	$28,509	$23,635	$25,406	$28,081	$25,150	$26,378	$29,299
Engineering + Surv (4)	$2,560	$2,745	$3,051	$2,564	$2,741	$3,008	$2,715	$2,838	$3,130
Total (no cover)	$26,163	$28,192	$31,560	$26,199	$28,147	$31,089	$27,865	$29,216	$32,429
Cover	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710
Subtotal	$33,057	$40,807	$56,219	$33,089	$40,766	$55,791	$34,604	$41,738	$57,009
Engineering + Surv (4)	$3,506	$4,281	$5,822	$3,509	$4,277	$5,779	$3,660	$4,374	$5,901
Total (with cover)	$36,563	$45,088	$62,041	$36,598	$45,043	$61,570	$38,264	$46,112	$62,910

Footnote (1) Included in the heading "General" is a $10,000 hydrogeological study and a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost to install a concrete pad that is used for a pumping stand.
Footnote (3) Utilities is the intial cost of the manure pump and hook up.
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200.

Table A26 Manure Storage w/ Hydrogeological Study - Engineering Cost Worksheet - Earthen Storage Basin - One Ft Liner

ENGINEERING COST WORKSHEET w/ Hydrogeological Study									
	Earthen Storage Basin (1 foot clay liner)								
	cut only			bal cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030
Site Preparation	$211	$347	$511	$221	$393	$612	$267	$419	$612
Earthwork	$3,622	$7,208	$12,760	$3,671	$7,030	$11,969	$5,989	$9,051	$12,962
Structures (2)	$155	$155	$310	$155	$155	$310	$155	$155	$310
Utilities(3)	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810
Landscaping	$2,468	$3,058	$3,628	$2,516	$3,214	$3,908	$2,708	$3,298	$3,908
Subtotal	$26,296	$30,608	$37,049	$26,403	$30,632	$36,639	$28,959	$32,763	$37,632
Engineering + Surv (4)	$2,830	$3,261	$3,905	$2,840	$3,263	$3,864	$3,096	$3,476	$3,963
Total (no cover)	$29,126	$33,869	$40,954	$29,243	$33,895	$40,503	$32,055	$36,239	$41,595
Cover	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710
Subtotal	$35,750	$45,968	$64,759	$35,857	$45,992	$64,349	$38,413	$48,123	$65,342
Engineering + Surv (4)	$3,775	$4,797	$6,676	$3,786	$4,799	$6,635	$4,041	$5,012	$6,734
Total (with cover)	$39,525	$50,765	$71,435	$39,643	$50,791	$70,984	$42,454	$53,135	$72,076

Footnote (1) Included in the heading "General" is a $10,000 hydrogeological study and a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost to install a concrete pad that is used for a pumping stand.
Footnote (3) Utilities is the intial cost of the manure pump and hook up.
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200.

Table A27 Manure Storage w/ Hydrogeological Study - Engineering Cost Worksheet - Earthen Storage Basin - Three Ft Liner

ENGINEERING COST WORKSHEET w/ Hydrogeological Study Earthen Storage Basin (3 foot clay liner)	cut only			bal cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030
Site Preparation	$211	$347	$511	$221	$393	$612	$267	$419	$612
Earthwork	$4,670	$8,699	$15,111	$11,550	$20,285	$32,561	$17,137	$26,129	$37,651
Structures (2)	$155	$155	$310	$155	$155	$310	$155	$155	$310
Utilities(3)	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810
Landscaping	$2,468	$3,058	$3,628	$2,516	$3,214	$3,908	$2,708	$3,298	$3,908
Subtotal	$27,344	$32,099	$39,400	$34,282	$43,887	$57,231	$40,107	$49,841	$62,321
Engineering + Surv (4)	$2,934	$3,410	$4,140	$3,628	$4,589	$5,923	$4,211	$5,184	$6,432
Total (no cover)	$30,278	$35,509	$43,540	$37,910	$48,476	$63,154	$44,318	$55,025	$68,753
Cover	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710	$9,454	$15,360	$27,710
Subtotal	$36,798	$47,459	$67,110	$43,736	$59,247	$84,941	$49,561	$65,201	$90,031
Engineering + Surv (4)	$3,880	$4,946	$6,911	$4,574	$6,125	$8,694	$5,156	$6,720	$9,203
Total (with cover)	$40,678	$52,405	$74,021	$48,310	$65,372	$93,635	$54,717	$71,921	$99,234

Footnote (1) Included in the heading "General" is a $10,000 hydrogeological study and a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost to install a concrete pad that is used for a pumping stand.
Footnote (3) Utilities is the intial cost of the manure pump and hook up.
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200.

Table A28 Manure Storage w/ Hydrogeological Study - Engineering Cost Worksheet - Earthen Storage Basin - Flexible Membrane Liner

ENGINEERING COST WORKSHEET w/ Hydrogeological Study Earthen Storage Basin (Flexible Membrane Liner (FML))	cut only			bal cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030
Site Preparation	$342	$451	$651	$309	$470	$738	$309	$532	$748
Earthwork	$2,699	$3,627	$5,479	$3,393	$4,432	$9,810	$3,393	$7,749	$10,527
Structures (2)	$155	$155	$310	$155	$155	$310	$155	$155	$310
Utilities(3)	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810
Landscaping	$2,988	$3,398	$4,008	$2,868	$3,458	$4,224	$2,868	$3,638	$4,248
Subtotal	$42,326	$46,638	$74,642	$42,867	$47,522	$79,276	$42,867	$51,081	$80,027
Engineering + Surv (4)	$4,433	$4,864	$7,664	$4,487	$4,952	$8,128	$4,487	$5,308	$8,203
Total (no cover)	$46,759	$51,502	$82,306	$47,354	$52,474	$87,404	$47,354	$56,389	$88,230
Cover	$1,191	$2,296	$3,980	$1,191	$2,296	$3,980	$1,191	$2,296	$3,980
Subtotal	$43,517	$48,934	$78,622	$44,058	$49,818	$83,256	$44,058	$53,377	$84,007
Engineering + Surv (4)	$4,552	$5,093	$8,062	$4,606	$5,182	$8,526	$4,606	$5,538	$8,601
Total (with cover)	$48,069	$54,027	$86,684	$48,664	$55,000	$91,782	$48,664	$58,915	$92,608

Footnote (1) Included in the heading "General" is a $10,000 hydrogeological study and a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost to install a concrete pad that is used for a pumping stand.
Footnote (3) Utilities is the intial cost of the manure pump and hook up.
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200.

Table A29 Manure Storage w/ Hydrogeological Study - Engineering Cost Worksheet - Earthen Storage Basin - Flexible Membrane Liner w/ Geotextile

ENGINEERING COST WORKSHEET w/ Hydrogeological Study Earthen Storage Basin (FML w/ Geotextile)	cut only			bal cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030
Site Preparation	$211	$347	$511	$221	$393	$612	$267	$419	$612
Earthwork	$929	$2,047	$4,220	$903	$1,804	$3,411	$2,180	$2,666	$4,629
Structures (2)	$155	$155	$310	$155	$155	$310	$155	$155	$310
Utilities(3)	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810	$7,810
Landscaping	$2,468	$3,058	$3,628	$2,516	$3,214	$3,908	$2,708	$3,298	$3,908
Subtotal	$41,505	$54,307	$81,644	$41,537	$54,266	$81,216	$43,052	$55,238	$82,434
Engineering + Surv (4)	$4,351	$5,631	$8,364	$4,354	$5,627	$8,322	$4,505	$5,724	$8,443
Total (no cover)	$45,856	$59,938	$90,008	$45,891	$59,893	$89,538	$47,557	$60,962	$90,877
Cover	$1,191	$2,296	$3,980	$1,191	$2,296	$3,980	$1,191	$2,296	$3,980
Subtotal	$42,696	$56,603	$85,624	$42,728	$56,562	$85,196	$44,243	$57,534	$86,414
Engineering + Surv (4)	$4,470	$5,860	$8,762	$4,473	$5,856	$8,720	$4,624	$5,953	$8,841
Total (with cover)	$47,166	$62,463	$94,386	$47,201	$62,418	$93,916	$48,867	$63,487	$95,255

Footnote (1) Included in the heading "General" is a $10,000 hydrogeological study and a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost to install a concrete pad that is used for a pumping stand.
Footnote (3) Utilities is the intial cost of the manure pump and hook up.
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200.

