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**Agricultural
Waste Management
Field Handbook**

Chapter 13

**Operation, Maintenance,
and Safety**

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Chapter 13

Operation, Maintenance, and Safety

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651.1300 Introduction

The purpose of an Agricultural Waste Management System (AWMS) is to control and use by-products of agricultural production in a manner that sustains or enhances the quality of air, water, soil, plant, and animal resources. Important to the success in achieving this purpose is adequate design and construction of the AWMS. At least as important to a system's success are its proper operation and maintenance (O&M). Safety is always coupled with proper O&M as an essential and integral part.

This chapter describes actions that would be taken by the operator of an AWMS or choices that would be made by the decisionmaker. It recognizes that the decisionmaker and the operator for an AWMS may not be the same person. For example, on an absentee owner's farm the decisionmaker and the operator are most likely different people. However, for the purpose of this chapter, reference to the decisionmaker implies the operator when appropriate to the context. The operation and maintenance described in this handbook is not all inclusive, but addresses the most common components.

Two prerequisites are necessary for proper O&M. First, the decisionmaker must have been involved throughout the decisionmaking process in planning the AWMS. This is essential if the decisionmaker is to accept full ownership of what is planned. Second, the decisionmaker must have a complete understanding of the system's O&M requirements. The AWMS plan is an essential tool for conveying these requirements to the decisionmaker. An AWMS plan is prepared as an integral part of and in concert with conservation plans. The purpose of this chapter is to discuss general operation, maintenance, and safety requirements for an AWMS.

651.1301 Operation

Operation of an AWMS includes the administration, management, and performance of nonmaintenance actions needed to keep the system safe and functioning as planned. The operation actions required depend on such factors as the type of enterprise, the components of the system, and the level of management. Because of this, the operational requirements for each AWMS must be system-specific. Following is a general description of the operational requirements for each function of an AWMS.

(a) Production function operation

The majority of the operational actions required for the production function are managerial. Examples of operation actions could include management of the amount of bedding and washwater used. The AWMS plan should document the production rate assumed in the design of the system and give a method for determining the actual rate. An important reason for doing this is to assure that the actual rate does not exceed that assumed in the design of the system. Repercussions can occur if the design rate is exceeded. For example, a storage facility of an AWMS could fill up more quickly than anticipated, requiring that the facility be emptied earlier than intended. A response is needed where a production rate exceeds design assumptions. For a dairy operation, the response might be reducing the amount of daily washwater used, excluding clean water entering the system, or enlarging the storage facility.

(b) Collection function operation

The collection function involves the initial capture and gathering of waste from the point of origin or deposition to a collection point. The managerial aspects of this function involve frequency and timing, which should be described in the AWMS plan. Frequency of collection is dependent on the type of operation. For a feedlot, the frequency of collection might be only once a year. On the other hand, a dairy with a flush system might collect waste several times a day.

Timing of collection can be an important consideration. For a feedlot without a storage facility, the timing should coincide with when the waste can be utilized. Timing for a poultry broiler operation may be most appropriate between production cycles when the facility is empty of birds.

(c) Storage function operation

Storage function components include waste storage ponds and structures. Storage structures include tanks and stacking facilities. Monitoring storage levels in relationship to the storage period is of prime importance in the operation of storage components.

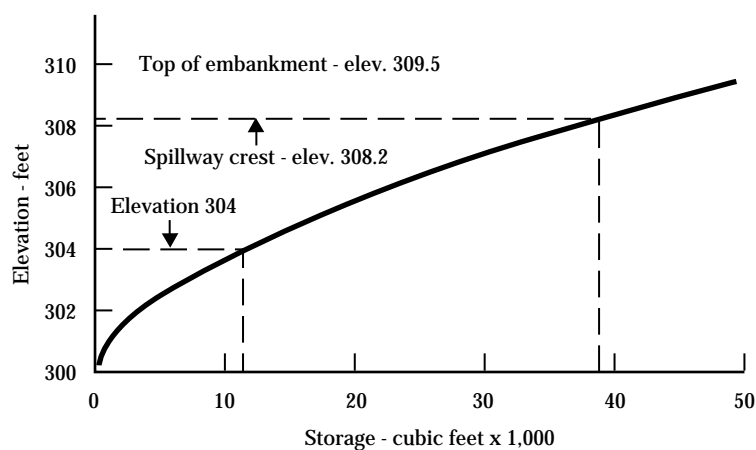
The AWMS plan should give target storage levels by date throughout the storage period. To assure that the facilities do not fill prematurely, these levels should not be exceeded. An excellent way to present this in the AWMS plan is to equip an impoundment type storage facility with a staff gauge so that target gauge readings versus dates are given. A stage-storage curve (fig. 13-1) can also assist the decisionmaker in moni-

toring the storage's filling. The stage-storage curve relates the pond's water surface at any elevation to the pond's storage at that elevation. For example, if the waste storage pond for figure 13-1 was measured as having a water surface elevation of 304 feet, it can be determined using the stage-storage curve that the pond contains 12,500 cubic feet of wastewater at that elevation. This storage can then be compared to anticipated storage if the pond had filled at the design filling rate.

To illustrate comparing actual versus design filling rate using the stage-storage curve, say the pond above is in its 50th day of the storage period, and the design filling rate is 200 cubic feet per day. Therefore, the target storage level for that day would be: 200 cubic feet per day times 50 days, or 10,000 cubic feet plus the depth of precipitation less evaporation assumed to occur during this 50-day period.

Using the stage-storage curve, it can be determined that at a storage of 10,000 cubic feet the water surface elevation in the pond would be 303.4. Add the assumed depth of precipitation less evaporation assumed for this 50-day period to this elevation.

Figure 13-1 Stage-storage curve



For this example, if the precipitation less evaporation was assumed in design to be 0.6 feet, the target filling elevation for the 50th day would be $303.4 + 0.6 = 304.0$, which would indicate actual filling is at the assumed design rate. However, actual precipitation amounts may vary from that assumed in design. For this reason, actual precipitation less evaporation should also be evaluated. For example, if the actual precipitation is less than that assumed, it would mean the pond above is filling at a rate in excess of the 200 cubic feet per day. On the other hand, if the actual precipitation less evaporation is more, the pond is filling at a rate less than the 200 cubic feet per day.

Keeping a record of the waste accumulation throughout the storage period should be recommended. A record of precipitation and evaporation amounts may also be important in determining the source of filling.

Storage components are generally operated so they are empty at the beginning of the storage period and are filled to or below capacity at the end. The management of storage components may need to be coordinated with the management of the production function if the rate of filling exceeds that assumed in design. Uncovered impoundment storage components are subject to storm events that prematurely fill them. The AWMS plan should describe a procedure for emptying these facilities to the extent necessary in an environmentally safe manner to provide the capacity needed for future storms.

The design of liquid storage components may require a storage volume reserve for residual solids after the liquids have been removed. The amount reserved for this purpose depends on such things as the agitation before pumping and the care taken in pumping.

(d) Treatment function operation

Treatment components include waste treatment lagoons, composting, oxidation ditches, solid/liquid separation, and drying/dewatering. The treatment function reduces the polluting potential of the waste and facilitates further management of the waste. Proper operation of this function is essential if the desired treatment is to be achieved.

(1) Waste treatment lagoons

Proper operation of waste treatment lagoons includes maintaining proper liquid levels and assuring that the maximum loading rates are not exceeded. Lagoons are designed for an assumed loading rate. The AWMS plan should document the maximum loading rate and suggest that it be monitored to assure that it is not exceeded. This can be done by comparing the sources and amounts of waste entering the lagoon to what was considered in design, such as number of animals.

Laboratory testing may be required if loading becomes a serious question. If the design loading rate is exceeded, the lagoon may not treat the waste as needed and undesirable and offensive odors may result. The rate of filling is important as well. If the rate of filling exceeds the design rate, the storage period is reduced and the lagoon must be pumped more frequently. See section 651.1301(c). The AWMS plan should describe a procedure for emptying part of the lagoon contents following a storm event that fills the lagoon prematurely to near its capacity to provide storage for future storms.

