RIGHT-TO-FARM GUIDE

SPECIAL SUPPLEMENT TO THE MICHIGAN FARM NEWS — MICHIGAN FARM BUREAU

MICHIGAN FARM BUREAU

January 30, 1997
Issue 1

PRINTED WITH SOY INK

Practices for managing manure in Michigan

In the event of an agricultural pollution emergency such as a chemical or fertilizer spill or manure lagoon breech, the Michigan Department of Agriculture and/or the Michigan Department of Environmental Quality should be contacted at the following emergency telephone numbers:

Michigan Department of Agriculture
(800) 405-0101

Michigan Department of Environmental Quality
(800) 292-4706

If there is not an emergency, but you have questions on the Michigan Right-to-Farm Act or items concerning a farm operation, please contact:
Michigan Department of Agriculture
Right-to-Farm Program
P.O. Box 30017
Lansing, MI 48909
(517) 373-1087

As a service to Michigan Farm Bureau members, this special supplement on manure manage guidelines is the first in a four-part series that will deliver three of the major Right-to-Farm practice areas, including Manure Management, Nutrient Management and Pesticide Management. A final installment in the series will be a supplement featuring groundwater stewardship activities conducted by Michigan producers.

Changes in modern agriculture bring manure management to the forefront

Managing manure properly is an increasingly important challenge for livestock and poultry producers. This guide outlines Generally Accepted Manure Management Practices in Michigan.

Like all other segments of our economy, agriculture has changed significantly during the past 50 years and will continue to change in the future. The trend toward larger facilities (the overwhelming majority being family owned) has resulted in farm operations becoming more capital intensive and less labor intensive.

Larger farm size offers marketing advantages and generally a lower unit cost of production compared to smaller-sized operations. However, increased numbers of animals in livestock operations bring new management challenges dealing with manure and odors generated.

Animal agriculture in Michigan must have the flexibility and opportunity to change agricultural enterprises and to adopt new technology as it becomes available to remain viable and competitive in the market place. If a healthy, growing livestock industry in Michigan is to be assured, efforts must continue to address the concerns of livestock producers and their neighbors, particularly in two areas:

- **Producers who use generally accepted manure management practices in their livestock operations should be protected from harassment and nuisance complaints.**
- **Persons living near livestock operations that do not follow generally accepted agricultural and management practices need to have concerns addressed when odor nuisance or water-quality problems occur.**

Technical recommendations for livestock manure and wastewater management practices have been consolidated in two major sources of information. (See box at right for how to obtain them.) These are the *Natural Resources Conservation Service* (NRCS) *Field Office Technical Guide*, or NRCS-FOTG and the *Midwest Plan Service Livestock Waste Facilities Handbook*, or MWPS-18. Each has published waste management specifications and management guides that are a consensus of agricultural engineers and professionals working in the waste management field.

Use of alternative bedding materials, such as shredded newspaper, has presented new ways of handling manure on Michigan farms. Use this guide for managing the manure practices on your operation.

Because these documents are dynamic and periodically reviewed and updated, they contain current state-of-knowledge guidance on generally accepted management practices for livestock operations that will not be duplicated here. These documents provide more in-depth information about the manure management practices presented in this document.

Other documents that specifically relate to recommendations contained in this paper are the *National Pork Industry Handbook and Fertilizer Recommendations for Field Crops* (Christenson *et al.*, 1992) and *Vegetable Crops* (Warncke *et al.*, 1992) *in Michigan*, each available from Michigan State University Extension (MSU-E).

A manure management system is a coordinated combination of structural components and management practices necessary to control and use manure and other byproducts of livestock production in a manner that minimizes adverse impacts on the environment.

A manure management system plan briefly describes the manure production, collection, storage, treatment, transfer and utilization processes for the farm and lists the associated components and practices. The system plan does not include any detailed designs or construction drawings. A successful manure management system is the result of sound planning, design, construction, operation and maintenance.

These recommendations and practices reflect the best judgment of professional livestock producers and professionals who assist livestock producers with designing and managing their operations to be good stewards of the environment.

An important aspect of generally accepted agricultural and management practices requires that the producer manage the manure and wastewater handling system in a manner that minimizes any negative effect on the environment. This requires that the producer consider the total management aspects of the manure handling system rather than only parts of the system.

A good recordkeeping system helps the producer record the past history of manure management, so that future management of the system will be enhanced and can provide a factual basis for documenting sound environmental stewardship. The generally accepted agricultural and management practices that follow should be incorporated in most situations. However, adverse weather conditions may, in part, prevent responsible livestock operators from adhering to these practices for a short duration of time.

Also, no two livestock operations in Michigan can be expected to be the same due to the large number of variables that, together, determine the nature of a particular operation. These variables include such items as the kind and number of livestock, type of housing and manure handling system, feed rations used, type of manure application equipment, soil types and landscape features on the farm, crops grown, etc.

These manure management practices are reasonable and may be accomplished by the majority of livestock producers without creating a competitive disadvantage to the Michigan livestock industry.

Manure management publications

Several sources are mentioned in this guide. Here's how to obtain copies:

- ***Natural Resources Conservation Service Field Office Technical Guide*** **(NRCS-FOTG). Your local NRCS field office has a copy you may view.**
- ***Midwest Plan Service Livestock Waste Facilities Handbook*** **(MWPS-18). Call Iowa State University at (800) 562-3618. Cost is $8, plus $3.50 shipping.**
- **For MSU Extension publications, ask your county Extension office or call the bulletin office at (517) 355-0240.**

Look for three more special supplements in the Right-to-Farm series — coming soon in future issues

Runoff control and wastewater management

Rainfall- and snowfall-induced runoff from uncovered livestock facilities requires control to protect neighboring land areas and prevent direct discharge to surface waters. Livestock facilities that require runoff control include all holding areas where livestock density precludes sustaining vegetative growth on the soil surface.

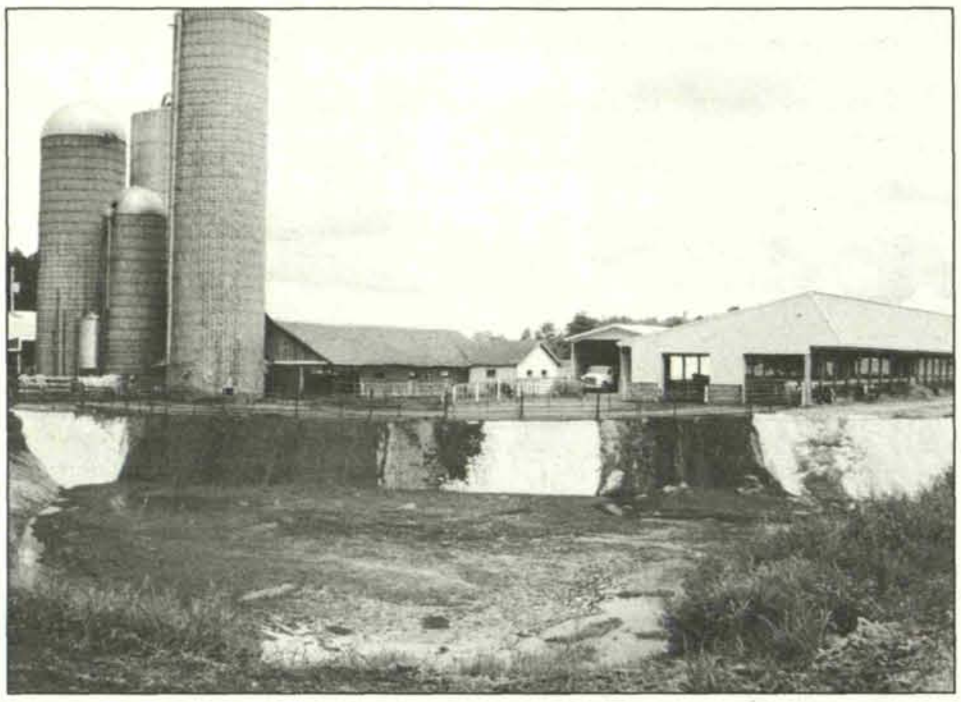
- Facilities may be paved, partially paved around waterers and feed bunks, or unpaved.
- **Runoff control is required for any facility if runoff from the lot leaves the property. This would include runoff to a neighbor's land, a roadside ditch, a drain ditch, stream or lake.**

Storage ponds for runoff control

Runoff control can be achieved by providing facilities to collect and store the runoff for later application to cropland. The quantity of water to be handled in the runoff control facility can be minimized by diverting roof runoff and off-site runoff away from livestock areas to a drainage system independent of the manure management system.

- **Runoff storage ponds should be designed to handle all runoff for at least a six-month-long design storage period, plus contain the runoff from the maximum 25-year, 24-hour storm event rainfall for the area. Storage ponds must be constructed to reduce seepage loss to acceptable levels.**

The NRCS-FOTG or MWPS-18 can be consulted for detailed design information. See "Construction design for manure ponds and lagoons" on page 4 for more information.



Runoff control can be achieved by providing facilities to collect and store the runoff for later application to cropland.

Land application of runoff

Equipment must be available for land application of stored runoff water. Land application should be done when the soil is dry enough to accept the water.

- **Application rates should be determined based upon the ability of the soil to accept and store the water and the ability of plants growing in the application area to utilize nutrients in the near term. Land application should be done when the water can be beneficially used by a growing crop. Sprinkler irrigation methods will provide uniform application of liquid with minimum labor requirements. Directing lot runoff through a structure for settling solids can reduce odor from the liquid during storage and application to the land (see NRCS-FOTG and MWPS-18).**

Infiltration areas

An alternative to a storage pond is a structure for settling solids and an infiltration area (or vegetative filter) for handling lot runoff.

The vegetated area may be either a long, grassed, slightly sloping channel or a broad, flat area with little or no slope surrounded by a berm or dike. All outside surface water should be excluded from the infiltration area so the only water applied is lot runoff and direct precipitation. Vegetation should be maintained and harvested at least once per year to prevent excessive nutrient buildup in the soil of the infiltration area.