Table A30 Manure Storage w/ Hydrogeological Study - Engineering Cost Worksheet - ADL Precast and Butler Liqui-stor

ENGINEERING COST WORKSHEET w/ Hydrogeological Study Manure Storage Tanks ADL Precast and Butler Livestock Liqui-stor	Tank A			Tank B		
	small	medium	large	small	medium	large
General (1)	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030
Site Preparation	$65	$125	$192	$39	$39	$72
Earthwork	$7,875	$13,156	$17,349	$472	$472	$769
Structures (2)	$17,043	$24,447	$37,206	$35,614	$40,614	$49,243
Utilities(3)	$7,094	$7,094	$7,094	$0	$0	$0
Landscaping	$1,196	$1,246	$1,296	$285	$335	$385
Subtotal	$45,303	$58,098	$75,167	$48,440	$53,490	$62,499
Engineering + Surv (4)	$4,730	$6,010	$7,717	$5,044	$5,549	$6,450
Total (no cover)	$50,033	$64,108	$82,884	$53,484	$59,039	$68,949

Footnote (1) Included in the heading "General" is a $10,000 hydrogeological study and a $2,030 soil analysis.

Footnote (2) Structures is defined as the cost of the facilitie. Tank A refers to ADL precast Concrete Tanks
Tank B refers to Butler Livestock Liqui-stor

Footnote (3) Utilities is the intial cost of the manure pump and risers.

Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200.

Table A31 Manure Storage w/ Hydrogeological Study - Engineering Cost Worksheet - Rochester Silo Slurry

ENGINEERING COST WORKSHEET w/ Hydrogeological Study

Manure Storage Tanks - Rochester Silo Slurry Vat

	cut only			cut and fill			GW limitations		
	small	medium	large	small	medium	large	small	medium	large
General (1)	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030	$12,030
Site Preparation	$66	$66	$117	$85	$91	$158	$100	$114	$199
Earthwork	$3,669	$3,669	$6,649	$5,541	$6,979	$12,826	$9,137	$13,965	$28,244
Structures (2)	$26,937	$31,959	$49,885	$24,312	$29,536	$47,623	$23,392	$28,325	$44,983
Utilities(3)	$6,734	$6,734	$6,734	$7,094	$7,094	$7,094	$7,094	$7,094	$7,094
Landscaping	$568	$618	$668	$1,196	$1,325	$1,453	$1,196	$1,325	$1,453
Subtotal	$50,004	$55,076	$76,083	$50,258	$57,055	$81,184	$52,949	$62,853	$94,003
Engineering + Surv (4)	$5,200	$5,708	$7,808	$5,226	$5,906	$8,318	$5,495	$6,485	$9,600
Total (no cover)	$55,204	$60,784	$83,891	$55,484	$62,961	$89,502	$58,444	$69,338	$103,603

Footnote (1) Included in the heading "General" is a $10,000 hydrogeological study and a $2,030 soil analysis.
Footnote (2) Structures is defined as the cost of the Rochester Silo Slurry Vat.
Footnote (3) Utilities is the intial cost of the manure pump and risers.
Footnote (4) Engineering + Surveying is equal to 10% cost of the job + $200.

Table A32 Manure Storage w/ Hydrogeological Study - Small Farm - Summary Table

SMALL FARM: WASTE STORAGE FACILITY w/ HYDROGEOLOGICAL STUDY					
FACILITY TYPE	Investment Cost	An. Standardized Cost	Total Dsctd Cos	$/Pig for Inv.	$/Pig An. Cost
Basic Earth Storage Basin					
cut only (1)	$26,163	$3,751	$27,923	$21.91	$3.14
cut and fill (2)	$26,199	$3,755	$27,954	$21.94	$3.14
fill only (3)	$27,865	$3,954	$29,437	$23.34	$3.31
With Cover					
cut only	$36,563	$4,994	$37,177	$30.62	$4.18
cut and fill	$36,598	$4,998	$37,208	$30.65	$4.19
fill only	$38,264	$5,197	$38,691	$32.05	$4.35
ESB w/ 1ft Clay Liner					
cut only	$29,126	$4,105	$30,559	$24.39	$3.44
cut and fill	$29,243	$4,119	$30,664	$24.49	$3.45
fill only	$32,055	$4,455	$33,166	$26.85	$3.73
With Cover					
cut only	$39,525	$5,348	$39,813	$33.10	$4.48
cut and fill	$39,643	$5,362	$39,918	$33.20	$4.49
fill only	$42,454	$5,698	$42,420	$35.56	$4.77
ESB w/ 3ft Clay Liner					
cut only	$30,278	$4,243	$31,585	$25.36	$3.55
cut and fill	$37,910	$5,155	$38,376	$31.75	$4.32
fill only	$44,318	$5,921	$44,078	$37.12	$4.96
With Cover					
cut only	$40,678	$5,486	$40,839	$34.07	$4.59
cut and fill	$48,310	$6,398	$47,630	$40.46	$5.36
fill only	$54,717	$7,164	$53,332	$45.83	$6.00
Flexible Membrane Liner					
cut only	$46,759	$6,213	$46,250	$39.16	$5.20
cut and fill	$47,354	$6,284	$46,779	$39.66	$5.26
fill only	$47,354	$6,284	$46,779	$39.66	$5.26
With Cover					
cut only	$45,856	$6,105	$45,446	$38.40	$5.11
cut and fill	$45,891	$6,109	$45,478	$38.43	$5.12
fill only	$47,557	$6,308	$46,960	$39.83	$5.28
F M L. w/ Geotextile					
cut only	$48,069	$6,369	$47,416	$40.26	$5.33
cut and fill	$48,664	$6,440	$47,945	$40.76	$5.39
fill only	$48,664	$6,440	$47,945	$40.76	$5.39
With Cover					
cut only	$47,166	$6,261	$46,612	$39.50	$5.24
cut and fill	$47,201	$6,265	$46,643	$39.53	$5.25
fill only	$48,867	$6,465	$48,126	$40.93	$5.41
Tank A	$50,033	$6,604	$49,164	$41.90	$5.53
Tank B	$53,484	$7,017	$52,234	$44.79	$5.88
Tank C					
Below ground	$55,204	$7,222	$53,765	$46.23	$6.05
One half in ground	$55,484	$7,256	$54,014	$46.47	$6.08
Above ground	$58,444	$7,609	$56,648	$48.95	$6.37
Average costs differences					
Below ground	$39,018	$7,359	$37,693	$32.68	$6.16
One half in ground	$40,701	$7,607	$39,071	$34.09	$6.37
Above ground	$43,212	$7,977	$41,128	$36.19	$6.68

Footnote (1): Cut only refers to type of excavation where the basin is completely below previous ground level.
Footnote (2): Cut and fill refers to type of excavation where the basin is 1/2 below previous ground level.
Footnote (3): Fill only refers to type of excavation where the basin is completely above previous ground level.