The AWMS plan must emphasize the need to maintain the liquid level in anaerobic lagoons at or above the minimum design volume (fig. 13-2). The proper pH must also be maintained if the desired treatment is to be achieved. As such, the pH should be measured periodically. The minimum acceptable pH is about 6.5. If pH falls below 6.5, a pound of hydrated lime or lye should be added per 1,000 square feet of lagoon surface daily until the pH reaches 7.0.

Aerobic lagoons require a design surface area and a depth within the range of 2 to 5 feet to effectively treat waste. This information must be provided in the AWMS plan. Mechanically aerated lagoons require that a minimum design volume be maintained and the designed amount of aeration be provided for effective treatment and odor reduction. The plan should recommend that these operational aspects be carefully monitored.

(2) Composting facilities

Composting requires careful management to effectively treat waste. It relies on a proper blend of ingredients, called the recipe, to achieve the microbial activity necessary to stabilize reactive constituents and to attain the temperature necessary to destroy disease-causing organisms. For this reason, the AWMS

plan should address careful monitoring of internal temperatures in the compost pile. The plan should give the recipe and recommendations for its adjustment if the temperature levels are either too low or too high. Caution should be given to the potential for spontaneous combustion. The plan must also address mixing requirements. See chapter 10 for a complete discussion of the management responses necessary for effective composting.

(3) Solid/liquid separation

Solid/liquid separation facilities include settling basins and a variety of stationary and mechanical screening devices. Maximum and minimum allowable flow rates are critical for these type facilities and need to be documented in the AWMS plan. If the flow rate exceeds the rate assumed in design, the residence time in settling basins may not be adequate for efficient settling. If it exceeds the design capacity of a screening device, its efficiency will diminish. Generally, the screen manufacturer's information provides data on minimum and maximum flow rates. However, the decisionmaker may need to fine tune the flow rate to fit the consistency of waste produced.

The frequency of cleaning out settling basins needs to be established by the design and documented in the AWMS plan. Solids sometimes adhere to screening devices and, if allowed to dry, can clog the screen. Rinsing the screen following use should be emphasized in the AWMS plan as a way to help avoid this problem.

(4) Oxidation ditches

Oxidation ditches require a high level of management to effectively treat the waste in a safe manner. Careful attention must be given to assure that pumps and other equipment are operating properly and that the ditch is not overloaded. Velocities must be maintained that do not permit solids to settle and accumulate. Input from the designer is essential in developing the operational requirements for oxidation ditches.

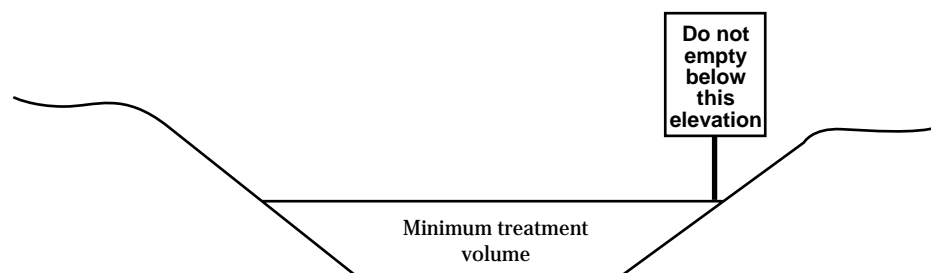
(e) Transfer function operation

Transfer function components include reception pits, pipelines, picket dams, pumps, and other equipment, such as tank wagons, agitators, chopper-agitation pumps, and elevators. A surveillance type inspection should be recommended to assure that the components are functioning properly.

A clean water flush following use of pipelines, tank wagons, and conveyors is helpful in minimizing the build up of sludge. Methods for unplugging pipelines should be described. Draining of pipelines or other protective freeze protection measures should be addressed.

Struvite, a phosphate mineral that can form a hard-scale deposit in pipelines and other similar waste transfer components, is a potential problem in an AWMS that utilizes recycled lagoon or waste storage pond effluent for flushing. Occasional clean water

Figure 13-2 Maintenance of minimum treatment volume



flushes of the transfer component or addition of struvite formation inhibitors to the wastewater may be effective in reducing struvite buildup. If a struvite buildup occurs, the system may need to be cleaned with an acid solution.

Proper agitation prior to transfer needs to be described in the AWMS plan. Agitation should be continued long enough so that the solids in the waste, including those in corners and recesses, are moved into suspension. The plan should address the spacing and duration of agitation. It should also give any precautions needed during agitation to prevent damage to pond liners. The consequences of inadequate agitation can be solids buildup, which can lead to difficult problems.

(f) Utilization function operation

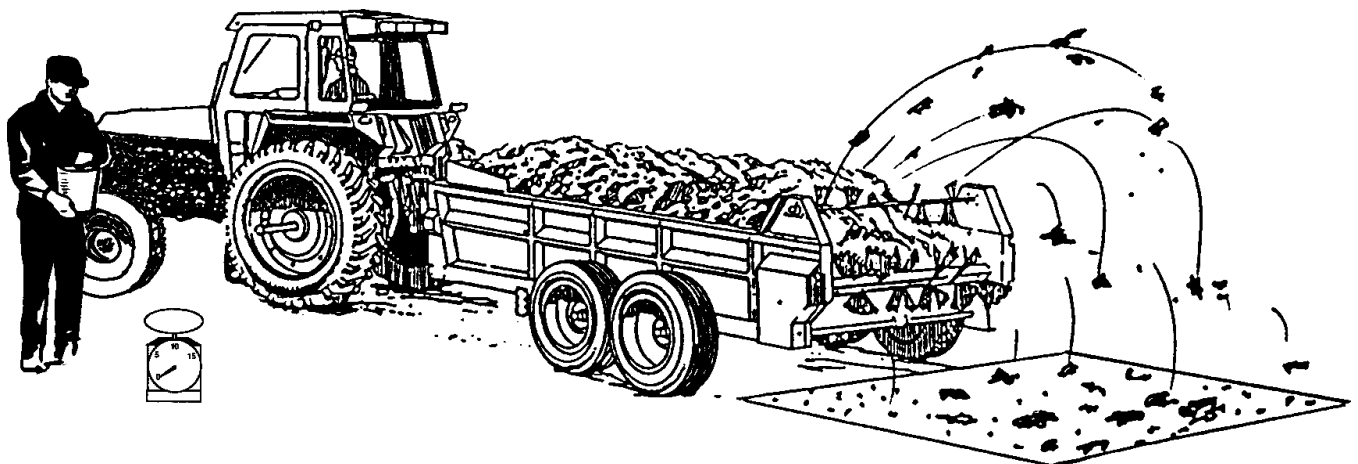
Utilization is a function in an AWMS for the purpose of taking advantage of the beneficial properties of agricultural wastes, such as its nutrient content. Components of utilization are land application of nutrients and biogas generation. Land application is the most prevalently used method.

The AWMS plan should establish the amount, method, placement, and timing of land application of agricultural wastes. The timing required should consider climate and stage of crop growth to maximize crop uptake and minimize environmental impact. Timing should also consider the potential for premature germination of planted crops if the waste is applied too early. Testing the waste and the soil for nutrient content must be recommended as good practice for use in determining the actual rates of application. See appendix 13A for more information on manure testing.

For liquid waste applied with an irrigation system, the plan should give sprinkler numbers, size and types of sprinklers, length of setting, and flow rates of waste and dilution water, if any. For slurry or solid wastes, the plan should indicate the necessity of calibrating spreading equipment to assure the desired rate of application is achieved (fig. 13-3). Appendix 13A also describes several methods of manure spreader calibration.

Utilization involving biogas/methane production and recovery requires a high level of management to be successful. Complicating the operation of a digester is coordinating use of gas once it is produced. Since compression and storage of biogas is not practical, its use must generally match the energy production. The designer of the biogas system must be involved in developing the specific operational requirements.