Design information about infiltration areas (such as sizing, establishment and maintenance) is available in the NRCS-FOTG, MWPS-18, or the *Pork Industry Handbook* (MSU Extension Bulletin E-1132 by Vanderholm and Nye, 1987). These systems are not practical for every situation.

Pasture systems

Pasture land is land that is primarily used for the production of forage upon which livestock graze. Pasture land is characterized by a predominance of vegetation consisting of desirable forage species (see Moline *et al.*, 1991; Moline and Plummer, 1991a, 1991b).

Sites such as loafing areas, confinement areas or feedlots, which have excessive livestock densities that preclude a predominance of desirable forage species, are not considered pasture land.

- **Stocking densities and management systems should be employed that ensure that desirable forage species are present with an intensity of stand sufficient to slow the movement of runoff water and control soil erosion and movement of manure nutrients from the pasture land (NRCS-FOTG).**
- **Livestock should be excluded from actual contact with streams or water courses except for controlled crossings and accesses for water (NRCS-FOTG).**

As authorized by the Riparian Doctrine, producers are entitled to utilize surface waters traversing their property. However, this use is limited to activities that do not result in water quality degradation. The goal for controlling livestock access to surface waters is to prevent water quality degradation. Livestock impact water quality by the erosion of sediment and nutrients from stream banks and by the direct deposition of manure nutrients, organic matter and pathogens.

Direct deposition is effectively prevented by restricting livestock to controlled access locations. Banks are effectively stabilized by maintaining vegetation or, as in the case of controlled watering accesses and crossings, stream banks and beds may be stabilized with appropriate protective cover such as concrete, rocks, crushed rock, gravel or other suitable cover.

In addition to addressing environmental and public health aspects, controlling livestock access to surface water and providing alternate drinking water sources may improve herd health by reducing exposure to water- and soil-borne pathogens.

- **Runoff from pasture, feeding and watering areas should travel through a vegetated area of at least 66 feet before it travels into a surface water course.**
- **Milk parlor and milk house wastewater shall be managed in a manner to prevent direct discharge into surface water.**

Animal odor management recommendations

Odor perception is a subjective response to what people detect, through their sense of smell, in the air they breathe. While there is no scientific evidence that odorous gases that escape from livestock operations are toxic at the concentrations experienced by neighbors, they can become an annoyance or a nuisance to neighbors.

- **Livestock producers should plan, design, construct and manage their operations in a manner that minimizes odor impacts upon neighbors.**

The goal for effective odor management is to reduce the frequency, intensity, duration and offensiveness of odors, and to manage the operation in a way that tends to create a positive attitude toward the operation. Because of the subjective nature of human responses to certain odors, recommendations for appropriate technology and management practices is not an exact science. The recommendations in this section represent the best professional judgment available.

The proximity of livestock operations to neighbors and populated areas is usually the most critical factor in determining the level of technology and management needed to minimize odor impacts upon neighbors. Therefore, site selection is an important factor.

The more remote the livestock operation, the greater the likelihood that odors will not become an annoyance for neighbors; therefore a lower level of technology and management will adequately manage odors at the livestock facility. However, the distance a livestock operation should be from neighboring land to effectively control odors is not easily established.

No scientific basis exists for determining such distances quantitatively, nor is there any commonly held community consensus in Michigan at this time for what these distances should be.

The principles, upon which the most common and effective techniques for odor control are based, include:

- Reducing the formation of odor-causing gases.
- Reducing the release of odorous gases into the atmosphere.

The degree to which these principles can be applied to the various odor sources found in livestock operations depends on the level of technology and management that can be utilized. The following subsections discuss the most common and predominant odor sources, which are feed materials and manure.

Feed materials

Using fermented feeds such as corn or hay silage is an acceptable animal husbandry practice throughout Michigan for dairy and beef cattle, horses, sheep and goats. Some odors associated with the storage and feeding of these materials are normal for these livestock operations.

Controlling the odor of feedstuffs like silage is an important challenge.

- **The odor of these fermented feed materials such as corn or hay silage can be minimized by harvesting and storing them at an appropriate dry matter content (generally greater than 33 percent dry matter).**

The practice of feeding food processing byproducts — such as cull potatoes, dairy whey, pastry byproducts, sugarbeet pulp and sweet corn husks — to livestock is a generally accepted practice. This is especially common where livestock operations exist within close proximity to food processing facilities. Using these materials for livestock feed diverts useful byproducts (that can pose a substantial load on local sewage treatment plants and a major problem for food processing plants) from the waste stream and converts them into a valuable resource.

Properly handled in a livestock operation, these feeds pose no threat to the environment. These products may require special feed handling systems and may substantially increase or change the manure generated by the animals to which they are fed.

Some of these byproducts, and the manure produced from their consumption by livestock, can generate rather offensive and intense odors. In these situations, feed handling and manure management practices should be used to control and minimize the frequency and duration of such odors. Human garbage can only be fed under permit in Michigan (P.A. 173 of 1953 as amended).

Manure

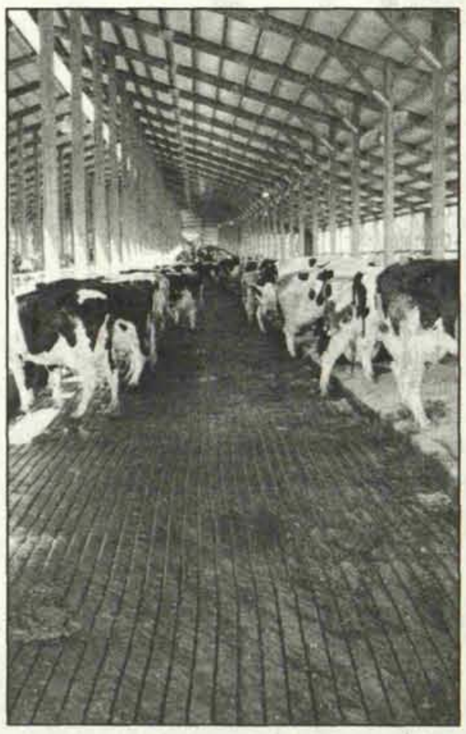
Fresh manure is usually considered to be less odorous than anaerobically decomposing manure. Fresh manure emits ammonia but in general is not accompanied by other products of decomposition that contribute to odors.

- **Frequent (daily or every few days) removal of manure from animal space coupled with storage or stacking and followed by application to crop land at agronomic rates is an acceptable practice throughout Michigan.**

Manure odors are generally those associated with the anaerobic (in the absence of oxygen) decomposition of organic material by microorganisms. The intensity of odors depends upon the biological reactions that take place within the material, the nature of the excreted material (dependent upon the species of animal and its diet), the type of bedding material and the surface area of the odor source.

Sources of decomposing manure can include stacked solid manure, outside lots when manure is allowed to accumulate, uncovered manure storages, manure treatment systems and land application areas.

Stacked solid manure



Use of slatted floors quickly removes manure from the alleyways of dairy farms.

- **Solid manure that may contain bedding materials or manure that is dried sufficiently — such as that from poultry, cattle, sheep, swine, horse and fur-bearing animal facilities — can be temporarily stacked outside the livestock building.**

Odors from such manure storages are minimal except when disturbed, as for land application. Provisions to control leachate and runoff from surrounding areas need to be in place to protect groundwater and surface waters. (See chapter 6 of MWPS-18 for alternative design concepts and details.)

Livestock operations may utilize a variety of bedding materials as part of their manure management system. The use of straw, hay, sand, sawdust, wood shavings, waste paper or other suitable materials, either individually or in combination, as livestock or poultry bedding is a common generally accepted practice.

Bedding materials should be of an appropriate size to maximize absorptive properties and to prevent blowing and dispersion when subsequently applied to crop land. Waxed paper, aluminum foil and plastics should not be in bedding material.

Methods for managing manure odor

Outside open lots with or without shelters are acceptable for raising livestock in Michigan. In these systems, manure is deposited over a relatively large surface area per animal (compared to a roofed confinement system, for example) and begins to decompose in place. The soil compaction that occurs on outside lots limits movement of water and nutrients from the lot toward groundwater.

Odor impacts can be mitigated by keeping the lot surface as dry as possible, thus limiting the microbiological activity that generates odors. Providing adequate lot slopes, lot orientation that takes advantage of sunlight, diverting up-slope runoff water away from the lot and using recommended stocking densities will enhance drying of the lot surface.

The MWPS-18, *Pork Industry Handbook* and *Michigan Beef Production Notebook* provide details and alternatives to accomplish this.

Most feed additives and odor control chemicals applied to feedlot surfaces have not been demonstrated to be effective in reducing odors from feedlots in humid areas such as Michigan.

In spite of good facility design and management, odors may be generated from outside livestock lot systems. The intensity of these odors is somewhat proportional to the surface area of the odor-producing sources. The frequency of impact and offensiveness to neighbors is often related to the distance to neighbors' houses and their location relative to prevailing winds.