Table A33 Manure Storage w/ Hydrogeological Study - Medium Farm - Summary Table

MEDIUM FARM: WASTE STORAGE FACILITY w/ HYDROGEOLOGICAL STUDY					
FACILITY TYPE	Investment Cost	An. Standardized Cost	Total Dsctd Cost	/Pig for Inv	$/Pig An. Cost
Basic Earth Storage Basin					
cut only (1)	$28,192	$3,993	$29,728	$7.09	$1.00
cut and fill (2)	$28,147	$3,988	$29,688	$7.07	$1.00
fill only (3)	$29,216	$4,116	$30,639	$7.34	$1.03
With Cover					
cut only	$45,088	$6,013	$44,763	$11.33	$1.51
cut and fill	$45,043	$6,007	$44,723	$11.32	$1.51
fill only	$46,112	$6,135	$45,674	$11.59	$1.54
ESB w/ 1ft Clay Liner					
cut only	$33,869	$4,672	$34,780	$8.51	$1.17
cut and fill	$33,895	$4,675	$34,803	$8.52	$1.17
fill only	$36,239	$4,955	$36,889	$9.11	$1.25
With Cover					
cut only	$50,765	$6,691	$49,815	$12.76	$1.68
cut and fill	$50,791	$6,695	$49,838	$12.76	$1.68
fill only	$53,135	$6,975	$51,924	$13.35	$1.75
ESB w/ 3ft Clay Liner					
cut only	$35,509	$4,868	$36,239	$8.92	$1.22
cut and fill	$48,476	$6,418	$47,778	$12.18	$1.61
fill only	$55,025	$7,201	$53,606	$13.83	$1.81
With Cover					
cut only	$52,405	$6,888	$51,274	$13.17	$1.73
cut and fill	$65,372	$8,437	$62,813	$16.43	$2.12
fill only	$71,921	$9,220	$68,641	$18.08	$2.32
Flexible Membrane Liner					
cut only	$51,502	$6,780	$50,471	$12.94	$1.70
cut and fill	$52,474	$6,896	$51,336	$13.19	$1.73
fill only	$56,389	$7,364	$54,820	$14.17	$1.85
With Cover					
cut only	$59,938	$7,788	$57,977	$15.06	$1.96
cut and fill	$59,893	$7,783	$57,937	$15.05	$1.96
fill only	$60,962	$7,910	$58,889	$15.32	$1.99
F M L. w/ Geotextile					
cut only	$54,027	$7,081	$52,718	$13.58	$1.78
cut and fill	$55,000	$7,198	$53,583	$13.82	$1.81
fill only	$58,915	$7,666	$57,067	$14.81	$1.93
With Cover					
cut only	$62,463	$8,090	$60,225	$15.70	$2.03
cut and fill	$62,418	$8,084	$60,185	$15.69	$2.03
fill only	$63,487	$8,212	$61,136	$15.96	$2.06
Tank A	$64,108	$8,286	$61,688	$16.11	$2.08
Tank B	$59,039	$7,681	$57,178	$14.84	$1.93
Tank C					
Below ground	$60,784	$7,889	$58,730	$15.28	$1.98
One half in ground	$62,961	$8,149	$60,667	$15.82	$2.05
Above ground	$69,338	$8,912	$66,342	$17.43	$2.24
Average costs differences					
Below ground	$47,376	$8,591	$44,538	$11.91	$2.16
One half in ground	$50,151	$9,001	$46,811	$12.60	$2.26
Above ground	$53,140	$9,442	$49,259	$13.36	$2.37

Footnote (1): Cut only refers to type of excavation where the basin is completely below previous ground level.
Footnote (2): Cut and fill refers to type of excavation where the basin is 1/2 below previous ground level.
Footnote (3): Fill only refers to type of excavation where the basin is completely above previous ground level.

Table A34 Manure Storage w/ Hydrogeological Study - Large Farm - Summary Table

LARGE FARM: WASTE STORAGE FACILITY w/ HYDROGEOLOGICAL STUDY					
FACILITY TYPE	Investment Cost	An. Standardized Cost	Total Dsctd Cos	$/Pig for Inv.	$/Pig An. Cost
Basic Earth Storage Basin					
cut only (1)	$31,560	$4,396	$32,725	$3.97	$0.55
cut and fill (2)	$31,089	$4,340	$32,306	$3.91	$0.55
fill only (3)	$32,429	$4,500	$33,499	$4.07	$0.57
With Cover					
cut only	$62,041	$8,039	$59,849	$7.80	$1.01
cut and fill	$61,570	$7,983	$59,430	$7.74	$1.00
fill only	$62,910	$8,143	$60,622	$7.90	$1.02
ESB w/ 1ft Clay Liner					
cut only	$40,954	$5,519	$41,085	$5.15	$0.69
cut and fill	$40,503	$5,465	$40,683	$5.09	$0.69
fill only	$41,595	$5,595	$41,655	$5.23	$0.70
With Cover					
cut only	$71,435	$9,162	$68,208	$8.98	$1.15
cut and fill	$70,984	$9,108	$67,807	$8.92	$1.14
fill only	$72,076	$9,239	$68,779	$9.06	$1.16
ESB w/ 3ft Clay Liner					
cut only	$43,540	$5,828	$43,386	$5.47	$0.73
cut and fill	$63,154	$8,172	$60,839	$7.93	$1.03
fill only	$68,753	$8,842	$65,822	$8.64	$1.11
With Cover					
cut only	$74,021	$9,471	$70,509	$9.30	$1.19
cut and fill	$93,635	$11,816	$87,963	$11.76	$1.48
fill only	$99,234	$12,485	$92,945	$12.47	$1.57
Flexible Membrane Liner					
cut only	$82,306	$10,462	$77,882	$10.34	$1.31
cut and fill	$87,404	$11,071	$82,418	$10.98	$1.39
fill only	$88,230	$11,170	$83,153	$11.09	$1.40
With Cover					
cut only	$90,008	$11,382	$84,736	$11.31	$1.43
cut and fill	$89,538	$11,326	$84,317	$11.25	$1.42
fill only	$90,877	$11,486	$85,509	$11.42	$1.44
F M L. w/ Geotextile					
cut only	$86,684	$10,985	$81,778	$10.89	$1.38
cut and fill	$91,782	$11,594	$86,314	$11.53	$1.46
fill only	$92,608	$11,693	$87,049	$11.64	$1.47
With Cover					
cut only	$94,386	$11,906	$88,632	$11.86	$1.50
cut and fill	$93,916	$11,849	$88,213	$11.80	$1.49
fill only	$95,255	$12,010	$89,405	$11.97	$1.51
Tank A	$82,884	$10,531	$78,396	$10.41	$1.32
Tank B	$68,949	$8,865	$65,996	$8.66	$1.11
Tank C					
Below ground	$83,891	$10,651	$79,293	$10.54	$1.34
One half in ground	$89,502	$11,322	$84,286	$11.25	$1.42
Above ground	$103,603	$13,007	$96,833	$13.02	$1.63
Average costs differences					
Below ground	$67,694	$11,588	$61,179	$8.51	$1.46
One half in ground	$72,357	$12,276	$64,998	$9.09	$1.54
Above ground	$74,397	$12,577	$66,668	$9.35	$1.58

Footnote (1): Cut only refers to type of excavation where the basin is completely below previous ground level.
Footnote (2): Cut and fill refers to type of excavation where the basin is 1/2 below previous ground level.
Footnote (3): Fill only refers to type of excavation where the basin is completely above previous ground level.

Table A35 Incorporation - Disking Worksheet

SUMMARY TITLES	DISKING WORKSHEET		
	SMALL	MEDIUM	LARGE
Volume of Manure Yearly (gal)	276390	47888	105650
Lbs Nitrogen per gal	0.05	0.05	0.05
Volume of Nitrogen Yearly (lbs)	14372	47888	105650
Nitrogen Saved (lbs)	1437	4789	10565
Dollars Saved Yearly	$216	$718	$1,585
Aftertax Savings	$155	$517	$1,141
Cost of Manure application			
Number of acres	122	405	811
Cost to disk 1 acre (1)	$1.71	$1.71	$1.71
Increased Operation cost due to using disk to incorporate	$208	$692	$1,386
Aftertax operation cost	$150	$498	$998
Aftertax Cost Total (2)	($5)	($19)	($143)

Footnote (1) Calculations used to determine cost to disk 1 acre

		Units
Disc width	192	inches
Operating speed	4.5	miles/hour
Field efficiency factor	0.85	
Fuel usage	0.8	gal gas per acre
Rate	7.344	acres per hour
Fuel prices	$1.00	$/gal
Fuel cost per acre	$0.93	$/acre
Labor cost	$5.00	$/hour
Labor cost per acre	$0.68	$/acre
Repair cost per acre	$0.10	$/acre
Total cost per acre	$1.71	$/acre