Figure 13-3 Manure spreader calibration



Methane production and recovery system options include the covered anaerobic lagoon, complete mix digester, and plug flow digester. Because each operates at a constant level and does not provide for waste storage, they must be operated in conjunction with a storage facility of some type. Operation of biogas components is dependent upon proper loading of waste in terms of volatile solids, total solids, and waste volume. As such, their loading must be carefully monitored. Some manure requires treatment, such as solid/liquid separation and dilution, before it enters a lagoon or digester. The amount of gas produced is a good indication of proper loading. If gas production falls off, the loading should be checked.

(1) Covered anaerobic lagoon

Operation of a covered lagoon for biogas production is much like that of a lagoon not associated with biogas production. The exceptions are that it is operated to have a constant liquid level, loaded at a higher rate, and has a minimum hydraulic retention time.

The inlet and outlet of the covered lagoon must remain free-flowing to maintain the required liquid level. The lagoon cover requires special attention to assure that methane produced is captured and directed to where it will be used. The cover should be periodically inspected for accumulation of excessive rainwater, tearing, wear holes, and proper tensioning. Excessive rainwater should be removed in the manner prescribed by the designer, usually by pumping or draining it into the lagoon or storage facility.

(2) Complete mix and plug flow digesters

These digesters require a constant temperature within a narrow range of variation to produce an optimum amount of biogas. Temperature is maintained by a heating system. The digester operating temperature must be monitored and kept within the temperature range specified by the designer. If the heating system is not functioning properly, waste should be routed around the digester to the storage facility. Both digesters have a cover of some kind. Like the lagoon cover, they must be periodically inspected to assure they are in good condition and are directing the gas to the exit point.

Effluent from anaerobic digesters has essentially the same amount of nutrients as the influent. As such, the O&M plan must address use of the effluent for land application.

651.1302 Maintenance

Maintenance of an AWMS includes actions that are taken to prevent deterioration of the system components, to repair damage, or to replace parts. Maintenance includes routine and recurring actions. The purpose of maintenance is to assure proper functioning and to extend the service life of AWMS components and equipment.

The two types of maintenance required by an AWMS are preventive and reactive. Preventive maintenance involves performing regularly scheduled procedures, such as lubricating equipment and mowing grass. Reactive maintenance involves performing repairs or rehabilitation of system components and equipment when they have deteriorated or cease to function properly. Examples of reactive maintenance include repair of a leak in a waste storage structure and replacement of a badly corroded piece of pipeline.

Essential to reactive maintenance is the discovery of items requiring attention before there is a serious consequence. Timely discovery can best be accomplished by regularly scheduled inspection of the AWMS components and equipment. The general maintenance and inspection requirements that should be considered for inclusion in the AWMS plan for each function of an AWMS are described in this section.

Proper maintenance of equipment used in an AWMS is essential for continuous operation. A thorough inventory of each function and its related equipment is recommended as a way to organize what must be maintained. The AWMS plan should recommend actions that will assist in the maintenance of equipment. An action to include would be collecting and filing information on equipment, such as name plate data, shop manuals, catalogs, drawings, and other manufacturer information. Other actions to recommend:

- Prepare checklists that give required maintenance and maintenance frequency.
- Keep a log book of the hours each piece of equipment is used to assist in determining when maintenance should be performed.
- Keep a replacement parts list indicating where the parts can be obtained.
- Keep frequently needed replacement parts on hand.

(a) Production function maintenance**(1) Roof gutters and downspouts**

A good time to inspect roof gutters and downspouts is during storm events when leaks and plugged outlets can easily be discovered. Maintenance items would include cleaning debris from the gutters, unplugging outlets, repair of leaks, repair or replacement of damaged sections of gutters and downspouts, repair of gutter hangers and downspout straps, and repair of protective coatings.

(2) Diversions

Maintenance of diversions includes, as appropriate to the type of construction, mowing vegetation, eliminating weeds, repair of eroded sections, removal of debris and siltation deposits, and repair of concrete. Inspections should be made on a regularly scheduled basis and after major storm events.

(b) Collection function maintenance

Maintenance requirements for the collection function are primarily directed at mechanical equipment. Regularly scheduled lubrication and other preventive maintenance must be performed on electric motors, sprockets, and idle pulleys according to the manufacturer's recommendations.

Flush systems employ pumps, valves, and mechanical equipment involving gear boxes, stems, and guides. This type equipment also needs regularly scheduled preventive maintenance. Broken sprockets, idle pulleys, drive cables and rods, chains, and scraper blades must be repaired when they are seen to be damaged.

Tractors used in collection must be regularly maintained according to the manufacturer's recommendations. Equipment used in collection must be under constant surveillance to assure continuous and proper operation. Grates and covers on reception pits must be kept in place and in good condition.

(c) Storage function maintenance**(1) Waste storage ponds**

Regularly scheduled inspections and timely maintenance are required for waste storage ponds because their failure can result in catastrophic consequences. The consequences of failure may affect public safety and environmental degradation. Inspections should focus on and result in the repair of leaks, slope failures, excessive embankment settlement, eroded banks, and burrowing animals.

Flow from toe and foundation drains should be inspected for quantity of flow changes and for discoloration. If flows from these drains suddenly increase, it could mean a leak has developed. If the flow is normally clear and suddenly becomes cloudy with silt, piping of the embankment could be suspected. Appurtenances, such as liners, concrete structures, pipelines, and spillways, need to be inspected and repaired if found to be deficient. Vegetative cover needs to be routinely maintained by mowing, and weeds and woody growth need to be eliminated. Safety features, such as fences, warning signs (fig. 13-4), tractor stop blocks, and rescue equipment, need careful maintenance.

Earthen waste storage ponds should be inspected carefully during and after they are emptied. Generally, these ponds are completely emptied over a short time. A consequence of this drawdown may be inside bank failures, especially where the pond is constructed in heavier soils or has an imported soil liner constructed

Figure 13-4 Waste storage pond warning sign



of heavier soils. Therefore, it should be recommended that the pond be carefully inspected during and immediately after emptying. Some pond features are best inspected when the pond is filling or is full. For example, inspection for toe drainage and foundation leaks is best done when the pond is filling or full.

(2) Waste storage structures—tanks

Inspection and maintenance of waste storage tanks depend on the type of tank and the material used in construction. However, regardless of the construction they should be inspected regularly for leaks and degradation. Concrete tanks should be inspected on a regularly scheduled basis for cracks and degradation of the concrete. Any sudden or unexpected drop or rise in the liquid level should be documented, the cause investigated, and the problem corrected.

Inspection or repair of waste storage tanks is a hazardous undertaking because it may involve entry into the tank where toxic, oxygen displacing, or explosive gases may be present. The safety section of this chapter gives a procedure for safe entry into confined spaces. Because of the caustic nature of wastes, a specialist in the repair of concrete should be consulted if cracks or degradation of concrete are observed.

An important consideration for below ground tanks is maintaining the water table below the elevations assumed in the design of the tank. Drains installed to control the water table must be inspected on a regular basis to assure that they are operating properly. If applicable, a caution should be included in the AWMS plan that liquid waste or water should not be allowed to pond on the ground surface surrounding the tank. This ponding can result in hydrostatic pressures that exceed the tank's design loadings, which can cause cracking or uplift.

A popular material for aboveground waste storage tanks is fused glass-coated steel. This material is virtually indestructible to the caustic action of the waste if the coating remains intact; however, deterioration of the steel may result if the coating is damaged. As such, it is important that the surface of these tanks be regularly inspected and repairs made. The area around bolts should be checked for loss of coating and rusting. Repairs should be made according to the manufacturer's recommendations.

Cathodic protection is required for some installations. When included, the cathodic protection system should be inspected to assure that it is functioning properly. The cathodic protection inspection requirements are dependent upon the type of system installed. The designer of the cathodic protection should be consulted on what to include in the O&M plan.

Steel tanks generally are not designed to withstand a load against the outside of the tank. Because of this, waste or other material should not be allowed to build up against the outside wall of the tank.

Careful attention needs to be given to the maintenance of safety features associated with waste storage tanks. These features include warning signs, grates and lids for openings, fences, barriers, and rescue equipment. Grates, lids, and gates should be secured in place when left unattended.