- **New outside lot systems should not be located in close proximity to residences and other odor-sensitive land uses. They should not be located uphill along a confining valley leading toward residences. New residences or other sensitive land uses should not be located within close proximity to outside lot facilities.**

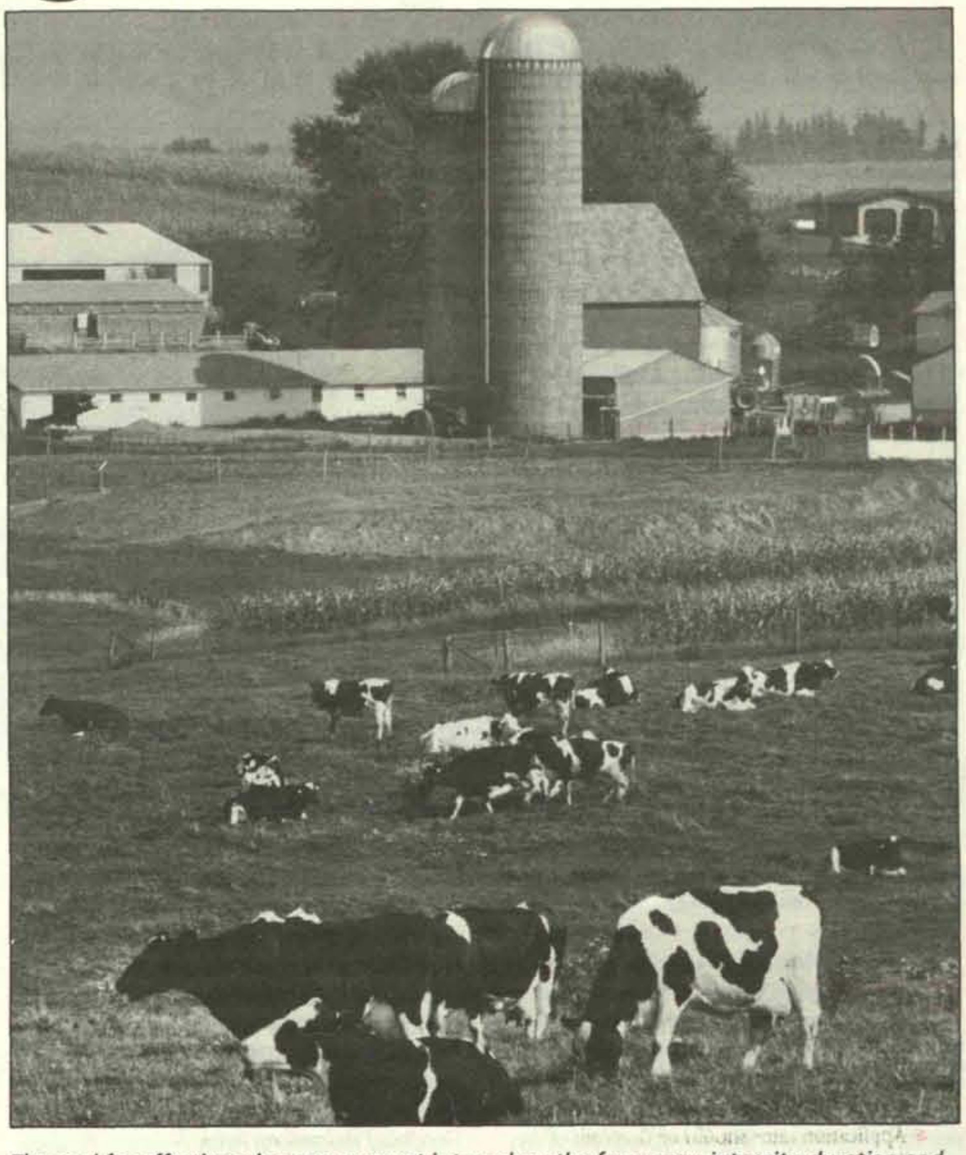
Manure storages and acceptable covers

- **Use covered manure tanks if technically and economically feasible.**
- **Where possible, do not locate manure storage in close proximity to residential areas.**

The primary objective of storage is to temporarily store the manure before application to land. However some biological activity occurs in these storages and the gases generated can be a source of odors. If storage facilities are left uncovered, the potential for manure odors to be carried away by air movement will increase. Various types of covers can be used to prevent wind driven air from coming into direct contact with a liquid manure surface and incorporating odors.

Acceptable covers that can retard odor escape from manure storages include the following:

- ***Natural fibrous mats similar to those that develop on liquid manure storages receiving manure from beef and dairy cattle fed a high roughage diet.***
- ***Slotted flooring or other under-building tanks. Ventilation must be provided in the building to prevent accumulation of noxious and flammable gases.***
- ***A flexible plastic or similar material that covers the liquid surface and is of such strength, anchorage and design that the covering will not tear or pull loose when subjected to normal winds that have an average recurrence interval of 25 years. Gas escape ports should be provided that allow any gas that may evolve to escape.***
- ***A solid covering such as concrete, wood, plastic or similar material that covers the entire liquid surface and is of such strength, anchorage and design that they will withstand winds and expected vertical loads. Adequate air exchange should be provided, which will prevent the occurrence of explosive concentrations of flammable gases.***



The goal for effective odor management is to reduce the frequency, intensity, duration and offensiveness of odors, and to manage the farm in a way that creates a positive attitude.

Taking time to treat waste before applying to land may have odor payoff

A biological treatment system is designed to convert organic matter (feed, bedding, manure) in animal wastes to more stable end products. Anaerobic processes occur without free oxygen and liquefy or degrade high BOD (biochemical oxygen demand) wastes. They can decompose more organic matter per unit volume than aerobic treatment processes.

Aerobic processes require free oxygen and are generally considered uneconomical for livestock operations. They are helpful in reducing odor. Facultative microorganisms can function either anaerobically or aerobically, depending on their environment.

Extreme environmental changes alter microbial activity. When microorganisms are stressed by the environment, waste treatment processes can malfunction and odors may become more intense.

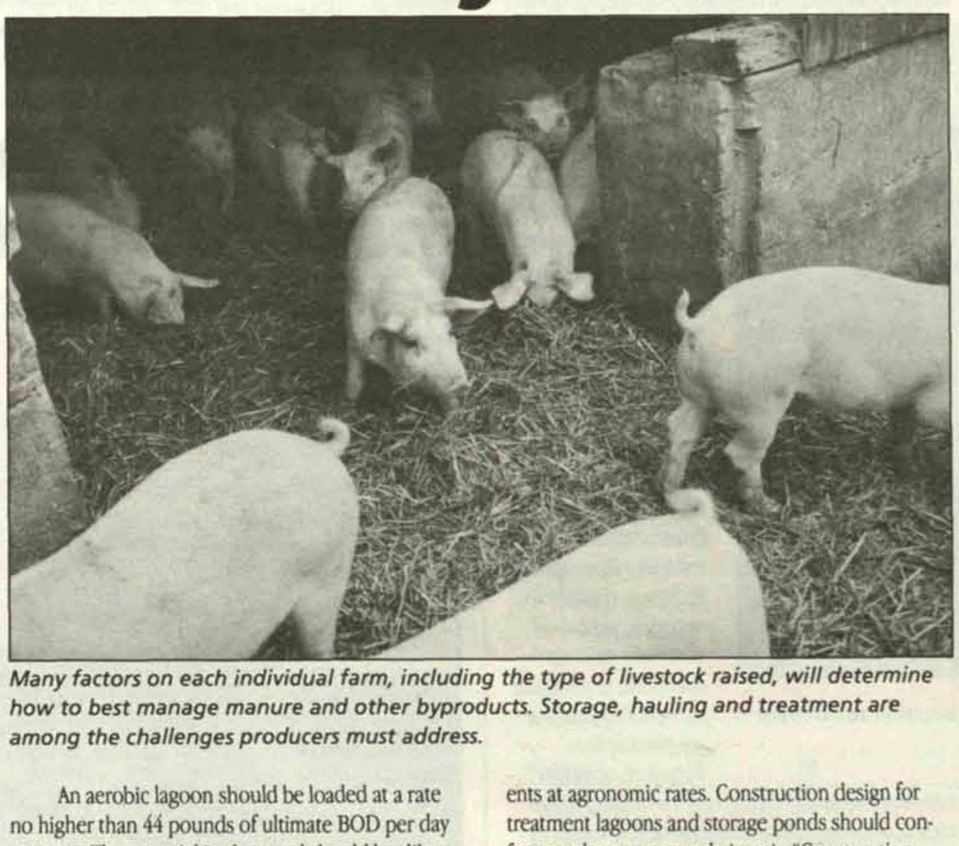
Treatment lagoons and storage ponds

Anaerobic treatment lagoons are generally earthen basins containing diluted manure and are designed to provide degradation of the organic material. Well-designed and managed anaerobic lagoons can be short-term odor sources. The occurrence of purple, sulfur-fixing bacteria can significantly reduce odors from an anaerobic treatment lagoon. The intensity of odors is usually greatest during the early spring and occasionally in the fall.

Aerobic treatment of manure liquids can be accomplished by natural or mechanical aeration. In a naturally aerated system, such as a facultative oxidation pond, an aquatic environment occurs in which photosynthesis from algae and surface aeration from the atmosphere provide an aerobic zone in the upper regions of the pond.

A transition zone occurs below this aerobic zone that has a limited amount of oxygen. This is the facultative zone where bacteria can live either with or without oxygen. At the bottom there may be a sludge layer that is anaerobic. The processes that occur in the aerobic zone have a low odor potential.

The odorous compounds that are created in the facultative and anaerobic zones are converted to low odor forms in the aerobic zone. For a naturally aerated system to function properly, design specifications and quantities of manure solids to be treated must be closely followed.



Many factors on each individual farm, including the type of livestock raised, will determine how to best manage manure and other byproducts. Storage, hauling and treatment are among the challenges producers must address.

An aerobic lagoon should be loaded at a rate no higher than 44 pounds of ultimate BOD per day per acre. The material in the pond should be dilute enough to allow light to penetrate three to four feet into the water. The lagoon should be a minimum of four feet deep to prevent rooted vegetation from growing from the bottom of the lagoon, and may be deeper to allow for accumulation of sludge.

Mechanically aerated systems can be used to treat animal manures to control odors, decompose organic material, remove nitrogen, conserve nitrogen or a combination of these functions. When adequate oxygen is supplied, a community of aerobic bacteria grow that produce materials with low odor potential.

Alternative treatment systems to accomplish mechanical aeration include facultative lagoons, oxidation ditches or completely mixed lagoons.

Effluent from treatment lagoons and storage ponds should be land applied to avoid long-term and extensive ponding and to utilize manure nutrients at agronomic rates. Construction design for treatment lagoons and storage ponds should conform to the recommendations in "Construction design for manure ponds and lagoons" on page 4.

Methane digestors

Methane can be produced from animal wastes by anaerobic digestion. This process converts the biodegradable organic portion of animal wastes into biogas (a combination of methane and carbon dioxide). The remaining semisolid is relatively odor-free but still contains all the nitrogen, phosphorus and potassium originally present in the animal manure, although some of the nitrogen can be lost after storage in a holding pond.