Footnote (2) Aftertax cost total is the aftertax operation cost minus the aftertax savings(does not include ownership costs)

Table A36 Incorporation - Injection Worksheet

SUMMARY TITLES	INJECTION WORKSHEET		
	SMALL	MEDIUM	LARGE
Volume of Manure Yearly (gal)	276390	47888	105650
Lbs Nitrogen per gal	0.05	0.05	0.05
Volume of Nitrogen Yearly (lbs)	14372	47888	105650
Nitrogen Saved (lbs)	2156	7183	15848
Dollars Saved Yearly	$323	$1,077	$2,377
Aftertax Savings	$233	$776	$1,712
Cost of Manure application (1)			
without injection	$6,300	$12,992	$24,496
with injection	$6,981	$14,117	$26,363
Increased Operation cost due to using injectors to incoporate	$681	$1,125	$1,867
Aftertax Operation Cost	$490	$810	$1,344
Aftertax Cost Total (2)	$257	$34	($367)

Footnote (1) Cost of Manure applications are determined using Manure Application Economics software package

Footnote (2) Aftertax cost total is the aftertax operation cost minus the aftertax savings(does not include ownership costs)

Table A37 Incorporation - Disking - Small Farm - Cost Summary Table

	Cost Summary Table for Disking for Small Farm										
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	TOTALS
Outstanding Balance	$6,400	$5,754	$5,034	$4,232	$3,339	$2,344	$1,235	$0	0	0	
Payments (1)	$1,376	$1,376	$1,376	$1,376	$1,376	$1,376	$1,376	$0	0	0	$9,630
Principle	$646	$720	$802	$893	$995	$1,109	$1,235	$0	0	0	$6,400
Depreciation (2)	$685	$1,224	$962	$784	$784	$784	$784	$392	$0	$0	$6,400
Tx Svngs due to Dep	$192	$343	$269	$220	$220	$220	$220	$110	$0	$0	$1,792
Post Tax Cost	$454	$377	$533	$674	$776	$889	$1,015	($110)	$0	$0	$4,608
Interest Cost	$730	$656	$574	$482	$381	$267	$141	$0	$0	$0	$3,230
Repairs (3)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operations Cost (4)	$197	$197	$197	$197	$197	$197	$197	$197	$197	$197	$1,965
Pretax Cash Cost	$926	$852	$770	$679	$577	$464	$337	$197	$197	$197	$5,196
Aftertax Cash Cost	$667	$614	$555	$489	$416	$334	$243	$141	$141	$141	$3,741
Aftertax Cost (5)	$1,121	$991	$1,087	$1,163	$1,191	$1,223	$1,258	$32	$141	$141	$8,349
Aftertax $/N Saved(6	$155	$155	$155	$155	$155	$155	$155	$155	$155	$155	$1,552
Aftertax Cost Total(7	$966	$836	$932	$1,007	$1,036	$1,068	$1,103	($124)	($14)	($14)	$5,831
Discount Factor (8)	0.9455	0.8940	0.8453	0.7993	0.7558	0.7146	0.6757	0.6389	0.6041	0.5712	
Discounted Cost	$913	$747	$788	$805	$783	$763	$745	($79)	($8)	($8)	$5,450

Annual standardized cost $732

Footnote (1) Payments are based on a 7 year loan at 11.4% interest
Footnote (2) Depreciation rate is determined by using MACRS method using 7 year property
Footnote (3) Repairs are included in the operations cost (4)
Footnote (4) Operations cost is yearly expense of fuel costs and labor costs to disk
Footnote (5) The aftertax cost is sum of post tax cost and after tax cost
Footnote (6) $/N saved is the dollar value of Nitrogen saved by Injection
Footnote (7) Aftertax total is aftertax cost (5) minus aftertax $/N saved (6)
Footnote (8) The discount factor is equivalant to the after tax return on a U.S. treasury bond

Table A38 Incorporation - Disking - Medium Farm - Cost Summary Table

	Cost Summary Table for Disking for Medium Farm										
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	TOTALS
Outstanding Balance	$6,400	$5,754	$5,034	$4,232	$3,339	$2,344	$1,235	$0	0	0	
Payments (1)	$1,376	$1,376	$1,376	$1,376	$1,376	$1,376	$1,376	$0	0	0	$9,630
Principle	$646	$720	$802	$893	$995	$1,109	$1,235	$0	0	0	$6,400
Depreciation (2)	$685	$1,224	$962	$784	$784	$784	$784	$392	$0	$0	$6,400
Tx Svngs due to Dep	$192	$343	$269	$220	$220	$220	$220	$110	$0	$0	$1,792
Post Tax Cost	$454	$377	$533	$674	$776	$889	$1,015	($110)	$0	$0	$4,608
Interest Cost	$730	$656	$574	$482	$381	$267	$141	$0	$0	$0	$3,230
Repairs (3)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operations Cost (4)	$652	$652	$652	$652	$652	$652	$652	$652	$652	$652	$6,524
Pretax Cash Cost	$1,382	$1,308	$1,226	$1,135	$1,033	$920	$793	$652	$652	$652	$9,754
Aftertax Cash Cost	$995	$942	$883	$817	$744	$662	$571	$470	$470	$470	$7,023
Aftertax Cost (5)	$1,449	$1,319	$1,415	$1,491	$1,519	$1,551	$1,587	$360	$470	$470	$11,631
Aftertax $/N Saved(6)	$517	$517	$517	$517	$517	$517	$517	$517	$517	$517	$5,172
Aftertax Cost Total(7)	$932	$802	$898	$974	$1,002	$1,034	$1,069	($157)	($47)	($47)	$5,527
Discount Factor (8)	0.9455	0.8940	0.8453	0.7993	0.7558	0.7146	0.6757	0.6389	0.6041	0.5712	
Discounted Cost	$881	$717	$759	$778	$757	$739	$723	($101)	($29)	($27)	$5,198

Annual standardized cost $698

Footnote (1) Payments are based on a 7 year loan at 11.4% interest
Footnote (2) Depreciation rate is determined by using MACRS method using 7 year property
Footnote (3) Repairs are included in the operations cost (4)
Footnote (4) Operations cost is yearly expense of fuel costs and labor costs to disk
Footnote (5) The aftertax cost is sum of post tax cost and after tax cost
Footnote (6) $/N saved is the dollar value of Nitrogen saved by Injection
Footnote (7) Aftertax total is aftertax cost (5) minus aftertax $/N saved (6)
Footnote (8) The discount factor is equivalant to the after tax return on a U.S. treasury bond

Table A39 Incorporation - Disking - Large Farm - Cost Summary Table

	Cost Summary Table for Disking for Large Farm										
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Totals
Outstanding Balance	$6,400	$5,754	$5,034	$4,232	$3,339	$2,344	$1,235	$0	0	0	
Payments (1)	$1,376	$1,376	$1,376	$1,376	$1,376	$1,376	$1,376	$0	0	0	$9,630
Principle	$646	$720	$802	$893	$995	$1,109	$1,235	$0	0	0	$6,400
Depreciation (2)	$685	$1,224	$962	$784	$784	$784	$784	$392	$0	$0	$6,400
Tx Svngs due to Dep	$192	$343	$269	$220	$220	$220	$220	$110	$0	$0	$1,792
Post Tax Cost	$454	$377	$533	$674	$776	$889	$1,015	($110)	$0	$0	$4,608
Interest Cost	$730	$656	$574	$482	$381	$267	$141	$0	$0	$0	$3,230
Repairs (3)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operations Cost (4)	$1,306	$1,306	$1,306	$1,306	$1,306	$1,306	$1,306	$1,306	$1,306	$1,306	$13,064
Pretax Cash Cost	$2,036	$1,962	$1,880	$1,789	$1,687	$1,574	$1,447	$1,306	$1,306	$1,306	$16,294
Aftertax Cash Cost	$1,466	$1,413	$1,354	$1,288	$1,215	$1,133	$1,042	$941	$941	$941	$11,732
Aftertax Cost (5)	$1,920	$1,790	$1,886	$1,962	$1,990	$2,022	$2,057	$831	$941	$941	$16,340
Aftertax $/N Saved(6)	$1,141	$1,141	$1,141	$1,141	$1,141	$1,141	$1,141	$1,141	$1,141	$1,141	$11,410
Aftertax Cost Total(7)	$779	$649	$745	$821	$849	$881	$916	($310)	($200)	($200)	$4,151
Discount Factor (8)	0.9455	0.8940	0.8453	0.7993	0.7558	0.7146	0.6757	0.6389	0.6041	0.5712	
Discounted Cost	$737	$580	$630	$656	$642	$630	$619	($198)	($121)	($114)	$4,060