(3) Waste storage structures—Stacking facilities

Concrete and lumber are used in the construction of waste stacking facilities. Concrete should be inspected for cracks and premature degradation. If any problems are found with the concrete, appropriate repairs should be made.

Lumber should be inspected for damage either by natural deterioration or from man, animal, or weather event causes. Damaged lumber should be replaced. Roofs should be inspected regularly for leaks and damaged trusses, and repairs made promptly.

(d) Treatment function maintenance

(1) Waste treatment lagoons

The inspection and maintenance requirements for a waste treatment lagoon are about the same as those for a waste storage pond. One difference is that ponds generally are completely emptied, whereas lagoons retain a minimum storage pool. Maintenance of aerated lagoons would be complicated by the aeration equipment involved. The AWMS plan should indicate that the maintenance of the aeration equipment is to be according to the manufacturer's recommendations.

(2) Composting facilities

Composting facilities vary widely mainly because there are several methods of composting. However, many facilities use standard construction materials, such as concrete, concrete blocks, lumber, and steel.

Concrete should be inspected regularly for cracks and deterioration, and repaired as necessary. Lumber should be inspected for deterioration and physical damage, and replaced if found to be nonservicable. Protective coatings for steel structures should be inspected and repaired when damage is found. Manufactured composters should be maintained according to the manufacturer's instructions.

(3) Solid/liquid separation facilities

Settling basins are constructed of earth, concrete, or other material. Inspection and maintenance of these facilities are much the same as those for components constructed of similar material.

Screening devices are generally constructed using various kinds of steel. These devices should be inspected regularly for deterioration of protective coatings, and repaired as necessary. Many of these devices also involve the use of electric motors, pumps, and gears. These should be routinely maintained as recommended by the manufacturer.

(4) Oxidation ditches

The channel for oxidation ditches is generally constructed of concrete. The concrete should be inspected regularly for cracks and deterioration, and repairs made as needed. The rotor should be lubricated regularly and inspected for proper operation. Other equipment, such as pumps, agitators, and valves used in its operation, should be maintained as recommended by the manufacturer.

(e) Transfer function maintenance

Components and equipment for the transfer function of an AWMS vary widely. Manufactured transfer equipment, such as pumps, conveyors, and tank wagons, should be maintained according to the manufacturer's instructions. Pipelines should be inspected to assure that proper cover is maintained, vents are not plugged, valves are working properly, and inlet and outlet structures are in good condition.

(f) Utilization function maintenance

Waste utilization equipment includes solid manure spreaders, liquid manure spreaders, injection equipment, and irrigation equipment. The equipment should be maintained according to the manufacturer's recommendation.

If covered lagoons are used for biogas production, maintenance is similar to that needed for uncovered lagoons. The covered lagoons and other covered digesters need routine inspection of the covers or enclosures to check for tears or other opening that would allow gas to escape. Timely repairs must be made. The covered lagoon is generally designed for a constant level that is controlled by a pipe that discharges to either another lagoon or a waste storage pond. This pipe must be kept free of obstructions. Digestors accumulate sludge that must be periodically removed. Some digesters are heated, and use pumps to circulate heated water. These pumps must be lubricated and impellers and seals repaired as necessary.

651.1303 Safety

Safety hazards are inherent to an agricultural waste management system. Some of these hazards lie hidden and await the unsuspecting. Others may be more obvious, but are just as formidable to the careless. For these reasons, attention to safety must always be given first consideration in the planning, design, construction, and operation of an AWMS.

Hazards associated with an AWMS can be minimized by incorporating safety features in the design and consequent construction of AWMS components. The AWMS plan needs to address operation and maintenance of these safety features. The safe operation requires that those involved in its operation be aware of the system's hazards, follow procedures of safe operation, and maintain its safety features. These procedures must be clearly defined in the AWMS plan.

Hazards associated with an AWMS are many and lurk in each of its functions. Because safety hazards of similar nature are not limited to one function, they will be described as those associated with gases, impoundments, and equipment operation.

Most states have rules and regulations for occupational safety and health in agricultural operations. The state occupational safety and health agency should be contacted to determine applicable regulations. The AWMS plan should be developed to be in accordance with these rules and regulations and the type of hazards that will be involved in the AWMS.

(a) Hazards from gases

A variety of gases can be generated in the operation of an AWMS. Some of these gases are toxic and can cause illness and even death at relatively low concentrations. Other gases are not toxic, but can displace oxygen and result in asphyxiation. What makes these gases especially insidious is that some are colorless and odorless, and defy detection except with specialized equipment. Colorless gases produced by an AWMS include carbon dioxide, ammonia, hydrogen sulfide, and methane. Numerous odorous gases are produced by an AWMS. These gases fall into the gen-

eral classification of amines, amides, mercaptans, sulfides, and disulfides.

No direct tie between odors and safety problems has been found; however, odors can be a nuisance and cause complaints and even lawsuits. As such, they are an important consideration in the operation of an AWMS and need to be minimized. Chapter 8, *Siting Agricultural Waste Management Systems*, describes ways that odor problems can be minimized.

Gases can accumulate in any area of an AWMS where proper ventilation is not provided, such as animal housing and covered manure impoundments. Certain activities, such as agitation, can release gases that can cause problems if the facility is not properly ventilated. The major gases that may be produced by an AWMS and the consequences if these gases are encountered by humans and animals are described in the following paragraphs.

(1) Gases produced in an AWMS

Carbon dioxide (CO₂)—Carbon dioxide is a by-product of manure decomposition. Most of the gas bubbling up from storage and lagoons is CO₂. Carbon dioxide is not highly toxic in itself, but contributes to oxygen deficiency or asphyxiation. Concentrations above 10 percent (by volume) can cause a human to pant violently, and at increased levels are narcotic even if adequate oxygen is available. At 25 percent concentration, death occurs to humans after a few hours. Animals can tolerate up to a 7 to 9 percent CO₂ concentration, but with considerable discomfort. Concentrations above 10 percent may cause dizziness and even unconsciousness in animals.

Ammonia (NH₃)—Ammonia is released from fresh manure and anaerobic decomposition. Odors from as little as 0.0001 percent concentration can be detected and identified. Mixtures over 16 percent with air are explosive. Low concentrations, 0.0025 to 0.0030 percent, can irritate eyes and the respiratory tract of humans; higher levels can cause suffocation. Ammonia is an irritant to animals at concentrations up to 0.02 percent inducing sneezing, salivation, and appetite loss. Above 0.005 percent, eye inflammation develops in chickens. Prolonged exposure may increase respiratory diseases and pneumonia.

Hydrogen sulfide (H₂S)—Hydrogen sulfide is produced by anaerobic decomposition of organic wastes. It smells like rotten eggs at low concentrations, but cannot be detected at higher concentrations because it overpowers the sense of smell. High concentrations can be released by agitation and pumping. H₂S is the most toxic gas associated with manure storage, being both an irritant and asphyxiant. It is also flammable. Low concentrations severely irritate the eyes and respiratory tract of humans within an hour. Concentrations of 0.1 percent cause immediate unconsciousness and death through respiratory paralysis. Animals living continuously in facilities where the level of H₂S is 0.002 percent develop nervousness, appetite loss, and fear of light. Concentrations at 0.005 to 0.02 percent can cause vomiting, nausea, and diarrhea.

Methane (CH₄)—Methane is an odorless gas produced by anaerobic decomposition of organic wastes. It is not normally considered a toxic gas; however, it is highly explosive when mixed with air in concentrations as low as 5 percent. Lighter than air, methane tends to accumulate near the top of stagnant corners of buildings or covered manure impoundments. Accumulations of methane can be asphyxiating to both humans and animals; however, explosions are a more serious concern.

Carbon monoxide (CO)—Carbon monoxide gases in an AWMS result from operation of internal combustion engines and from gas, oil, and coal heaters rather than the decomposition of organic wastes. CO is mentioned because it is generated by equipment used in the operation of an AWMS. It is a colorless, odorless, toxic gas that can cause drowsiness at low concentrations and death at high concentrations.