Anaerobic digestion is a stable and reliable process as long as the digestor is loaded daily with a uniform quantity of waste, digestor temperature does not fluctuate widely and antibiotics in the waste do not slow biological activity.

One major problem with digestors is manure handling — pumping, grinding, mixing and screening miscellaneous debris. Gas leakage (methane is explosive at 5 to 15 percent in air) and pipe and valve corrosion have also been problems. To reduce these problems, obtain competent engineering design and purchase quality materials.

Application of manure to land

The following list of practices may be used to reduce odor in the application of manure to land. Appropriate implementation will help reduce complaints of odors.

- **Avoid spreading when the wind is blowing toward populated areas.**
- **Avoid spreading on weekends and holidays when people are likely to be engaged in nearby outdoor and recreational activities.**
- **Spread in the morning when air begins to warm and is rising, rather than in late afternoon.**
- **Use available weather information to best advantage. Turbulent breezes will dissipate and dilute odors. Hot and humid weather tends to concentrate and intensify odors, particularly in the absence of breezes.**
- **Take advantage of natural vegetation barriers, such as woodlots or windbreaks, to help filter and dissipate odors.**
- **Establish vegetated air filters by planting conifers and shrubs as windbreaks and visual screens between cropland and residential developments.**
- **Incorporate manure into soil during or soon after application. This can be done by soil injection or incorporation within 48 hours after application. However, incorporation may not be feasible where manures are applied to pastures or forage crops, such as alfalfa, or where no-till practices are used.**

Irrigation of manure to land can be an effective land application method for delivering manure to land in a short period of time without the potential damage to soil structure that can occur with other methods. However, the process can be odorous for a short period of time.

Consider soil nutrient needs when surface-applying manure to cropland

Among the most popular uses for livestock manure is for adding nutrients to cropland. This practice has been used successfully by many producers for many years. Recycling manure in this manner takes advantage of the nutrients in it.

One of the best uses of animal manure is as a fertilizer for crop production. Recycling plant nutrients from the crop to animals and back to the soil for growth of crops again is an age-old tradition.

Depending on the species of animal, 70 to 80 percent of the nitrogen (N), 60 to 85 percent of the phosphorus (P) and 80 to 90 percent of the potassium (K) fed to animals as feed will be excreted in the manure and are potentially available for recycling to soils.

Livestock operations can generate large amounts of manure and increase the challenge of recycling manure nutrients for crop production. Good management is the key to ensure that the emphasis is on manure utilization rather than on waste disposal.

Utilizing manure nutrients to supply the needs of crops and avoiding excessive loadings achieves two desirable goals. First, efficient use of manure nutrients for crop production will accrue economic benefits by reducing the amount of commercial fertilizers needed. Second, water quality concerns for potential contamination of surface waters and groundwater can best be addressed when nutrients are applied at agronomic rates.

The following management practices are suggested for livestock producers to help them achieve the type of management that will accomplish these two goals. However, adverse weather conditions may, in part, prevent responsible livestock producers from adhering to these practices for a short duration of time.

In addition to effective nutrient management and water quality protection, applying manure to land warrants close attention to management practices so potential odor problems can be minimized or avoided.

Soil fertility testing

- **All fields should be sampled at least every three years and the soils tested to determine where manure nutrients can best be utilized.**

One goal of a well-managed land application program is to utilize soil testing and fertilizer recommendations as a guide for applying manures. This will allow as much of the manure nutrients as possible to be used for supplying crop nutrient requirements, then any additional nutrients needed can be provided by commercial fertilizers. Therefore, soil testing and manure analysis information can assist the producer in using manure nutrients for the greatest economic benefit.

Additional information on soil sampling and soil testing can be found in MSU Extension bulletins (Christenson *et al.,* 1992; Meints and Robertson, 1983; Warncke, 1988; and Warncke *et al.,* 1992.)

Fertilizer recommendations

- **Use fertilizer recommendations, based on MSU-E bulletins E-550A (Christenson *et al.*, 1992) and E-550B (Warncke *et al.*, 1992), to determine the total nutrient needs for crops to be grown on each field that could have manure applied.**

Fertilizer recommendations made by MSU-E are based on the soil fertility test, soil texture, crop to be grown, a realistic yield goal (average for past three to five years) and past crop management. (See Christenson *et al.*, 1992 and Warncke *et al.*, 1992.)

Fertilizer recommendations can then be utilized by the livestock producer to help identify on which fields manure nutrients will have the greatest value in reducing the amounts of commercial fertilizers needed, thereby returning the greatest economic benefit.

Manure analysis

- **To determine the nutrient content of manure, analyze it for percent dry matter (solids), ammonium N (NH_4-N) and total N, P and K.**

Several factors that will determine the nutrient content of manures prior to land application are:

- Type of animal species.
- Composition of the feed ration.
- Amount of feed, bedding and water added to manure.
- Method of manure collection and storage.
- Climate.

Because of the large variation in manure nutrient content due to these factors, it is not advisable to use average nutrient contents provided in publications when determining manure nutrient loadings for crop production. The best way to determine the nutrient content of manure and provide farm-specific information is to obtain a representative sample of that manure and have a laboratory analyze it.

In order to establish "baseline" information about the nutrient content of each manure type on the farm, sample and test manures for at least a two-year period. MSU-E can provide information on collecting representative manure samples and where to send them for analysis.

Selection of sites for manure application depends largely on crops grown and the harvest schedule.

Timing of manure application

Deciding when to apply manure can be a critical decision to nutrient management.

Timing manure applications around weather and other factors is essential. Applying at different times of the year hold different advantages.

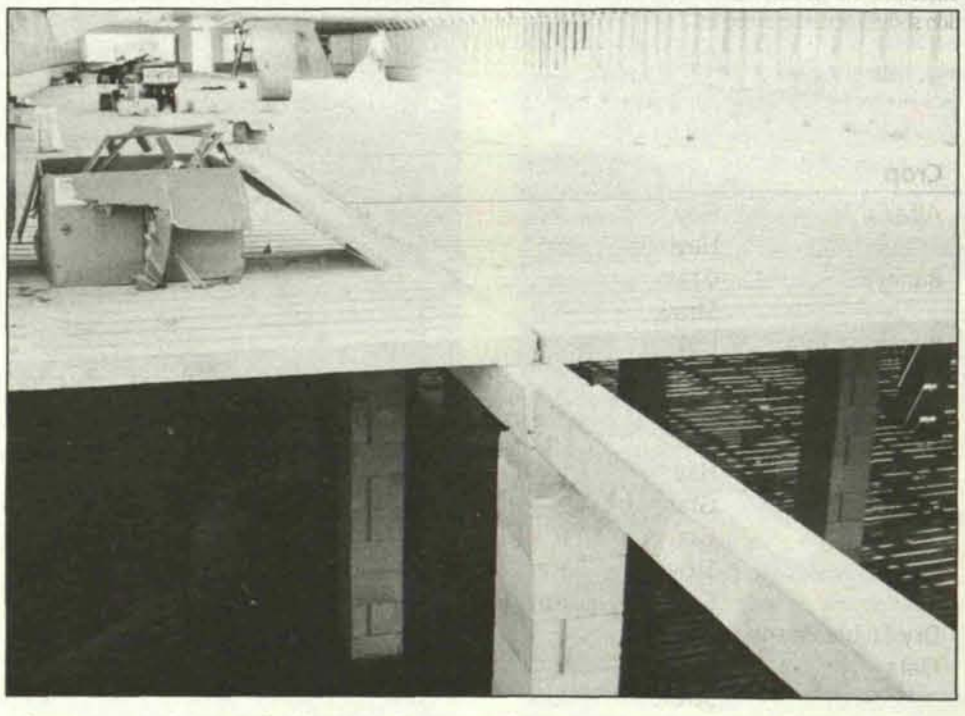
- **Where application of manure is necessary in the fall rather than spring or summer, using as many of the following practices as possible will help to minimize potential loss of NO3-N by leaching: (1) apply to medium or fine rather than to coarse textured soils, (2) delay applications until soil temperatures fall below 50°F, or (3) establish cover crops before or after manure application to help remove NO3-N by plant uptake.**
- **Application of manure to frozen or snow-covered soils should be avoided, but where necessary: (1) solid manures should only be applied to areas where slopes are 6 percent or less and (2) liquid manures should only be applied to soils where slopes are 3 percent or less. In either situation, provisions must be made to control runoff and erosion with soil and water conservation practices such as vegetative buffer strips between surface waters and manure-treated soils.**

Ideally, manure nutrients (like any other sources of nutrients) should be applied as close as possible to, or during, periods of maximum crop nutrient uptake to minimize nutrient loss from the soil-plant system. Therefore, spring or early summer application is best for conserving nutrients, whereas fall application generally results in greater nutrient loss, particularly for NO_3-N on coarse textured soils (that is, sands, loamy sands, sandy loams).

Winter application of manure is the least desirable in terms of nutrient utilization and prevention of nonpoint pollution. Frozen soils and snow cover will limit nutrient movement into the soil and greatly increase the risk of manure being lost to surface waters by runoff and erosion during thaws or early spring rains.

When winter application is necessary, appropriately sized buffer strips should be established and maintained between surface waters and frozen soils where manure is applied to minimize any runoff and erosion of manure from reaching surface waters. Particular attention to soil slopes and manure application rates can help prevent runoff and erosion from frozen and/or snow-covered soils where manure is applied.

Construction design for manure ponds and lagoons



When constructing new facilities, producers need to evaluate what manure management system will work best with their operation.

To protect groundwater and prevent manure storage areas from leaking, producers may take several precautions.