Annual standardized cost $545

Footnote (1) Payments are based on a 7 year loan at 11.4% interest
Footnote (2) Depreciation rate is determined by using MACRS method using 7 year property
Footnote (3) Repairs are included in the operations cost (4)
Footnote (4) Operations cost is yearly expense of fuel costs and labor costs to disk
Footnote (5) The aftertax cost is sum of post tax cost and after tax cost
Footnote (6) $/N saved is the dollar value of Nitrogen saved by Injection
Footnote (7) Aftertax total is aftertax cost (5) minus aftertax $/N saved (6)
Footnote (8) The discount factor is equivalant to the after tax return on a U.S. treasury bond

Table A40 Incorporation - Injection - Small Farm - Cost Summary Table

	Cost Summary Table for Injection for Small Farm										
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Totals
Outstanding Balance	$3,200	$2,877	$2,517	$2,116	$1,669	$1,172	$617	$0	0	0	
Payments (1)	$688	$688	$688	$688	$688	$688	$688	$0	0	0	$4,815
Principle	$323	$360	$401	$447	$498	$554	$617	$0	0	0	$3,200
Depreciation (2)	$343	$612	$481	$392	$392	$392	$392	$196	$0	$0	$3,200
Tx Svngs due to Dep	$96	$171	$135	$110	$110	$110	$110	$55	$0	$0	$896
Post Tax Cost	$227	$189	$266	$337	$388	$445	$508	($55)	$0	$0	$2,304
Interest Cost	$365	$328	$287	$241	$190	$134	$70	$0	$0	$0	$1,615
Repairs (3)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operations Cost (4)	$681	$681	$681	$681	$681	$681	$681	$681	$681	$681	$6,810
Pretax Cash Cost	$1,046	$1,009	$968	$922	$871	$815	$751	$681	$681	$681	$8,425
Aftertax Cash Cost	$753	$726	$697	$664	$627	$587	$541	$490	$490	$490	$6,066
Aftertax Cost (5)	$980	$915	$963	$1,001	$1,015	$1,031	$1,049	$435	$490	$490	$8,370
Aftertax $/N Saved(6)	$233	$233	$233	$233	$233	$233	$233	$233	$233	$233	$2,328
Aftertax Cost Total(7)	$747	$682	$730	$768	$782	$798	$816	$203	$257	$257	$5,295
Discount Factor (8)	0.9455	0.8940	0.8453	0.7993	0.7558	0.7146	0.6757	0.6389	0.6041	0.5712	
Discounted Cost	$707	$610	$617	$614	$591	$570	$551	$129	$156	$147	$4,693

Annual standardized cost $630

Footnote (1) Payments are based on a 7 year loan at 11.4% interest
Footnote (2) Depreciation rate is determined by using MACRS method using 7 year property
Footnote (3) Repairs are included in the operations cost (4)
Footnote (4) Operations cost is yearly expense of fuel costs and labor costs to inject
Footnote (5) The aftertax cost is sum of post tax cost and after tax cost
Footnote (6) $/N saved is the dollar value of Nitrogen saved by Injection
Footnote (7) Aftertax total is aftertax cost (5) minus aftertax $/N saved (6)
Footnote (8) The discount factor is equivalant to the after tax return on a U.S. treasury bond

Table A41 Incorporation - Injection - Medium Farm - Cost Summary Table

	Cost Summary Table for Injection for MediumFarm										
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Totals
Outstanding Balance	$3,200	$2,877	$2,517	$2,116	$1,669	$1,172	$617	$0	$0	$0	
Payments (1)	$688	$688	$688	$688	$688	$688	$688	$0	$0	$0	$4,815
Principle	$323	$360	$401	$447	$498	$554	$617	$0	$0	$0	$3,200
Depreciation (2)	$343	$612	$481	$392	$392	$392	$392	$196	$0	$0	$3,200
Tx Svngs due to Dep	$96	$171	$135	$110	$110	$110	$110	$55	$0	$0	$896
Post Tax Cost	$227	$189	$266	$337	$388	$445	$508	($55)	$0	$0	$2,304
Interest Cost	$365	$328	$287	$241	$190	$134	$70	$0	$0	$0	$1,615
Repairs (3)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operations Cost (4)	$1,125	$1,125	$1,125	$1,125	$1,125	$1,125	$1,125	$1,125	$1,125	$1,125	$11,250
Pretax Cash Cost	$1,490	$1,453	$1,412	$1,366	$1,315	$1,259	$1,195	$1,125	$1,125	$1,125	$12,865
Aftertax Cash Cost	$1,073	$1,046	$1,017	$984	$947	$906	$861	$810	$810	$810	$9,263
Aftertax Cost (5)	$1,300	$1,235	$1,283	$1,321	$1,335	$1,351	$1,368	$755	$810	$810	$11,567
Aftertax $/N Saved(6)	$776	$776	$776	$776	$776	$776	$776	$776	$776	$776	$7,758
Aftertax Cost Total(7)	$524	$459	$507	$545	$559	$575	$593	($21)	$34	$34	$3,285
Discount Factor (8)	0.9455	0.8940	0.8453	0.7993	0.7558	0.7146	0.6757	0.6389	0.6041	0.5712	
Discounted Cost	$495	$410	$429	$435	$423	$411	$400	($13)	$21	$20	$3,031

Annual standardized cost $407

Footnote (1) Payments are based on a 7 year loan at 11.4% interest
Footnote (2) Depreciation rate is determined by using MACRS method using 7 year property
Footnote (3) Repairs are included in the operations cost (4)
Footnote (4) Operations cost is yearly expense of fuel costs and labor costs to inject
Footnote (5) The aftertax cost is sum of post tax cost and after tax cost
Footnote (6) $/N saved is the dollar value of Nitrogen saved by Injection
Footnote (7) Aftertax total is aftertax cost (5) minus aftertax $/N saved (6)
Footnote (8) The discount factor is equivalant to the after tax return on a U.S. treasury bond

Table A42 Incorporation - Injection - Large Farm - Cost Summary Table

	Cost Summary Table for Injection for Large Farm										
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Totals
Outstanding Balance	$3,200	$2,877	$2,517	$2,116	$1,669	$1,172	$617	$0	0	0	
Payments (1)	$688	$688	$688	$688	$688	$688	$688	$0	0	0	$4,815
Principle	$323	$360	$401	$447	$498	$554	$617	$0	0	0	$3,200
Depreciation (2)	$343	$612	$481	$392	$392	$392	$392	$196	$0	$0	$3,200
Tx Svngs due to Dep	$96	$171	$135	$110	$110	$110	$110	$55	$0	$0	$896
Post Tax Cost	$227	$189	$266	$337	$388	$445	$508	($55)	$0	$0	$2,304
Interest Cost	$365	$328	$287	$241	$190	$134	$70	$0	$0	$0	$1,615
Repairs (3)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operations Cost (4)	$1,867	$1,867	$1,867	$1,867	$1,867	$1,867	$1,867	$1,867	$1,867	$1,867	$18,670
Pretax Cash Cost	$2,232	$2,195	$2,154	$2,108	$2,057	$2,001	$1,937	$1,867	$1,867	$1,867	$20,285
Aftertax Cash Cost	$1,607	$1,580	$1,551	$1,518	$1,481	$1,440	$1,395	$1,344	$1,344	$1,344	$14,605
Aftertax Cost (5)	$1,834	$1,769	$1,817	$1,855	$1,869	$1,885	$1,903	$1,289	$1,344	$1,344	$16,909
Aftertax $/N Saved(6)	$1,712	$1,712	$1,712	$1,712	$1,712	$1,712	$1,712	$1,712	$1,712	$1,712	$17,115
Aftertax Cost Total(7)	$122	$57	$106	$143	$158	$173	$191	($422)	($367)	($367)	($328)
Discount Factor (8)	0.9455	0.8940	0.8453	0.7993	0.7558	0.7146	0.6757	0.6389	0.6041	0.5712	
Discounted Cost	$116	$51	$89	$115	$119	$124	$129	($270)	($222)	($210)	$42