(2) Gas hazard situation categories

Gases generated by an AWMS can be lethal if ventilation systems break down, during agitation of waste, and in poorly ventilated confined spaces, such as manure tanks including those that are uncovered. The hazards to both humans and animals include death, incapacitation, impairment of the ability to self rescue, or acute illness. A hazardous atmosphere occurs when flammable gases and vapors reach their flammable limit, when oxygen concentration is below 19.5 percent or above 23.5 percent, and when concentration of toxic gases exceeds permissible exposure limits. The

AWMS plan should address these hazards and how to appropriately remediate or improve them. It is important that others, such as family members, who may frequent an AWMS be aware of the hazards of these situations as well.

Ventilation breakdowns—Ventilation depends on properly operating fans or vents. With no natural drafts to replenish the air in confined areas, death by asphyxiation from lack of oxygen and increased carbon dioxide, by poisoning from other gases, or by some combination of these can occur. Operators must be alert to failure of ventilation systems and take immediate action to either repair the system or activate a backup system until repairs can be made. Operators must also be aware of the dire consequences of purposely blocking ventilation systems, which may be considered during cold weather to reduce heat loss.

Agitation—Agitation of wastes to facilitate transfer and other waste management functions is a common practice in an AWMS. This activity may release large quantities of noxious gases and create dangerous and possible lethal conditions even with maximum ventilations. If agitation is done outdoors, it seldom is a problem; however, lethal conditions are a potential when it is done within buildings. To minimize the hazards, agitation should be done on mild days so the building can be ventilated to full capacity. For naturally ventilated buildings, it is best done on windy days. Animals should be removed from the building before the agitation is started, but if they are not removed, they should be observed for signs of ill effects.

Confined space—Death resulting from persons entering a covered waste storage tank or other confined space in an AWMS occurs all too often in the United States. Multiple deaths frequently occur when the first person to enter the confined space and the would-be rescuers all succumb to the atmosphere of the facility. These are tragic occurrences, and every safety precaution should be used to prevent them.

Often a person enters a tank as a spur-of-the-moment reaction to the desperate need for assistance to an animal or person who has accidentally fallen into the facility. Steps can be taken to avoid this type of accident. First, the AWMS design should include, and its plan should indicate, maintenance of such devices as grates and covers that prevent accidental entry from happening. Design consideration should also be given to:

- Features that minimize the need for confined space entry.
- Provisions that allow for maintenance of equipment outside the space or for equipment parts that can be easily retracted for maintenance.
- Corrosion resistant equipment that performs with minimum maintenance in caustic environments.
- Power ventilation systems that provide for both a supply of fresh air and exhaust of accumulated gases.

Secondly, the people who operate or frequent an AWMS must be made aware of the absolute rule that no one enters these facilities under any circumstance unless preparations have been made for their safe entry. Signs (fig. 13-5) should be prominently posted and maintained that warn of the hazard. Children and those that cannot read must be given special instruction to assure that they are aware of the hazard.

Entry into a confined space is sometimes necessary. Examples include:

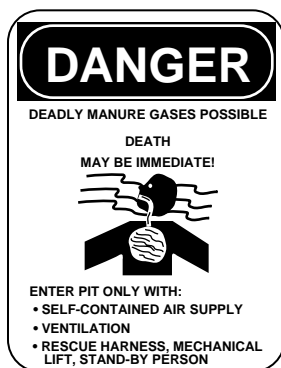
- To inspect a tank for cracks and leaks.
- To rescue someone or something.

Confined spaces should, however, only be entered after preparations have been made for a safe entry. For this reason, the AWMS plan needs to address safe entry into confined spaces.

Some States may regulate entry into confined spaces for agricultural operations. The appropriate occupational and safety agency should be contacted to determine what the requirements are. The U.S. Department of Labor, Occupational Safety and Health Administration, has rules and regulations on entering confined spaces (Federal Register 1993). The regulatory aspects of these rules do not apply to agriculture. However, from a safety standpoint these rules should be followed to ensure the safety of persons required to enter hazardous confined spaces. Following is a summary of the practical aspects of these rules as they apply to entry of AWMS confined spaces:

- Any condition making it unsafe to remove an entrance cover to a confined space shall be eliminated before the cover is removed.
- When entrance covers are removed, the opening shall be promptly guarded by a railing, temporary cover, or other temporary barrier that will prevent an accidental fall through the opening and will protect persons working in the space from objects entering the space.
- Before a person enters the space, the internal atmosphere shall be tested with a calibrated direct-reading instrument for the following conditions in the order given:
 1. Oxygen content
 2. Flammable gases and vapors
 3. Potential toxic air contaminants

Figure 13-5 Confined space warning signs



- No hazardous atmosphere can be within the space whenever any person is inside the space.
- Continuous forced air ventilation shall be used as follows:
 - † A person may not enter the space until the forced air ventilation has eliminated any hazardous atmosphere.
 - † The forced air ventilation shall be so directed as to ventilate the immediate areas where a person is or will be present within the space and shall continue until all persons have left the space.
 - † The air supply for the forced air ventilation shall be from a clean source and may not increase the hazards in the space.
- No one should enter a confined space without a qualified safety watcher stationed outside the space. Persons entering confined space should know the hazards that may be faced during entry, be equipped with a full body harness with a retrieval line attached to a mechanical rescue device, and be able to communicate with a safety watcher. The safety watcher must be able to communicate with those inside the space and be able to perform the actions required to retrieve those inside the space.
- The atmosphere within the space shall be periodically tested as necessary to ensure that the continuous forced air ventilation is preventing accumulation of a hazardous atmosphere.
- If a hazardous atmosphere is detected during entry:
 - † Each person shall leave the space immediately.
 - † The space shall be evaluated to determine how the hazardous atmosphere developed.
 - † Measures shall be implemented to protect persons from the hazardous atmosphere before any subsequent entry takes place.

To fully implement the above procedure, the AWMS plan should recommend employing a safety professional who has the training and the testing equipment necessary to ensure a safe confined space entry. Local or State Government safety agencies may provide this service upon request. Some States require insurance companies that supply coverage for occupational accidents to provide their clients with consultation services on safety related problems.

A well thought-out plan of action for dealing with emergencies involving accidental entry into confined spaces needs to be included in the AWMS plan. The plan should recommend that the decisionmaker educate all who are involved in the operation of an AWMS in carrying out the plan. An AWMS plan should:

- Include a rescue service that could be called for assistance in an emergency.
- Suggest that equipment needed for emergency rescue, such as self contained breathing apparatus, life lines, and harnesses, be close at hand.
- Address the specific hazards from gases in each of the applicable functions of the AWMS.

Safety equipment used in confined space is described in chapter 12.

(b) Hazards with impoundments

Impoundment type components, such as waste storage ponds, waste treatment lagoons, and waste storage tanks, present a drowning hazard. The hazard for earthen waste impoundments is similar to that associated with any farm pond. However, crusts that may form on the water surface and slime formation make waste impoundments more hazardous.

Crusts have the appearance that they would support a person's weight; however, they often will not. The consequence of falling through the crust on a waste impoundment would be similar to falling through the ice on a pond—there is no escape. Slime that forms on the surface of impoundments makes them very slippery, and as such makes it easy for a person to lose their footing on inclines. In cold climates, ice formation can make any surface unsafe. Geotextile liners are generally smooth, and when wet they are so slippery a foothold cannot be achieved.

The best approach to minimizing the hazards of drowning in waste impoundments is to include features in the design to exclude both animals and people (fig. 13-6). This can be accomplished with fences and warning signs. Gates should be locked to limit access except to those who need to enter the impoundment area. Provision needs to be provided for emergency exit in case someone accidentally enters these areas. Prominent signs indicating the hazard should be displayed. The AWMS plan needs to emphasize the importance of maintaining these safety features.