- **Construction design for manure storage and treatment facilities should meet specifications and guidelines found in the NRCS-FOTG. Additional publications that can be used are the *National Pork Industry Handbook* fact sheets E-1341 (Sweeten *et al.*, 1981) and E-1399 (Melvin *et al.*, 1987) from MSU-E and the *Concrete Manure Storages Handbook* (MWPS-36).**

Seepage control for earthen basins

- **To protect groundwater from possible contamination, use liners that meet specifications and guidelines in the NRCS-FOTG. Liners include natural existing soil (Barrington and Jutras, 1985; Barrington *et al.*, 1987a, 1987b), bentonite or similar high-swell clay materials, compacted earthen liners and flexible membranes.**

Keep track of nutrient loadings when applying manure to land

These generally accepted practices concern manure nutrient loading.

■ The agronomic (fertilizer) rate of N recommended for crops (consistent with those in MSU-E bulletins E-550A and E-550B) should not be exceeded by the amount of available N added, either by manure applied or by manure plus fertilizer N applied and other sources.

The available N per ton or per 1,000 gallons of manure should be determined by using a manure analysis and the appropriate mineralization factors (see ***Manure Management Sheet #2***, MSU-E bulletin E-2344 by Jacobs *et al.*, 1992b) for organic N released during the first growing season following application and the three succeeding growing seasons.

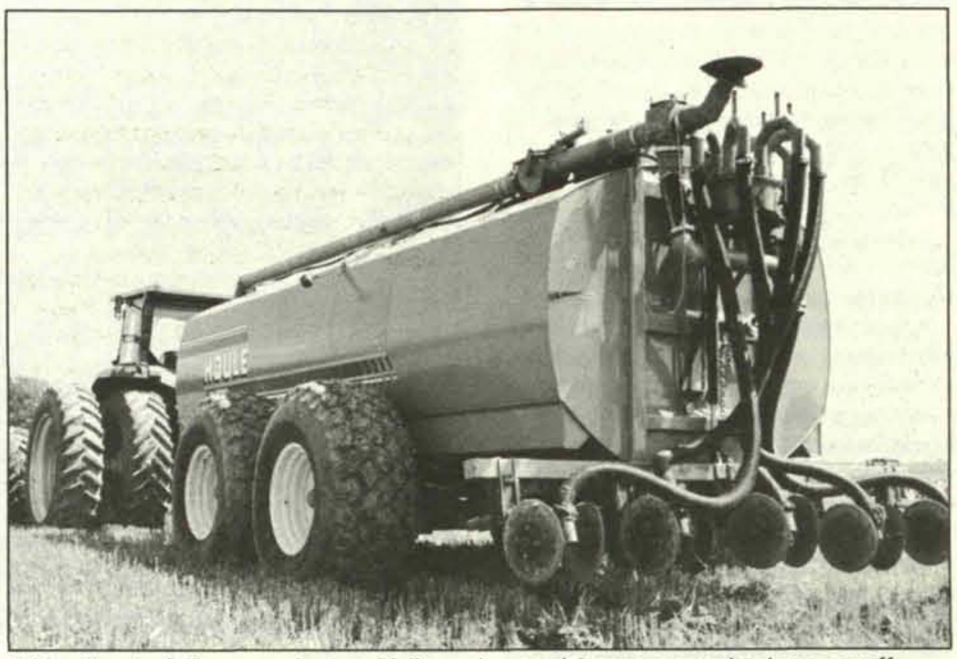
■ If the soil test level for P reaches 150 lb/acre (Bray P1), manure applications should be reduced to a rate where manure P added does not exceed the P removed by the harvested crop. (If this manure rate is impractical due to manure spreading equipment or crop production management, a quantity of manure P equal to the amount of P removed by two crop years can be used for the first crop year, if no additional fertilizer or manure P is applied for the second crop year.)

If the Bray P1 test reaches 300 lb/acre or higher, manure applications should be discontinued until nutrient harvest by crops reduces P test levels to less than 300 lb/acre. To protect surface water quality against discharges of P, adequate soil and water conservation practices should be used to control runoff and erosion from fields where manure is applied.

Excessive manure applications to soils can:

- Result in excess nitrate-N (NO_3-N) not being used by plants or the soil biology and increase the risk of NO_3-N being leached down through the soil and into groundwater.
- Cause P to accumulate in the upper soil profile and increase the risk of contaminating surface waters with P where runoff or erosion occurs.
- Create nutrient imbalances in soils, which may cause poor plant growth or animal nutrition disorders for grazing livestock.

The greatest water quality concern from excessive manure loadings, where soil erosion and runoff is controlled, is NO_3-N losses to groundwater. Therefore, the agronomic fertilizer N recommendation should never be exceeded.


Taking time to follow some basic guidelines when applying manure to land can pay off.

The availability of N in manure for plant uptake will not be the same as highly soluble, fertilizer N. Therefore, total manure N cannot be substituted for that in fertilizers on a pound-for-pound basis, because a portion of the N is present in manure organic matter, which must be decomposed before mineral (inorganic) forms of N are available for plant uptake.

The rate of decomposition (or mineralization) of manure organic matter will be less than 100 percent during the first year and will vary depending on the type of manure and the method of manure handling. In order to estimate the amount of available N that will be provided by each ton or 1,000 gallons of manure, the total N and NH_4-N content from the manure analysis can be used with the appropriate mineralization factors (see *Manure Management Sheet #2*, MSU-E bulletin E-2344 by Jacobs *et al.*, 1992b) to calculate this value.

Also, additional portions of the residual organic matter not decomposed the first year will be decomposed the second, third and fourth years and should be estimated and included as a N credit against the fertilizer recommendation to avoid excessive N additions to the soil-plant system.

At the present time, organic N released (mineralized) during the second, third and fourth cropping years is estimated to be 50 percent, 25 percent and 12.5 percent, respectively, of the amount released the first year. Further discussion of decomposition and appropriate mineralization factors to use in estimating available N from manure can be found in MSU-E bulletin E-2340 (Jacobs *et al.*, 1992a).

While the availability of N in manure may be considerably less than 100 percent, the availability of P and K in manure has normally been considered to be close to 100 percent. Periodic soil testing can be used to monitor the contribution to soil fertility levels made by manure P and K, but soil tests have not been very effective to determine the amount of N a soil can provide for plant growth.

When manures are applied to supply all the N needs of crops, the P needs of crops will usually be exceeded and soil test levels for P will increase over time. If soil test P levels reach 300 lb/acre (Bray P1), the risk of losing soluble P and sediment-bound P by runoff and erosion (that is, nonpoint source pollution) increases. Therefore, adequate soil and water conservation practices to control runoff and erosion should be implemented.

For example, conservation tillage can enhance infiltration of water into soils, thereby reducing runoff, soil erosion and associated P loadings to surface waters. Nevertheless, if soil test P levels reach 300 lb/acre (Bray P1), no more manure (or fertilizer) P should be applied until nutrient harvest by crops reduces P test levels to less than 300 lb/acre.

To avoid reaching the 300 lb/acre Bray P1 test level, manure application rates should be reduced to provide the P needs of crops rather than providing all of the N needs of crops and adding excess P. Therefore, if the soil test level for P reaches 150 lb/acre (BrayP1), manure applications should be reduced to a rate where manure P added does not exceed the P removed by the harvested crop.

The quantity of manure P_2O_5[1] that should be added can be estimated from Tables 1 and 2, using a realistic yield goal for the crop to be grown. For example, if a yield of 120 bu/acre for corn grain is anticipated, the amount of manure P_2O_5 added to this field should be limited to no more than 42 lb/acre (120 bu/acre × 0.35 lb P_2O_5/bu nutrient removal rate).

If the rate of manure application based on P removal by the crop is lower than the manure spreader can physically apply or is not realistic when planning for crop production management, the rate of manure application can be increased.

The higher rate of manure application can be the P removal for two crop years, as long as this rate does not exceed the N fertilizer recommendation for the first crop grown after the manure is applied. If this higher rate of manure application is used, no fertilizer or manure P should be applied the following crop year.

Manure nutrient loadings on pasture land

In pasture systems where the grazed forage is the sole feed source for livestock, nutrients from manure deposited by the grazing livestock will not exceed the nutrient requirement of the pasture forage. These types of pasture systems may require supplemental nutrient applications to maintain forage quality and growth.

Pasture systems utilizing supplemental feed (for example, swine farrow-to-finish) often result in manure nutrient deposition in excess of pasture forage requirements. Therefore, nutrient management with rotation to harvested forage or row crops is necessary.

Available nutrient deposition should be quantified based on livestock density and nutrient mineralization factors. Manure nutrient loadings should be based on the rotational crop nutrient requirement consistent with those recommended in MSU-E bulletins E-550A and E-550B, as noted above. ■

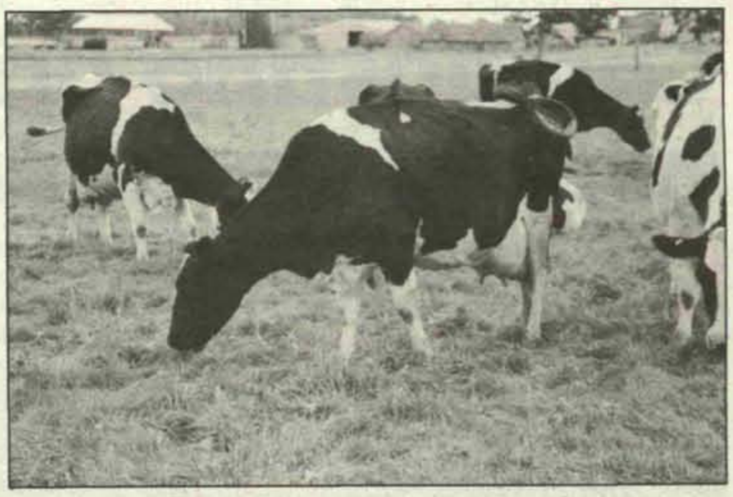

Top nutrients assure good pastureland.