Annual standardized cost $6

Footnote (1) Payments are based on a 7 year loan at 11.4% interest
Footnote (2) Depreciation rate is determined by using MACRS method using 7 year property
Footnote (3) Repairs are included in the operations cost (4)
Footnote (4) Operations cost is yearly expense of fuel costs and labor costs to inject
Footnote (5) The aftertax cost is sum of post tax cost and after tax cost
Footnote (6) $/N saved is the dollar value of Nitrogen saved by Injection
Footnote (7) Aftertax total is aftertax cost (5) minus aftertax $/N saved (6)
Footnote (8) The discount factor is equivalant to the after tax return on a U.S. treasury bond

Table A43 Incorporation - Summary Table

FACILITY TYPE	*INCORPORATION- ALL FARMS* Cost Worksheet		
	Annual Standard Cost	Total Discounted Cost	$/Pig Annual Cost
SMALL FARM			
Using Disk	$732	$5,450	$0.61
Using Injection	$630	$4,693	$0.53
MEDIUM FARM			
Using Disk	$698	$5,198	$0.18
Using Injection	$407	$3,031	$0.10
LARGE FARM			
Using Disk	$545	$4,060	$0.07
Using Injection	$6	$42	$0.00

Table A44 "MAE" Input Form for Small Farm - No Injection

```
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$ MAE -- MANURE APPLICATION ECONOMICS $
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$

TABLE 1. SUMMARY OF INPUT DATA:
***********************************************************
***********************************************************
**  OPERATION TYPE 3 - SWINE-FARROW TO FINISH            **
**  SPREADER TYPE 1 - VACUUM WAGON                       **
**  MANURE INJECTION -- NO                               **
**  OPERATION SIZE -   125000. POUNDS LIVE WEIGHT        **
**  NITROGEN APPLICATION RATE -    120. LBS/AC           **
**  MANURE DILUTION RATIO - 1: .5 (MANURE:DILUTION)      **
**  TRAVEL DISTANCE TO APPLICATION SITE -  .25 MILES     **
**  AREA REQUIRED FOR MANURE APPLICATION -  122. ACRES   **
**  TOTAL ANNUAL WASTE VOLUME -    91417. CU FT          **
**  AVAILABLE INTEREST RATE - 14.40 %                    **
**  ASSUMED COST FOR DIESEL FUEL - 1.00 $/GAL            **
**  ASSUMED COST FOR LABOR -  5.00 $/HR                  **
***********************************************************
***********************************************************
```

TABLE 2. TIME AND POWER REQUIREMENTS

WAGON SIZE (CU FT)	REQUIRED TRACTOR SIZE (HP)	TIME PER LOAD (MIN)	LOADS PER YEAR	ANNUAL LOAD TIME (HOURS)	ANNUAL UNLOAD TIME (HOURS)	ANNUAL WORK TIME (HOURS)	REQUIRED APPLICATION SPEED (MI/HR)
100.00	38.76	18.7	1015.7	50.6	45.1	316.0	.7
200.00	56.07	20.8	507.9	33.9	32.2	176.0	1.0
300.00	73.38	22.8	338.6	28.3	27.9	128.4	1.2
400.00	90.69	24.5	253.9	25.5	25.7	103.8	1.3
500.00	108.00	26.1	203.1	23.8	24.4	88.5	1.4
600.00	125.31	27.6	169.3	22.7	23.5	77.8	1.4

Table A45 "MAE" Output Form for Small Farm - No Injection

TABLE 3. ANNUAL COST REQUIREMENTS

WAGON SIZE (CU FT)	TOTAL FUEL COST ($/YR)	TOTAL LABOR COST ($/YR)	TOTAL OPERATION COST ($/YR)	TOTAL OWNERSHIP COST ($/YR)	TOTAL ANNUAL COST ($/YR)
100.00	4936.45	15387.44	33225.24	12751.25	45976.50
200.00	3916.10	8218.86	22102.37	9917.32	32019.69
300.00	3652.48	5796.63	18623.92	9483.71	28107.63
400.00	3587.89	4560.98	17058.47	9671.40	26729.86
500.00	3605.72	3799.97	16249.20	10113.87	26363.07
600.00	3665.78	3276.28	15807.73	10686.11	26493.84

Table A46 "MAE" Input Form for Small Farm - with Injection

MAE -- MANURE APPLICATION ECONOMICS

TABLE 1. SUMMARY OF INPUT DATA:

OPERATION TYPE 3 - SWINE-FARROW TO FINISH
SPREADER TYPE 1 - VACUUM WAGON
MANURE INJECTION -- YES, 4 INJECTION POINT SYSTEM
OPERATION SIZE - 125000. POUNDS LIVE WEIGHT
NITROGEN APPLICATION RATE - 120. LBS/AC
MANURE DILUTION RATIO - 1: .5 (MANURE:DILUTION)
TRAVEL DISTANCE TO APPLICATION SITE - .25 MILES
AREA REQUIRED FOR MANURE APPLICATION - 122. ACRES
TOTAL ANNUAL WASTE VOLUME - 91417. CU FT
AVAILABLE INTEREST RATE - 14.40 %
ASSUMED COST FOR DIESEL FUEL - 1.00 $/GAL
ASSUMED COST FOR LABOR - 5.00 $/HR

TABLE 2. TIME AND POWER REQUIREMENTS

WAGON SIZE (CU FT)	REQUIRED TRACTOR SIZE (HP)	TIME PER LOAD (MIN)	LOADS PER YEAR	ANNUAL LOAD TIME (HOURS)	ANNUAL UNLOAD TIME (HOURS)	ANNUAL WORK TIME (HOURS)	REQUIRED APPLICATION SPEED (MI/HR)
100.00	45.08	18.7	1015.7	50.6	45.1	316.0	.7
200.00	64.94	20.8	507.9	33.9	32.2	176.0	1.0
300.00	83.63	22.8	338.6	28.3	27.9	128.4	1.2
400.00	101.80	24.5	253.9	25.5	25.7	103.8	1.3
500.00	119.70	26.1	203.1	23.8	24.4	88.5	1.4
600.00	137.44	27.6	169.3	22.7	23.5	77.8	1.4

Table A47 "MAE" Output Form for Small Farm - with Injection

TABLE 3. ANNUAL COST REQUIREMENTS

WAGON SIZE (CU FT)	TOTAL FUEL COST ($/YR)	TOTAL LABOR COST ($/YR)	TOTAL OPERATION COST ($/YR)	TOTAL OWNERSHIP COST ($/YR)	TOTAL ANNUAL COST ($/YR)
100.00	389.91	1580.07	3161.32	2261.44	5422.76
200.00	329.11	880.13	2174.10	2649.90	4823.99
300.00	323.36	641.91	1890.07	3246.73	5136.80
400.00	331.54	519.12	1779.22	3895.66	5674.88
500.00	345.33	442.50	1735.44	4565.43	6300.87
600.00	361.92	388.97	1723.31	5245.61	6968.92