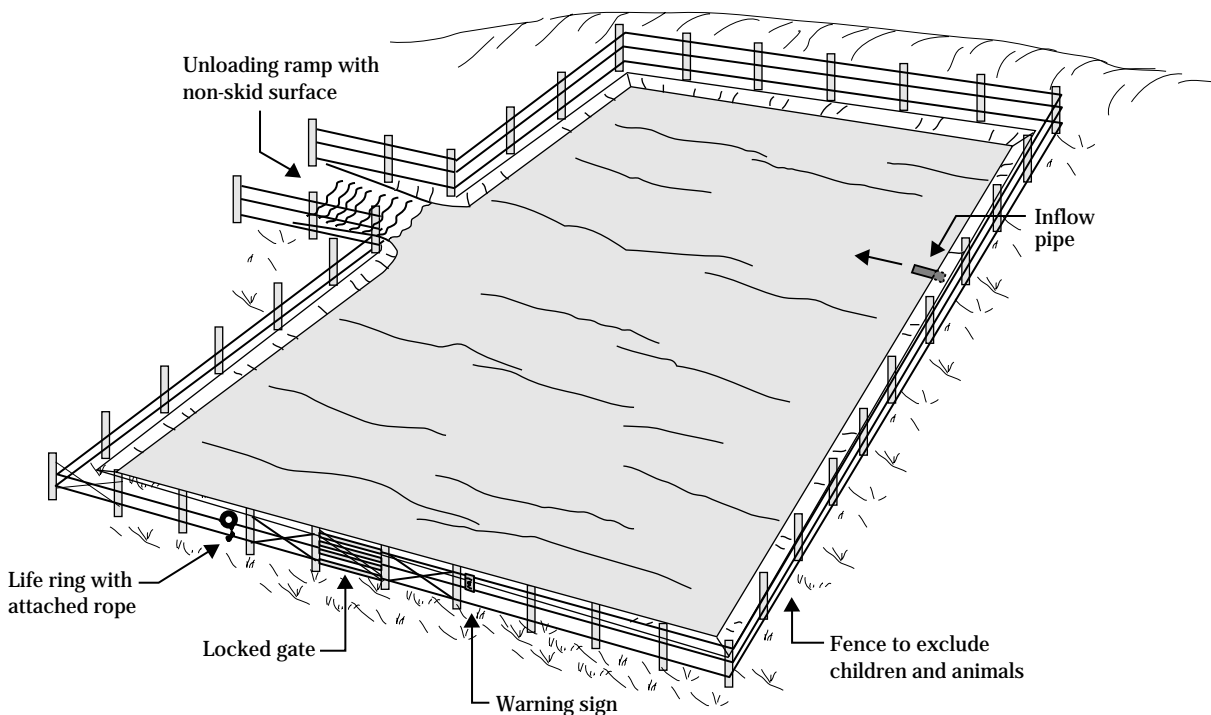
On some occasions, personnel must operate near these impoundments. The AWMS plan should recommend that life rings, life lines, poles, and boats be close at hand to assist in making a rescue.

Design of push-off ramps should include:

- Sturdy guard rails to prevent people and equipment from falling into waste impoundments.
- Loading ramps with a traction surface to minimize slipping.
- Walkways constructed of nonslip surfaces.

People can do little to escape if they fall into a storage tank with vertical walls. The side of the tank is slick and has nothing to hang onto unless it is provided. For this reason tank access should be limited to those who have need for entry. A ladder on the outside of the tank should terminate above the reach of people or should have locked entry guards.

Figure 13-6 Waste storage pond safety features



Some tanks have platforms for such equipment as solid/liquid separators and pumps. The platform should be equipped with guard rails to prevent accidental falls into the tank. A rope dangling from the platform would allow improved opportunity for survival from an accidental fall from the platform into the tank.

Providing a means of survival from accidental entry should also be considered for below-ground tanks; however, whatever is done should never invite entry. Examples of things to consider include:

- A ladder hinged to the tank cover that can be pulled down with a rope to allow escape.
- Perches installed on the tank floor or wall that a person can stand on to attain fresh air and call for help.

The AWMS plan should discuss the specific hazards of impoundments in each applicable function. Generally, this hazard would be discussed in an AWMS plan for systems that have waste storage ponds or tanks in the storage function and for systems that have waste treatment lagoons in the treatment function. See chapter 12, section 651.1204, for additional information on safety equipment for impoundments.

(c) Hazards in equipment operation

Equipment used in an AWMS is varied. Chapter 12, Waste Management Equipment, describes equipment used in an AWMS, as well as safety aspects of equipment operation. A few guiding principles in the safe operation of equipment should be included in the AWMS plan. Safety procedures should also be included. The procedures could include:

- Assuring that moving parts that would expose an operator to injury are properly guarded.
- Providing and using backup signals on equipment as appropriate.
- Maintaining electrical equipment and assuring that it is properly grounded.

Perhaps the most important safety precaution is assuring the equipment operators are trained in the safe use of the equipment before being allowed to operate it.

This should be recommended in the AWMS plan. It is equally important that operators only be allowed to use equipment when they are well rested and not under the influence of a drug, prescribed or otherwise, which would impair their ability to operate the equipment safely.

The decisionmaker should be advised in the AWMS plan of the necessity of requiring workers to use personal protective equipment when appropriate (fig. 13-7). Rollover protective structures and seat belts should be on all equipment that is ridden. Safety belts should be used if there is a potential of falling.

Because many surfaces in an AWMS are slippery, shoes or boots with soles having good traction should be used. Hearing protection should be used if the noise level and duration would contribute to hearing loss. Operators should use eye and face protection if machines or operations present potential eye or face injury. Work areas should be well ventilated. If they are not, workers should use appropriate respiratory protection. Proper lighting is also important in providing a safe work environment.

The AWMS plan should discuss the specific hazards of the equipment used in each function of the AWMS.

Figure 13-7 Personal safety equipment



Hard hat



Safety gloves



Hearing protection
 earmuffs



Safety goggles

651.1304 Agricultural waste management system plans

The purpose of an AWMS plan is to convey to the decisionmaker details of the construction and O&M requirements of the system. It is important to remember this in its preparation. As such, the plan should have an easily followed format, use familiar terms, and be concise. It should be neat, invite reading, and be worthy of retention. Presenting the plan to the decisionmaker in a 3-ring binder encourages retention. An electronic copy could be provided those decisionmakers having computers. See Chapter 2, Planning Considerations, and Chapter 9, Agricultural Waste Management Systems, for more information on the AWMS plan.

The preparation of the AWMS plan requires input from all disciplines involved in the planning and design of the system. Information from the AWMS's planning documentation must be extracted for inclusion in the plan. This would include information extracted from inventories, investigation reports, alternatives considered, design reports, installation schedules, and other information that is necessary for explaining the system requirements. However, it is generally not appropriate to include the planning and design documents in their entirety.

An AWMS component design report should be reviewed to ascertain O&M activities that may have been identified as necessary for the component's performance. These O&M activities should be included in the O&M plan. The plan should include maps, charts, and other illustrative aids that enhance understanding of the system's O&M requirements. Appendix C is an example AWMS plan for a simple agricultural waste management system. A suggested format follows.

Name, address, and location of AWMS—This is self-explanatory.

General statement—Should indicate the purpose of the AWMS and the importance of O&M.

General description of AWMS—Should include the type and size of operation and the basic components of the AWMS. Including a plan view drawing of the component layout would be helpful for describing the AWMS.

Decisionmaker's responsibilities—It is suggested that this section clearly state that proper and safe system operation and maintenance within the laws and regulations are the responsibility of the decisionmaker.

Component installation schedule—Should consider proper sequence of installation so that each component will function as intended in the system.

Operation and Maintenance of production, collection, storage, treatment, transfer, and utilization functions—The specific O&M requirements for each function of the AWMS should follow the component installation schedule section. These requirements should expand on the general O&M considerations described in this chapter and include the appropriate safety requirements.

Decisionmaker's acknowledgment—This last section is intended to include a signature line allowing the decisionmaker to attest to having read and understood the plan.