Table 1 — Nutrient removal by several Michigan field crops

lb/unit of yield

Crop		Unit	N	P_2O_5	K_2O
Alfalfa	Hay	ton	45[1]	10	45
	Haylage	ton	14	3.2	12
Barley	Grain	bu	0.88	0.38	0.25
	Straw	ton	13	3.2	52
Birdsfoot Trefoil	Hay	ton	48	12	42
Bromegrass	Hay	ton	33	13	51
Canola	Grain	bu	1.9	0.91	0.46
	Straw	ton	15	5.3	25
Clover-grass	Hay	ton	41	13	39
Corn	Grain	bu	0.90	0.35	0.27
	Grain[2]	ton	26	12	6.5
	Stover	ton	22	8.2	32
	Silage	ton	9.4	3.6	7.8
Dry Edible Beans	Grain	cwt	3.6	1.2	1.6
Oats	Grain	bu	0.62	0.25	0.19
	Straw	ton	13	2.8	57
Orchardgrass	Hay	ton	50	17	62
Potatoes	Tubers	cwt	0.33	0.13	0.63
Red Clover	Hay	ton	40	10	40
Rye	Grain	bu	1.1	0.41	0.31
	Straw	ton	8.6	3.7	21
Sorghum-	Hay	ton	40	15	58
Sudangrass	Haylage	ton	12	4.6	18
Soybeans	Grain	bu	3.8	0.88	1.4
Sugar Beets	Roots	ton	4.0	1.3	3.3
Wheat	Grain	bu	1.2	0.62	0.38
	Straw	ton	13	3.3	23

Source: Fertilizer Recommendations for Field Crops in Michigan (Christenson, *et al.*, 1992).
1 Legumes get most of their nitrogen from air.
2 High moisture grain.

Table 2 — Approximate nutrient removal in the harvested portion of several Michigan vegetable crops

lb/unit of yield

Crop	N	P_2O_5	K_2O
Asparagus	13	4.0	10
Beans, snap	24	2.4	11
Broccoli	4.0	1.0	11
Cabbage	7.0	1.6	7.0
Carrots	3.4	1.8	6.8
Cauliflower	6.6	2.6	6.6
Celery	5.0	2.0	16
Cucumbers	2.0	1.2	3.6
Lettuce	4.8	2.0	9.0
Muskmelon	8.4	2.0	11
Onions	5.0	2.6	4.8
Peas, shelled	20	4.6	10
Peppers	4.0	1.4	5.6
Pumpkins	4.0	1.2	6.8
Sweet Corn	8.4	2.8	5.6
Squash	3.6	1.6	6.6
Tomatoes	4.0	0.8	7.0

Source: Fertilizer Recommendations for Vegetable Crops in Michigan (Warncke *et al.*, 1992).

Methods for applying manure to land

These methods for applying manure are sound agronomic practices and can help protect the surrounding areas.

- Manures should be uniformly applied to soils. The amount of manure applied per acre (gallons or tons) should be known, so manure nutrients can be effectively managed.
- Manures should not be applied to soils within 150 feet of surface waters or to areas subject to flooding unless: (1) manures are injected or surface-applied with immediate incorporation (that is, within 48 hours after application) or (2) conservation practices are used to protect against runoff and erosion losses to surface waters.
- Liquid manures should be applied in a manner that will not result in ponding or runoff to adjacent property, drainage ditches or surface water.
- As land slopes increase from zero percent, the risk of runoff and erosion also increases, particularly for liquid manure. Adequate soil and water conservation practices should be used that will control runoff and erosion for a particular site, taking into consideration such factors as type of manure, bedding material used, surface residue or vegetative conditions, soil type and slope.

As is true with fertilizers, lime and pesticides, animal manures should be spread uniformly for best results in crop production. Also, in order to know the quantity of manure nutrients applied, the amount of manure applied must be known.

Determining the gallons per acre or tons per acre applied by manure spreading equipment can be accomplished by a variety of ways. One method is to measure the area of land covered by one manure spreader load or one tank wagon of manure.

A second method is to record the total number of spreader loads or tank wagons applied to a field of known acreage. With either approach, the capacity of the spreader (in tons) or the tank wagon (in gallons) must be known, and some way to vary the rate of application will be needed such as adjusting the speed of travel or changing the discharge settings on the manure spreading equipment.

Guidance is available from MSU-E to help determine the rates of manure application that a livestock producer's equipment can deliver.

Incorporating manure immediately (that is, within 48 hours following surface application) will minimize odors and ammonia (NH_3) loss. When manures are surface-applied, available N can be lost by volatilization of NH_3. These losses will increase with time and temperature and will be further increased by higher wind speeds and lower humidities.

Therefore, injecting manures directly into the soil or immediately incorporating surface-applied manure will minimize NH_3 volatilization losses and provide the greatest N value for crop production. Table 3 shows potential volatilization losses when manures are applied to the soil and allowed to dry on the surface before incorporation.

When dilute effluents from lagoons that contain low solids (less than 2 percent) are applied or irrigated at rates that do not cause ponding, most of the NH_4-N will likely be absorbed into the soil and retained (see Jacobs *et al.,* 1992 for additional information). Surface application of manures via irrigation or other methods without incorporation provide alternatives to producers using reduced- or no-till soil management, supplemental irrigation of crops, application to land with established pasture or other forages, etc.

Working manure into the soil shortly after application is an excellent way to hold nutrients in the ground.

Table 3 — Ammonium nitrogen volatilization losses for surface application of solid and semisolid manures

Days before incorporation	Retention Factor (RF)	Loss Factor (LF)
0-1 day	0.70	0.30
2-3 days	0.40	0.60
4-7 days	0.20	0.80
> 7 days	0.10	0.90

Source: Recordkeeping System for Crop Production. (Jacobs *et al.*, 1992a)

To reduce the risk of runoff or erosion losses of manure nutrients, manures should not be applied and left on the soil surface within 150 feet of surface waters. Manures that are injected or surface applied with immediate incorporation can be closer than 150 feet as long as conservation practices are used to protect against runoff and erosion.

A vegetative buffer between the application area and any surface water is a desirable conservation practice. Manure should not be applied to grass waterways or other areas where there may be a concentration of water flow, unless used to fertilize or mulch new seedlings following waterway construction.

Manure should not be applied to areas subject to flooding unless injected or immediately incorporated. Liquid manures should not be applied in a manner that will result in ponding or runoff to adjacent property, drainage ditches or surface water. Therefore, application to saturated soils, such as during or after a rainfall, should be avoided.

As land slopes increase, the risk of runoff and erosion losses to drainage ways, and eventually to surface waters, also increases. Soil and water conservation practices should be used to control and minimize the risk of non-point source pollution to surface waters, particularly where manures are applied.

Injection or surface application of manure with immediate incorporation should generally be used when the land slope is greater than 6 percent. However, a number of factors such as liquid versus solid or semisolid manures, rate of application, amount of surface residues, soil texture, drainage, etc. can influence the degree of runoff and erosion associated with surface water pollution. Therefore, adequate soil and water conservation practices to control runoff and erosion at any particular site are more critical than the degree of slope itself.

Composting bridges new technology with sound management techniques

Composting is a self-heating process carried on by bacteria, actinomycetes and fungi that decompose organic material in the presence of oxygen.

Composting of organic material including livestock manures can result in a rather stable end product that does not support extensive microbial or insect activity, if the process and systems are properly designed and managed.

The potential for odors during the composting process depends upon the moisture content of the organic material, the carbon-nitrogen ratio, the presence of adequate nutrients, the absence of toxic levels of materials that can limit microbial growth and adequate porosity to allow diffusion of oxygen into the organic material for aerobic decomposition of the organic material.

Stability of the end product and its potential to produce nuisance odors or be a breeding area for flies, depends upon the degree of organic material decomposition and the final moisture content.

Additional information and guidance about alternatives for composting manures are available in the *On-Farm Composting Handbook* (Rynk, 1992).

The occurrence of leachate from the composting material can be minimized by controlling the initial moisture content of the composting mixture to less than 70 percent and controlling water additions to the composting material from rainfall.

Either a fleece blanket or a roofed structure can be used as a cover to control rainfall additions or leachate from composting windrows.

If the composting process is conducted without a cover, provisions must be made to collect the surface runoff, which can either be temporarily stored and applied to land, added to composting material for moisture control during the composting process or applied to grassed infiltration areas.

A fleece blanket is a nonwoven textile material made from synthetic fibers such as polypropylene. The nonwoven texture of a fleece blanket prevents rainfall from penetrating into the composting material, but allows the necessary exchange of carbon dioxide and oxygen.

Ted Louden, MSU agricultural engineer, demonstrates equipment that facilitates manure composting.

Ken Gasper, an Ionia County dairy farmer, composts manure from his herd.

Managing manure applications to land

An important ingredient of a successful program for managing the animal manure generated by a livestock operation is "planning ahead." An early step of a manure application plan is to determine whether enough acres of cropland are available for utilizing manure nutrients without resulting in excess nutrient application to soils.

- **Records should be kept of manure analyses, soil test reports and rates of manure application for individual fields.**

Good recordkeeping demonstrates good management and will be beneficial for the producer. Records should include manure analysis reports and the following information for individual fields:

- *Soil fertility test reports.*
- *Dates of manure applications.*
- *Rate of manure applied (gallons or wet tons per acre).*
- *Previous crops grown on the field.*
- *Yields of past harvested crops.*

Tables 4 and 5 from MWPS-18 can help in making preliminary estimates of manure quantities and manure nutrients produced by different types of livestock and N losses during handling and storage of manures before they are applied. This information (or preferably manure analyses and actual quantities of manure for a particular farm) can be used to compare the quantity of available manure nutrients against the quantity of nutrients removed by the crops to be grown in the livestock operation. *Manure Management Sheet #1,* MSU-E bulletin E-2344 (Jacobs *et al.,* 1992b) can assist with this type of inventory.

If the quantity of manure nutrients being generated greatly exceeds the annual crop nutrient needs, then alternative methods for manure utilization should be identified. For example, cooperative agreements with neighboring landowners to provide additional land areas to properly utilize all of the manure nutrients may be necessary.

Another consideration is to use good judgment when planning manure applications in conjunction with normal weather patterns, the availability of land at different times during the growing season for different crops, and the availability of manpower and equipment relative to other activities on the farm which compete for these resources.