Table A48 "MAE" Input Form for Medium Farm - No Injection

```
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$ MAE -- MANURE APPLICATION ECONOMICS $
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$

TABLE 1. SUMMARY OF INPUT DATA:
**********************************************************
**********************************************************
**  OPERATION TYPE 3 - SWINE-FARROW TO FINISH           **
**  SPREADER TYPE 1 - VACUUM WAGON                      **
**  MANURE INJECTION -- NO                              **
**  OPERATION SIZE -   416500. POUNDS LIVE WEIGHT       **
**  NITROGEN APPLICATION RATE -   120. LBS/AC           **
**  MANURE DILUTION RATIO - 1: .5 (MANURE:DILUTION)     **
**  TRAVEL DISTANCE TO APPLICATION SITE -  .25 MILES    **
**  AREA REQUIRED FOR MANURE APPLICATION -  405. ACRES  **
**  TOTAL ANNUAL WASTE VOLUME -  304602. CU FT          **
**  AVAILABLE INTEREST RATE - 14.40 %                   **
**  ASSUMED COST FOR DIESEL FUEL - 1.00 $/GAL           **
**  ASSUMED COST FOR LABOR -  5.00 $/HR                 **
**********************************************************
**********************************************************
```

TABLE 2. TIME AND POWER REQUIREMENTS

WAGON SIZE (CU FT)	REQUIRED TRACTOR SIZE (HP)	TIME PER LOAD (MIN)	LOADS PER YEAR	ANNUAL LOAD TIME (HOURS)	ANNUAL UNLOAD TIME (HOURS)	ANNUAL WORK TIME (HOURS)	REQUIRED APPLICATION SPEED (MI/HR)
100.00	38.76	23.2	3384.5	168.7	150.4	1306.1	.7
200.00	56.07	25.1	1692.2	112.9	107.2	709.2	1.0
300.00	73.38	27.0	1128.2	94.3	92.8	506.9	1.2
400.00	90.69	28.6	846.1	85.0	85.6	403.3	1.3
500.00	108.00	30.1	676.9	79.4	81.3	339.2	1.4
600.00	125.31	31.4	564.1	75.6	78.4	294.8	1.4

Table A49 "MAE" Output Form for Medium Farm - No Injection

TABLE 3. ANNUAL COST REQUIREMENTS

WAGON SIZE (CU FT)	TOTAL FUEL COST ($/YR)	TOTAL LABOR COST ($/YR)	TOTAL OPERATION COST ($/YR)	TOTAL OWNERSHIP COST ($/YR)	TOTAL ANNUAL COST ($/YR)
100.00	478.40	1580.07	3366.63	2874.99	6241.62
200.00	394.89	880.13	2325.91	3242.67	5568.59
300.00	380.12	641.91	2020.50	3828.29	5848.79
400.00	383.34	519.12	1897.82	4470.20	6368.02
500.00	393.98	442.50	1846.47	5135.16	6981.63
600.00	408.39	388.97	1829.08	5811.84	7640.93

Table A50 "MAE" Input Form for Large Farm - with Injection

```
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$ MAE -- MANURE APPLICATION ECONOMICS $
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
```

TABLE 1. SUMMARY OF INPUT DATA:

```
************************************************************
************************************************************
**  OPERATION TYPE 3 - SWINE-FARROW TO FINISH             **
**  SPREADER TYPE 1 - VACUUM WAGON                        **
**  MANURE INJECTION -- YES,  4 INJECTION POINT SYSTEM    **
**  OPERATION SIZE -   416500. POUNDS LIVE WEIGHT         **
**  NITROGEN APPLICATION RATE -    120. LBS/AC            **
**  MANURE DILUTION RATIO - 1: .5 (MANURE:DILUTION)       **
**  TRAVEL DISTANCE TO APPLICATION SITE -  .25 MILES      **
**  AREA REQUIRED FOR MANURE APPLICATION -  405. ACRES    **
**  TOTAL ANNUAL WASTE VOLUME -  304602. CU FT            **
**  AVAILABLE INTEREST RATE - 14.40 %                     **
**  ASSUMED COST FOR DIESEL FUEL - 1.00 $/GAL             **
**  ASSUMED COST FOR LABOR -  5.00 $/HR                   **
************************************************************
************************************************************
```

TABLE 2. TIME AND POWER REQUIREMENTS

WAGON SIZE (CU FT)	REQUIRED TRACTOR SIZE (HP)	TIME PER LOAD (MIN)	LOADS PER YEAR	ANNUAL LOAD TIME (HOURS)	ANNUAL UNLOAD TIME (HOURS)	ANNUAL WORK TIME (HOURS)	REQUIRED APPLICATION SPEED (MI/HR)
100.00	45.08	23.2	3384.5	168.7	150.4	1306.1	.7
200.00	64.94	25.1	1692.2	112.9	107.2	709.2	1.0
300.00	83.63	27.0	1128.2	94.3	92.8	506.9	1.2
400.00	101.80	28.6	846.1	85.0	85.6	403.3	1.3
500.00	119.70	30.1	676.9	79.4	81.3	339.2	1.4
600.00	137.44	31.4	564.1	75.6	78.4	294.8	1.4

Table A51 "MAE" Output Form for Medium Farm - with Injection

TABLE 3. ANNUAL COST REQUIREMENTS

WAGON SIZE (CU FT)	TOTAL FUEL COST ($/YR)	TOTAL LABOR COST ($/YR)	TOTAL OPERATION COST ($/YR)	TOTAL OWNERSHIP COST ($/YR)	TOTAL ANNUAL COST ($/YR)
100.00	1675.07	6530.64	13213.02	5416.58	18629.61
200.00	1383.08	3545.83	8880.54	4782.56	13663.11
300.00	1333.81	2534.55	7579.45	5077.29	12656.75
400.00	1346.01	2016.65	7027.73	5604.21	12631.94
500.00	1382.91	1696.10	6768.38	6224.00	12992.38
600.00	1432.18	1474.23	6649.00	6890.23	13539.23

Table A52 "MAE" Input Form for Large Farm - No Injection

MAE -- MANURE APPLICATION ECONOMICS

TABLE 1. SUMMARY OF INPUT DATA:

- OPERATION TYPE 3 - SWINE-FARROW TO FINISH
- SPREADER TYPE 1 - VACUUM WAGON
- MANURE INJECTION -- NO
- OPERATION SIZE - 833300. POUNDS LIVE WEIGHT
- NITROGEN APPLICATION RATE - 120. LBS/AC
- MANURE DILUTION RATIO - 1: .5 (MANURE:DILUTION)
- TRAVEL DISTANCE TO APPLICATION SITE - .25 MILES
- AREA REQUIRED FOR MANURE APPLICATION - 811. ACRES
- TOTAL ANNUAL WASTE VOLUME - 609424. CU FT
- AVAILABLE INTEREST RATE - 14.40 %
- ASSUMED COST FOR DIESEL FUEL - 1.00 $/GAL
- ASSUMED COST FOR LABOR - 5.00 $/HR

TABLE 2. TIME AND POWER REQUIREMENTS

WAGON SIZE (CU FT)	REQUIRED TRACTOR SIZE (HP)	TIME PER LOAD (MIN)	LOADS PER YEAR	ANNUAL LOAD TIME (HOURS)	ANNUAL UNLOAD TIME (HOURS)	ANNUAL WORK TIME (HOURS)	REQUIRED APPLICATION SPEED (MI/HR)
100.00	38.76	27.3	6771.4	337.6	300.8	3077.5	.7
200.00	56.07	29.1	3385.7	225.8	214.5	1643.8	1.0
300.00	73.38	30.8	2257.1	188.6	185.7	1159.3	1.2
400.00	90.69	32.3	1692.8	170.0	171.3	912.2	1.3
500.00	108.00	33.7	1354.3	158.8	162.7	760.0	1.4
600.00	125.31	34.8	1128.6	151.3	156.9	655.3	1.4

Table A53 "MAE" Output Form for Large Farm - No Injection

TABLE 3. ANNUAL COST REQUIREMENTS

WAGON SIZE (CU FT)	TOTAL FUEL COST ($/YR)	TOTAL LABOR COST ($/YR)	TOTAL OPERATION COST ($/YR)	TOTAL OWNERSHIP COST ($/YR)	TOTAL ANNUAL COST ($/YR)
100.00	2049.68	6530.64	14029.35	6334.15	20363.50
200.00	1650.52	3545.83	9470.29	5603.42	15073.71
300.00	1558.23	2534.55	8076.50	5845.93	13922.43
400.00	1546.52	2016.65	7472.76	6340.16	13812.92
500.00	1568.12	1696.10	7179.89	6937.56	14117.45
600.00	1606.76	1474.23	7037.06	7587.50	14624.55