651.1305 References

- Federal Register. 1993. Part II, Department of Labor, Occupational safety and health administration, 29 CFR Parts 1910, Permit-required confined spaces for general industry; final rules (Jan. 14).
- Midwest Plan Service. 1985. Livestock facilities handbook. MWPS-18, Iowa State University.
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**651.1350 Appendix 13A—Calibrating
Manure Spreaders**

The use of animal manure as a cropland fertilizer is economically and environmentally important. However, farmers cannot simply spread manure. They must know the nutrient quality of the manure and control the quantity and uniformity of the manure spread to ensure that the entire crop receives the nutrients.

The nutrient content of the manure is estimated from laboratory tests, and the quantity to apply is determined through computations of crop need. Farmers can receive this information from their county Extension office or other nutrient management planners. In practice, farmers often do not know exactly how much or how uniformly manure has been applied. Manure spreader calibration provides this important information.

Manure spreaders can discharge manure at varying rates, depending on forward travel speed, PTO speed, gear box settings, discharge opening, width of spread, overlap patterns, and other parameters. Calibration defines the combination of settings and travel speed needed to apply manure at a desired rate. Following is a description of the measurement methods used to determine manure application rates and ensure uniform application.

Calibration techniques

Calibration requires the measurement of the quantity of manure applied to the soil under different conditions. There are two calibration techniques: the *load-area* method, which involves measuring the amount of manure in a loaded spreader and then calculating the number of spreader loads required to cover a known land area; and the *weight-area* method, which requires weighing manure spread over a small surface and computing the quantity of manure applied per acre.

The calibration method to use depends on the type of manure spreader. Soil-injection, liquid manure spreaders must be calibrated using the load-area method because soil-injected manure cannot be collected. Liquid manure surface applied through a tank spreader is also best measured by the load-area method because of the difficulty in collecting the liquid manure, but it can be measured with the weight-area method. Solid and semisolid manure also can be measured with either method.

Load-area calibration

Load-area calibration requires measuring the quantity of manure (tons or gallons) held in a spreader load; spreading a number of identical loads at a constant speed, spreader setting and overlap; measuring the total area of the spread; and computing the quantity of manure applied per acre. After completing the following steps, record the calculations on Worksheet 1, Manure Spreader Capacity and Worksheet 2, Load-Area Calibration.

Step 1. Determine the capacity of the manure spreader. The capacity of the manure spreader must be expressed in units compatible with the units used for the nutrient analysis and recommended application rate. In some cases, the manufacturer provides the appropriate information; in other instances, the manufacturer's information must be converted.

Liquid manure. Liquid manure analysis is expressed in pounds of nutrient per gallon and the application rate is provided in gallons per acre; therefore, use gallons to express the capacity of a liquid manure spreader. Manufacturers specify liquid manure spreaders by gallons of volumetric capacity. This information can be found in the owner's manual.

Solid and semisolid manure. Solid and semisolid manure analysis is expressed in pounds of nutrient per ton and the application rate is provided in tons per acre; therefore, solid and semisolid manure spreader capacity must be expressed in tons of manure.

Solid and semisolid manures of different moisture content have different weights; thus, the weight capacity of the spreader changes according to the kind of manure held. The most direct and accurate method of determining the weight of a load of manure is to actually weigh the spreader load on farm scales. If scales are not available, use the procedure in the next section to convert the volumetric capacity of the spreader to weight capacity for the particular manure held. Record your calculations on Worksheet 1, Manure Spreader Capacity.

Converting volumetric capacity to weight capacity. The volumetric capacity of box-type and open-tank or barrel spreaders for solid and semisolid manure is expressed in cubic feet. The manufacturer provides this information in the owner's manual. Two capacities

are usually provided: heaped load (manure piled higher than the sides of the box) and struck load (the volume contained within the box). The capacity of older spreaders is sometimes designated in bushels; multiply the bushel capacity by 1.24 to determine capacity in cubic feet.

Multiply the volumetric capacity in cubic feet by the bulk density of the manure (in pounds per cubic foot) and convert it to tons. Bulk density depends on the amount of water, solids and air in the manure and can be measured by weighing a known standard volume of manure. A 5-gallon bucket has a volume of 2/3 cubic foot and can be used as a standard volume as follows:

1. Weigh the empty bucket and write the weight on the side of the bucket. This establishes the bucket's tare weight (the container weight subtracted from the gross weight to determine the weight of the manure).
2. Fill the bucket with manure from the loaded spreader. Use all the space in the bucket and pack the manure to the same density as in the spreader.
3. Weigh the full bucket and subtract the tare weight. The result is the manure weight in pounds.
4. Multiply the manure weight by 3 and then divide the product by 2. This gives the manure bulk density in pounds per cubic foot of volume.
5. Multiply the manure bulk density (in pounds per cubic foot) by the spreader capacity (in cubic feet) to get the weight of the spreader load in pounds. Divide by 2,000 to get tons.
6. Repeat this procedure at least three times. Sample the manure at different places and in different spreader loads. Average the values to obtain a representative composite of the manure.

Step 2. Spread manure on a selected field. Spread at least three full loads of manure on a field. Maintain the same speed and spreader setting for each load. Choose spreader path spacing to achieve what appears to be the most uniform coverage. Try to spread in a rectangle or square for easy calculation.

Step 3. Measure the area of the spread. Place flags at the corners of the spread area. Measure the width and length between the flags in feet using a measuring tape, measuring wheel, or consistent pace. Multiply the length by the width and divide that product by 43,560 to determine the area in acres.

Step 4. Compute the application rate. Multiply the number of loads spread by the number of tons or gallons per load to determine the total amount of manure applied to the area. Divide the total amount of manure by the area of the spread in acres to determine the application rate in tons per acre or gallons per acre.

The load-area method should be repeated at different speeds and spreader settings until the desired application rate is obtained. Maintain a record of the application rates at different settings to avoid recalibrating the spreader each season.

Weight-area calibration

Spreader calibration by weight-area requires laying out a ground sheet of known dimensions on the soil; spreading manure over it at a selected speed, spreader setting and overlap; retrieving the ground sheet and the manure deposited on it; weighing the manure retrieved; and computing the quantity of manure applied per acre. The weight-area method does not require measuring the amount of manure in the spreader. As you complete the following steps, record your calculations on Worksheet 3. Weight-Area Calibration.

Step 1. Select a manure collection surface. A ground sheet can be a cloth or plastic (6 mil) sheet of at least 100 square feet (10 feet by 10 feet) in area. Multiply the length of the sheet by the width to determine its area in square feet.

Liquid manure may run off a flat ground sheet; shallow plastic or metal pans are more useful. The pans should have a minimum area of 1 square foot each. Multiply the length of one pan by its width to determine the area of one pan. Multiply the area of one pan by the number of pans used to determine the total collection area in square feet. For handling and cleaning convenience, place the pan inside a plastic garbage bag for each field test so that the bag and manure can be discarded leaving the pan clean. Six or more pans are necessary for a test.

Weigh the ground sheet or pan and record the weights for use as a tare weight in calculations. Dirty sheets and pans can be used for multiple tests only after major manure deposits have been removed. Dirty sheets and pans must be weighed before each test so that any manure residue is included in the new tare weight.

Step 2. Secure the collection surface in the field.

Lay the ground sheet out fully extended. Lay the sheet on the ground so that as the sheet is removed from the field the manure applied over the surface can be collected easily in its folds. If dirty sheets are being used for additional tests turn the dirty side up so that any manure residue included in the tare weight is not lost. Weights of stone metal or earth clods will be required to hold the ground sheet on the soil surface. A small breeze can easily fold the sheet or tractor wheels and forceful applications of manure can move it.

Pans are not as easily affected by wind, but may be moved by forceful streams from side outlet manure spreaders. Evenly space pans in a row perpendicular to the spreader's path. Pans are easily crushed by tires; allow for wheel tracks and adhere to the path provided. Placing flags at designated wheel tracks helps avoid pan damage.

Step 3. Spread manure over the collection area.

Spread manure over and near the ground sheet or pans in a manner that best duplicates the spreading pattern you plan for the field. With rear outlet spreaders, make three passes: the first pass directly over the center of the collection area and the remaining two passes on the opposite sides of the first pass with an overlap. With side outlet spreaders, locate a first pass off of, but along one edge of, the collection area. Follow with subsequent passes farther away from the collection area and at the intended overlap until manure no longer reaches the surface.