Having adequate storage capacity to temporarily hold manures can add flexibility to a management plan when unanticipated weather occurs, preventing timely applications. Nevertheless, unusual weather conditions do occur and can create problems for the best of management plans.

Table 5 — Nitrogen losses during handling and storage

Manure Type	Handling System	Percent Nitrogen Lost
Solid	Daily scrape and haul	15-35
	Manure pack	20-40
	Open lot	40-60
	Deep pit (poultry)	15-35
Liquid	Anaerobic pit	15-30
	Above-ground	10-30
	Earth storage	20-40
	Lagoon	70-80

Source: *Livestock Waste Facilities Handbook.* (Midwest Plan Service, 1985)

Finally, good recordkeeping is the "backbone" of a good management plan. Past manure analysis results will be good predictors of the nutrient content in manures being applied today. Records of past manure application rates for individual fields will be helpful for estimating the amount of residual N that will be available for crops to use this coming growing season.

Changes in the P test levels of soils with time due to manure P additions can be determined from good records, and that information can be helpful in anticipating where manure rates may need to be reduced and when additional land areas may be needed.

Recordkeeping systems, such as that described in MSU-E bulletin E-2340 (Jacobs *et al.,* 1992a), or available as a microcomputer program called *MSU Nutrient Management* (MacKellar *et al.,* 1994), may be helpful in accomplishing this goal.

Table 4 — Nutrient removal by several Michigan field crops

Animal Species	Type and Average Size		Production Per Day	Manure Nutrients (lb)		
		lb	ft³	N	P_2O_5	K_2O
Dairy Cattle		150	0.19	0.06	0.023	0.048
		250	0.32	0.10	0.045	0.084
		500	0.66	0.20	0.082	0.169
		1,000	1.32	0.41	0.166	0.325
		1,400	1.85	0.57	0.232	0.458
Beef Cattle		500	0.50	0.17	0.127	0.145
		750	0.75	0.26	0.191	0.229
		1,000	1.00	0.34	0.250	0.289
		1,250	1.20	0.43	0.318	0.373
	Beef Cow		1.05	0.36	0.273	0.313
Swine	Nursery Pig	35	0.038	0.016	0.0118	0.012
	Growing Pig	65	0.070	0.029	0.0223	0.024
	Finishing Pig	150	0.16	0.068	0.050	0.054
	Finishing Pig	200	0.22	0.090	0.068	0.071
	Gestating Sow	275	0.15	0.062	0.048	0.048
	Sow and Litter	375	0.54	0.230	0.173	0.181
	Boar	350	0.19	0.078	0.059	0.061
Sheep		100	0.062	0.05	0.015	0.039
Horse		1,000	0.75	0.27	0.105	0.205
Poultry	Chicken Broilers	2	0.24	0.123	0.09	
(per100 birds)	Chicken Layers	4	0.35	0.29	0.250	0.14
	Turkey[1]	16	1.40	1.16	1.00	0.56

Source: *Livestock Waste Facilities Handbook* (Midwest Plan Service, 1985).
1 Values for turkeys estimated by multiplying the "Chicken Layers" values times four.

References

These sources were used as references to develop Michigan's Generally Accepted Manure Management Practices. For more information about specific techniques, you may consult them.

Barrington, S.F. and R.S. Broughton. Designing earthen storage facilities for manure. Agricultural Engineering Department. McGill University, Montreal, Quebec, Canada H9X 1C0.

Barrington, S.F. and P.J. Jutras. 1985. Selecting sites for earthen manure reservoirs. p. 386-392. In Agricultural Waste Utilization and Management, Proceedings of the Fifth International Symposium on Agricultural Wastes. Dec. 16-17, 1985. Hyatt Regency, Chicago, IL.

Barrington, S.F., P.J. Jutras and R.S. Broughton. 1987a. The sealing of soils by manure. I. Preliminary investigations. Journal of Canadian Agricultural Engineering 29:99-103.

Barrington, S.F., P.J. Jutras and R.S. Broughton. 1987b. The sealing of soils by manure. II. Sealing mechanisms. Journal of Canadian Agricultural Engineering 29:105-108.

Best Management Practice Manual. Agricultural Best Management Practices Manual for Michigan's Nonpoint Source Pollution Program. 1994. MDNR Document.

Christenson, D.C., D.D. Warncke, M.L. Vitosh, L.W. Jacobs and J.G. Dahl 1992. Fertilizer recommendations for field crops in Michigan. Ext. Bull. E-550A, Mich. State Univ., East Lansing, MI.

Ellis, B.G. and R.A. Olson. 1986. Economic, agronomic and environmental implications of fertilizer recommendations. North Central Regional Research Publication No. 310, Agr. Exp. Sta., Mich. State Univ., East Lansing, MI.

Graves, R.E. (ed.). 1986. Field application of manure. Document FA, Manure management for environmental protection. Pennsylvania Department of Environmental Resources, Commonwealth of Pennsylvania, Harrisburg, PA.

Jacobs, L.W. 1989. Analysis and utilization of manure for crop production. Mimeo. Dept. of Crop and Soil Sciences, Mich. State Univ., East Lansing, MI.

Jacobs, L.W., S.U. Böhm and B.A. MacKellar. 1992a. Recordkeeping system for crop production. Ext. Bull. E-2340, Mich. State Univ., East Lansing, MI.

Jacobs, L.W., S.U. Böhm and B.A. MacKellar. 1992b. Recordkeeping system for crop production-Manure Management Sheets. Ext. Bull. E-2344, Mich. State Univ., East Lansing, MI.

MacKellar, B.M., L.W. Jacobs and S.U. Böhm. 1996. Michigan State University Nutrient Management (MSUNM), An Agricultural Integrated Management Software (AIMS) Microcomputer Program. CP-036, Version 1.3. MSU Bulletin Office, 10B Agriculture Hall, Michigan State University, East Lansing, MI 48824-1039.

Madison, F., K. Kelling, J. Peterson, T. Daniel, G. Jackson and L. Massie. 1986. Guidelines for applying manure to pasture and cropland in Wisconsin. Ext. Bull. A3392, University of Wisconsin-Extension, Madison, WI.

Meints, V.W. and L.S. Robertson. 1983. Soil sampling for no-till and conservation tillage crops. Ext. Bull. E-1616, Mich. State Univ., East Lansing, MI.

Melvin, S.W., F.J. Humenik and R.K. White. 1987. Swine waste management alternatives. National Pork Industry Handbook, Ext. Bull. E-1399, Mich. State Univ., East Lansing, MI.

Michigan Beef Production Notebook. Department of Animal Science, 113 Anthony Hall, Mich. State Univ., East Lansing, MI.

Midwest Plan Service. 1994. Concrete Manure Storages Handbook, (MWPS-36).

Midwest Plan Service. 1985. Livestock waste facilities handbook, 2nd Ed. MWPS-18, Midwest Plan Service, Iowa State Univ., Ames, IA.

Moline, W.J., J.M. Middleton and R. Plummer. 1991. Grasses and legumes for intensive grazing in Michigan. Ext. Bull. E-2307, Mich. State Univ., East Lansing, MI.

Moline, W.J. and R. Plummer. 1991a. Hay and pasture for horses in the North Central United States. Ext. Bull. E-2305, Mich. State Univ., East Lansing, MI.

Moline, W.J. and R. Plummer. 1991b. Pasture calendars for the North Central United States. Ext. Bull. E-2304, Mich. State Univ., East Lansing, MI.

Rynk, R. 1992. On-farm composting handbook. NRAES-54, Northeast Regional Agricultural Engineering Service, Ithaca, NY.

Sweeten, J.M., C.L. Barth, R.E. Hermanson and T. Loudon. 1981. Lagoon systems for swine waste treatment. National Pork Industry Handbook, Ext. Bull. E-1341, Mich. State Univ., East Lansing, MI.

Vanderholm, D.H. and J.C. Nye. 1987. Systems of runoff control. National Pork Industry Handbook, Ext. Bull. E-1132, Mich. State Univ., East Lansing, MI.

USDA, 1979. Animal waste utilization on cropland and pastureland. A manual for evaluating agronomic and environmental effects. USDA Utilization Research Rep. No. 6, October, 1979 (also EPA-600/2-79-059), U.S. Dept. of Agriculture, Natural Resources Conservation Service, Washington, D.C.

USDA, 1983. Water quality field guide. NRCS-TP-160, September, 1983. U.S. Dept. of Agriculture, Natural Resources Conservation Service, Washington, D.C.

USDA, 1992. Agricultural waste management field handbook. U.S. Dept. of Agriculture, Natural Resources Conservation Service, Washington, D.C.

USDA-NRCS. Field Office Technical Guide. U.S. Dept. of Agriculture, Natural Resources Conservation Service, East Lansing, MI.

Warncke, D.D., D.R. Christenson, L.W. Jacobs, M.L. Vitosh and B.H. Zandstra. 1992. Fertilizer recommendations for vegetable crops in Michigan. Ext. Bull. E-550B, Mich. State Univ., East Lansing, MI.

Warncke, D.D. 1988. Sampling soils for fertilizer and lime recommendations. Ext. Bull. E-498, Mich. State Univ., East Lansing, MI.

Manure management survey results

Study reveals manure management practices utilized by Michigan producers and knowledge of the Right-to-Farm guidelines.

Early in 1996, results were released of a survey conducted by Michigan State University on almost 600 farmers about the manure management practices they utilize and their knowledge of the Michigan Right-to-Farm (MRTF) Act.

The survey was conducted by Michigan Farm Bureau Commodity Specialist Kevin Kirk as part of a graduate project.

Almost 600 farmers completed the survey representing 60 of Michigan's counties and all major livestock groups, including swine, beef, dairy, sheep, horses, chickens and turkeys.

Approximately 80 percent of the respondents knew they were required to operate under generally accepted agricultural and management practices in order to gain protection from nuisance lawsuits under Michigan's Right-to-Farm Act.