Table A54 "MAE" Input Form for Large Farm - with Injection

```
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$ MAE -- MANURE APPLICATION ECONOMICS $
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$

TABLE 1. SUMMARY OF INPUT DATA:
************************************************************
************************************************************
**   OPERATION TYPE 3 - SWINE-FARROW TO FINISH            **
**   SPREADER TYPE 1 - VACUUM WAGON                       **
**   MANURE INJECTION -- YES,  4 INJECTION POINT SYSTEM   **
**   OPERATION SIZE -    833300. POUNDS LIVE WEIGHT       **
**   NITROGEN APPLICATION RATE -    120. LBS/AC           **
**   MANURE DILUTION RATIO - 1: .5 (MANURE:DILUTION)      **
**   TRAVEL DISTANCE TO APPLICATION SITE -  .25 MILES     **
**   AREA REQUIRED FOR MANURE APPLICATION -  811. ACRES   **
**   TOTAL ANNUAL WASTE VOLUME -  609424. CU FT           **
**   AVAILABLE INTEREST RATE - 14.40 %                    **
**   ASSUMED COST FOR DIESEL FUEL - 1.00 $/GAL            **
**   ASSUMED COST FOR LABOR -   5.00 $/HR                 **
************************************************************
************************************************************
```

TABLE 2. TIME AND POWER REQUIREMENTS

WAGON SIZE (CU FT)	REQUIRED TRACTOR SIZE (HP)	TIME PER LOAD (MIN)	LOADS PER YEAR	ANNUAL LOAD TIME (HOURS)	ANNUAL UNLOAD TIME (HOURS)	ANNUAL WORK TIME (HOURS)	REQUIRED APPLICATION SPEED (MI/HR)
100.00	45.08	27.3	6771.4	337.6	300.8	3077.5	.7
200.00	64.94	29.1	3385.7	225.8	214.5	1643.8	1.0
300.00	83.63	30.8	2257.1	188.6	185.7	1159.3	1.2
400.00	101.80	32.3	1692.8	170.0	171.3	912.2	1.3
500.00	119.70	33.7	1354.3	158.8	162.7	760.0	1.4
600.00	137.44	34.8	1128.6	151.3	156.9	655.3	1.4

Table A55 "MAE" Output Form for Large Farm - with Injection

TABLE 3. ANNUAL COST REQUIREMENTS

WAGON SIZE (CU FT)	TOTAL FUEL COST ($/YR)	TOTAL LABOR COST ($/YR)	TOTAL OPERATION COST ($/YR)	TOTAL OWNERSHIP COST ($/YR)	TOTAL ANNUAL COST ($/YR)
100.00	4040.68	15387.44	31349.52	11269.71	42619.23
200.00	3292.54	8218.86	20768.60	8679.69	29448.29
300.00	3138.79	5796.63	17514.99	8377.79	25892.77
400.00	3135.54	4560.98	16076.62	8647.91	24724.53
500.00	3192.79	3799.97	15349.68	9146.85	24496.52
600.00	3280.33	3276.28	14966.00	9760.19	24726.18

BIBLIOGRAPHY

Animal Waste Resource Committee. "Preliminary Report of the Animal Waste Resource Committee to the Michigan Commission of Agriculture". Environmental Division, Michigan Department of Agriculture. Lansing MI. 1987.

Christensen, L.A., J.R. Trierweiler, T.J. Ulrich, and M.W. Erickson. "Managing Animal Wastes: Guidelines for Decision-Making". ERS-671. Washington, D.C.: Natural Resource Economics Division, Economic Research Service, U.S. Department of Agriculture, 1981.

College of Agriculture and Extension Division: University of Missouri-Columbia. 1988. "Water Quality and Soil Conservation: Conflicts of Rights Issues". Agricultural Experiment Station 394.

Cooperative Extension Service. "The "Scoop" on Livestock Manures as a Resource--Regulations and Responsibilities". Cooperative Extension Bulletin E-720, East Lansing: Michigan State University, 1985.

Crowder, B., and C.E. Young. "Managing Farm Nutrients: Tradeoffs for Surface and Ground-water Quality". Resources and Technology Division, ERS 583. Washington DC: U.S.Department of Agriculture, 1988.

Good, D.L., C.R. Hoglund, L.J. Conner, and J.B. Johnson. "Economic Impacts of Applying Selected Pollution Control Measures on Michigan Dairy Farms". Agricultural Experiment Station bulletin 225 East Lansing:Michigan State University, 1973.

Hines, S., K. Norgaard, H. Person, and G. Schwab. "Description of MPPA Management Practices Survey". East Lansing: Michigan State University, 1987.

Hobbs, D.J., and R.C. Powers. "Changing Relationship Between Farm and Community". Cooperative Extension Bulletin FS46, East Lansing: Michigan State University, 1985.

Lehnert, D., "Nitrates in Your Drinking Water. Michigan Farmer". HBJ Farm Publications. Feb. 20, 1988.

Michigan Commission of Agriculture. "Right to Farm Act and Interim Guidelines". Department of Agriculture, Lansing MI, 1988.

Midwest Plan Service. Livestock Waste Facilities Handbook, 2nd Ed. MWPS-18. Iowa State University, 1985.

Miner, J.R., and C.L. Barth. "Controlling Odors from Swine Buildings". Cooperative Extension Bulletin E-1158, East Lansing: Michigan State University, 1979.

Morgan, R.M., and L.H. Keller. "Economic Comparisons of Alternative Waste Management Systems on Tennessee Dairy Farms". Knoxville: University of Tennessee Agricultural Experiment Station bulletin 656. 1987.

National Symposium of Animal Waste Management. "Animal Waste Management". The Airlie House, Warrenton, Virginia. 1971.

Person, H.L., and H.J. Doss., "Hazardous Gases in Manure Tanks in Livestock Operations", 1989, Cooperative Extension Bulletin AEIS-573, Michigan State University, East Lansing, MI

Person, H. "PigPlan" - software for estimating space requirements for swine. East Lansing Michigan State University, 1985.

Rural Nonpoint Source Pollution Subcommittee. "A strategy for the Reduction of rural Nonpoint Source Pollution in Michigan". Lansing: Michigan Department of Agriculture. 1985.

Rotz, Alan C. "A Standard Model for Repair Costs of Agricultural Machinery". Michigan Agricultural Experiment Station Journal Article No. 11833. East Lansing: Department of Agricultural Engineering, 1986.

Schwab, G.D. "Business Analysis Summary for Swine Farms". Agricultural Economics Report 485. East Lansing: Department of Agricultural Economics, 1985.

Schwab, G.D. "Estimates for Michigan Crop and Livestock Budgets". Agricultural Economics Report 524. East Lansing: Department of Agricultural Economics, 1989.

Shortle, J.S., and D.J. EPP. "The Environmental Connection". Cooperative Extension Bulletin FS37, East Lansing: Michigan State University, 1985.

Southern Natural Resource Economics Committee, "Economic Issues in Waste Management". Southern Rural Development Center and the Farm Foundation. 1985.

United States Government. Code of Federal Regulations. 40 CFR 122 Washington DC 1972.

Van Arsdall, R.N., R.B. Smith, and T.A. Stucker. "Economic Impact of Controlling Surface Water Runoff from Point Sources in U.S. Hog Production.

Vitosh, M.L., H.L. Person, and E.D. Purkhiser. "Livestock Manure Management". Cooperative Extension Bulletin WQ12, East Lansing: Michigan State University. 1986.

Webster's Ninth New Collegiate Dictionary. Merriam-Webster Inc. Springfield, Massachusetts. 1985.

Young, C.E., J.R. Alwang, and B.M. Crowder, "Alternatives for Dairy Manure Management". Natural Resource Economics Division, ERS AGES860422. Washington DC: U.S.Department of Agriculture, 1986.