Right-to-Farm knowledge gathered from the survey

About two-thirds of the farmers in the survey were familiar with the generally accepted agricultural and management practices for manure adopted under the Michigan Right-to-Farm Act.

"The results indicate to MSU where additional education is needed for producers," Kirk explains.

"Based on the results of the survey and the need to educate producers, Michigan Farm Bureau and the Michigan Department of Agriculture wanted to provide all producers with the full series of Right-to-Farm guidelines, starting with this insert on manure management," he adds.

According to Kirk, awareness of the MRTF Act was observed to be greatest among poultry farms — 95.1 percent — and large dairy farms, while large horse farm owners were the least aware.

Manure management complaints

Over the past five years, almost 17 percent of farmers had received a complaint about their manure management practices. Of those complaints, 48 percent were odor complaints and 21 percent were complaints about the location of the manure application. Others were about manure spillage, runoff and time of application.

Practices to control odors

According to Kirk, the most common practice used to control odor was to avoid spreading near neighbors' homes, and on weekends and holidays.

"The farmers who avoided spreading manure on weekends and holidays the most were large dairy farms and large swine farms," Kirk says. "Incorporating liquid manure into the soil followed as the next most widely used practice to avoid odor," he adds.

Liquid manure storage

Almost 40 percent of the farmers had liquid manure storage capabilities, according to the survey. Underground storage tanks were the most common method of manure storage, at 46.2 percent, followed closely by lagoons with 38.1 percent. Of those who did not have liquid manure storage facilities, almost one-quarter relied on hauling manure daily.

Soil testing practices

"The goal of a well-managed land application program is to utilize soil testing and fertilizer recommendations as a guide to applying manure," Kirk says. "This will allow as much of the manure nutrients as possible to be used for supplying crop nutrient requirements, while avoiding nutrient overload to the soil from excess commercial fertilizers."

According to the study, 69 percent test their soil at least once every three years, while 18.5 percent have never tested. The largest segment of the study that did not do any soil testing was large horse farms, with 60 percent never having their fields soil tested.

Nutrient values and need for testing

"Recycling plant nutrients from the crop to animals and back to the soil for growth of crops again is an age-old tradition," Kirk explains. "Depending on the species of animal, 70 to 80 percent of the nitrogen, 60 to 85 percent of the phosphorous and 80 to 90 percent of the potassium fed to animals as feed will be excreted in the manure and therefore be available for recycling to soils."

Only 21 percent of those surveyed reported that they test the nutrient content of manure, according to Kirk. Turkey operations, large feedlots and large dairy farms were the most common farms utilizing nutrient testing.

Survey Participants

Species	Animal Units	Surveys Sent	Responses
Dairy, Milkcows	25 - 149	276	91
Dairy, Milkcows	150+	279	117
Swine, Hogs	100 - 499	256	86
Swine, Hogs	500+	257	85
Beef, Beefcows	10 - 49	53	24
Beef, Beefcows	50+	58	28
Beef, Feedlots	50 - 399	52	22
Beef, Feedlots	400+	55	22
Sheep	10 - 199	55	23
Sheep	200+	56	30
Horses	5 - 14	49	11
Horses	15+	59	15
Poultry	3,000+	38	24
Turkeys	100,000+	10	5

Farmers' knowledge about recommended manure management practices

Recommended practices	Percentage of farmers indicating True	False
Incorporation within 48 hours	62.6%	37.4%
Applied on frozen ground	49.5	50.5
Applied next to streams	41.2	58.8
Livestock can access streams	63.9	36.1

***Above:** About 50 percent of those surveyed believed manure could be applied to frozen ground while the other 50 percent thought manure could not be applied to frozen ground. According to the Generally Accepted Agricultural and Management Practices for Manure Management and Utilization, application of manure to frozen or snow-covered ground should be applied to areas where slopes are 6 percent or less and liquid manure should only be applied to soils where slopes are 3 percent or less. In either situation, provisions must be made to control runoff and erosion with soil and water conservation practices such as vegetative buffer strips between surface waters and manure treated soils.*

***Below:** The Michigan Department of Agriculture Right to Farm Environmental Complaint Response Program addressed a total of 135 new farm-related environmental and nuisance complaints during 1994. This number is consistent with the 1990-94 five-year average of 137 complaints per year. As was typical for previous years, a large majority of the 1994 complaints concerned manure management practices at livestock and poultry facilities throughout Michigan. The Generally Accepted Manure Management Practices were used extensively during the investigation process for most of these complaints. These practices promote responsible management, which protects the environment and provides reasonable flexibility for farmers to manage their facilities and farm operations. The practices were first developed in 1987 and have been updated annually since that time. (MDA, 1994 Report)*

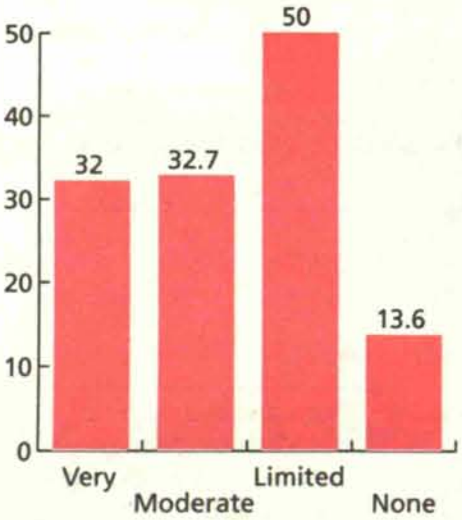
Knowledge of the Michigan Right-to-Farm Act by types of farms

Number of responses/percentage of total responses

Knowledge	Dairy small	Dairy large	Swine small	Swine large	Poultry	Turkey	Beef small	Beef large	Feedlot small	Feedlot large	Sheep small	Sheep large	Horse small	Horse large	Unknown
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Very	2 (2.2)	6 (5.3)	3 (3.5)	4 (4.8)	1 (4.2)	2 (40.0)	1 (4.2)	0	0	2 (9.1)	0	1 (3.3)	1 (9.1)	0	1 (7.7)
Moderate	27 (29.7)	48 (42.1)	21 (24.7)	34 (40.5)	10 (41.7)	1 (20.0)	5 (20.8)	9 (33.3)	7 (33.3)	10 (45.5)	7 (30.4)	12 (40.0)	3 (27.3)	1 (6.7)	3 (23.1)
Limited	53 (58.2)	53 (46.5)	45 (52.9)	36 (42.9)	12 (50.0)	2 (40.0)	14 (58.3)	14 (51.9)	11 (52.4)	9 (40.9)	12 (52.2)	14 (46.7)	6 (54.5)	3 (20.0)	6 (46.2)
None	9 (9.9)	7 (6.1)	16 (18.8)	10 (11.9)	1 (4.2)	0	4 (16.7)	4 (14.8)	3 (14.3)	1 (4.5)	4 (17.4)	3 (10.0)	1 (9.1)	11 (73.3)	3 (23.1)
Total	**91**	**114**	**85**	**84**	**24**	**5**	**24**	**27**	**21**	**22**	**23**	**30**	**11**	**15**	**13**

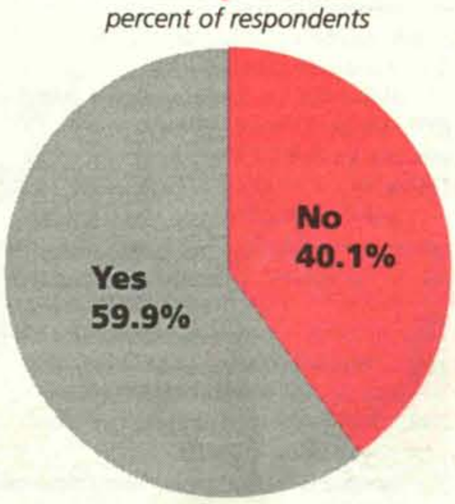
Level of knowledge of the MRTF Act

percent of respondents



During the past four years, the majority of complaints received by MDA involved manure practices

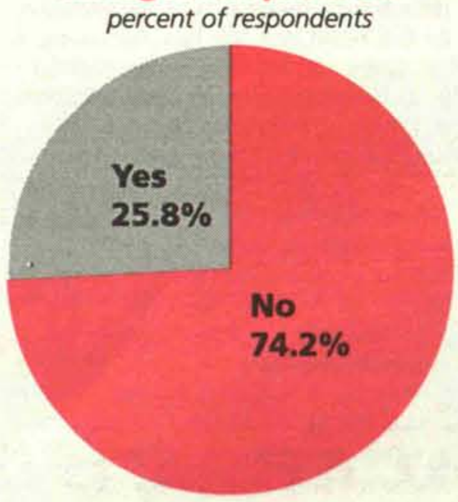
percent of respondents



Of approximately 1,100 complaints received by MDA, more pertain to manure management practices than any other issue.

Survey respondents having reviewed the Right-to-Farm Act and manure management practices

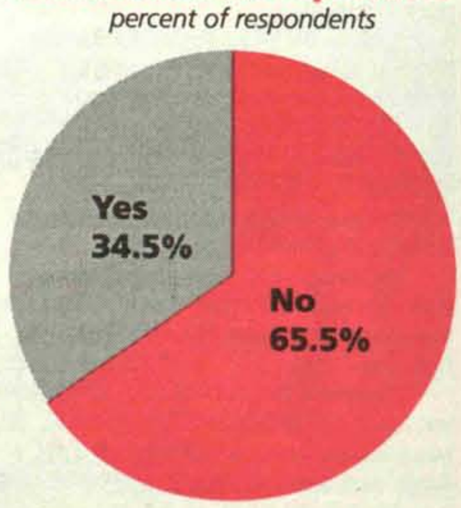
percent of respondents



The fact that only 25.8 percent of Michigan farmers have reviewed the Right-to-Farm manure management practices demonstrates the need for further education about the importance of the practices.

Knowledge that MDA can protect a farm operating with recommended practices

percent of respondents



The majority of the farmers (65.5 percent) were unaware that the MDA could document and consider a farm protected under MRTF if it was following the recommended practices.