In all cases, start spreading manure far enough before the collection area to ensure that the spreader is functioning. If a ground sheet is folded or a pan is moved during a spread pass, investigate its condition before continuing with the test. Folded edges can be straightened without major loss of accuracy. If more than one-fourth of the surface has moved and did not receive manure, the test should be conducted again with a newly weighed sheet. Pans that have been crushed but retain the applied manure can still be used. Return moved pans to their original position.

Step 4. Collect and weigh the manure. Remove weights used to hold the ground sheet in place. Fold the ground sheet and manure in short sections from all sides and corners inward to avoid losing any manure. A 10-foot by 10-foot sheet folded with wet manure may weigh as much as 150 pounds and tends to slip around when carried; place it in a feed tub or other container for easier handling.

Pans are easy to handle and will usually weigh less than 4 pounds each. Careful handling is required to avoid spilling liquid manure.

Select scales capable of accurately weighing the type and quantity of manure collected. A single pan may collect from 2 ounces to 4 pounds and can be weighed with a kitchen scale. A ground sheet may collect from 10 to 50 pounds with application rates of less than 10 tons per acre. A ground sheet can be weighed with spring-tension or milk scales. A ground sheet with application rates greater than 10 tons per acre will require a platform balance with a capacity of 50 to 150 pounds or greater.

The weight indicated on the scale will include the tare weight of the ground sheet or pan as well as that of any container used to hold the ground sheet or pan during weighing. Subtract the tare weights from the total weight to determine the net weight of the manure collected.

Step 5. Compute the application rate. The number of steps and the procedure used to compute the application rate depend on the method of collection and the units per acre.

Ground sheet to tons per acre. Divide the net pounds of manure collected by the area of the ground sheet to obtain the manure application rate in pounds of manure per square foot. Multiply the result by 43,560 and then divide by 2,000 to convert to tons per acre.

Pans to tons per acre. Add the net weights of manure collected in individual pans to determine the total weight of manure collected. Divide the total manure weight by the total collection area to obtain pounds of manure per square foot. Multiply the result by 43,560 and divide by 2000 to obtain tons per acre.

Pans to gallons per acre. If working with weight from pans to determine liquid applications in gallons per acre, make an additional measurement to calculate the weight per gallon of manure. Fill a 5-gallon bucket with liquid manure of the same consistency of that applied. Weigh the bucket of manure and subtract the tare weight of the bucket to determine the net weight of 5 gallons of manure. Divide the result by 5 to determine the weight in pounds per gallon. Follow the procedure for “Pans to tons per acre” through obtaining pounds of manure per square foot. Then multiply by 43,560 and divide by pounds per gallon to obtain gallons per acre.

Uniformity testing

The results of nonuniform manure spreading are often indicated by the lush, green growth within the spreader paths and the not-so-lush growth between spreader paths. This occurs because more manure was deposited in and near the spreader path than farther away from the path. Uniform application can be obtained by adjusting the application overlap. The amount of overlap necessary can be determined by a uniformity test. As you complete the steps in this uniformity test, record your calculations on Worksheet 4, Uniformity Testing.

The test procedure is identical to the weight-area calibration method, using pans or a series of 24-inch by 24-inch ground sheet sheets laid out with equal spacing across two spreader path widths. After the manure is applied, each pan or sheet is compared with the others. Uniformity can be recorded when manure is spread to determine the application rate.

If all containers collect about the same amount of manure during a test, the application is uniform; if some collect more than others, the overlap should be adjusted. High application in the center of paths and low application between paths indicate a need to increase the overlap by decreasing the path spacing. Higher application between paths than within paths indicates a need to decrease overlap by increasing path spacing.

Shortcuts

Developing a range of application rates for different manure spreader speeds can be simplified if the spreader is PTO-powered and the tractor or truck is equipped with a groundspeed indicator. Conduct one test at low groundspeed and one at high groundspeed, maintaining the same spreader setting and PTO speed for both tests. Plot these two application rates on a graph of groundspeed versus application and draw a straight line connecting the two points. The application rate available at intermediate groundspeeds can then be estimated from the graph. Conducting additional high-low tests at different settings or at different PTO speeds will define a full range of available application rates.

If solid or semisolid manure changes moisture content from season to season, the weight capacity in the spreader and the application rate by weight will change. Adjust previously calibrated spreader conditions for these changes by determining the bulk density of the new manure. To estimate the field application rate for the new manure for a particular speed and spreader setting, multiply the old application rate by the new bulk density and then divide by the old bulk density. This calculation eliminates the need to repeat the field test every time manure properties change.

Summary

By measuring the application rate and uniformity of manure spreading, a farmer can be sure of the amount of manure nutrients applied to a crop. This measurement, called calibration, can be accomplished with a little time and a few dollars. For further information, contact your county Extension office.

Source—Adapted from Calibrating Manure Spreaders, Fact Sheet 419, Cooperative Extension Service, University of Maryland System, H.L. Brodie, extension agricultural engineer, and G.L. Smith, extension agricultural engineer, Department of Agricultural Engineering, University of Maryland at College Park, Published 1985-86, revised 1990-91.

Worksheet 13A-1—Manure Spreader Capacity

A. Description of spreader.

Manufacturer _____ Model _____

Type: box open-tank liquid-tank

Capacity: This information is available from your dealer or owner's manual.

Older models: bushels x 1.24 = cubic feet

Box or open-tank: _____ ft³ struck load _____ ft³ heaped load

Liquid-tank: _____ gal

B. For open-tank and box spreaders, determine the pounds per cubic foot of manure and the weight capacity of the spreader.

Type of manure: solid semisolid

1. Determine manure density using a 5-gallon bucket.

| | Trial 1 | Trial 2 | Trial 3 | |
|---------------------------------------|---------|---------|---------|--------------------|
| a. Empty bucket weight or tare weight | _____ | _____ | _____ | lb |
| b. Bucket filled with manure | _____ | _____ | _____ | lb |
| c. Net weight of manure (b - a) | _____ | _____ | _____ | lb |
| d. Manure density [(c x 3) ÷ 2] | _____ | _____ | _____ | lb/ft ³ |
| e. Average of three trials | _____ | | | lb/ft ³ |

2. Weight capacity of the spreader.

| | Struck load | Heaped load |
|-------------------|--------------------------|--------------------------|
| Spreader capacity | _____ ft ³ | _____ ft ³ |
| x | x | x |
| Manure density | _____ lb/ft ³ | _____ lb/ft ³ |
| = | = | = |
| Load weight | _____ lb | _____ lb |
| ÷ | ÷ | ÷ |
| 2,000 | _____ tons | _____ tons |

Worksheet 13A-2—Load-Area Calibration

Liquid-Tank Spreaders (Liquid Manure)

1. Determine the capacity of the manure spreader. _____ gal
2. Spread at least three full loads at the desired speed, spreader setting and overlap.
3. Measure the area of the spread.
 - a. Spread manure area width _____ ft
 - b. Spread manure area length _____ ft
 - c. Spread area (a x b) _____ ft²
 - d. Spread area in acres ($c \div 43,560$) _____ acres
4. Compute the application rate.
 - e. Number of loads spread _____
 - f. Capacity per load _____ gal
 - g. Total manure spread (e x f) _____ gal
 - h. Application rate ($g \div d$) _____ gal/acre

Box and Open-Tank Spreaders (Solid and Semisolid Manure)

1. Determine the capacity of the manure spreader. _____ tons
2. Spread at least three full loads at the desired speed, spreader setting and overlap.
3. Measure the area of the spread.
 - a. Spread manure area width _____ ft
 - b. Spread manure area length _____ ft
 - c. Spread area (a x b) _____ ft²
 - d. Spread area in acres ($c \div 43,560$) _____ acres
4. Compute the application rate.
 - e. Number of loads spread _____
 - f. Capacity per load _____ tons
 - g. Total manure spread (e x f) _____ tons
 - h. Application rate ($g \div d$) _____ tons/acre

Nutrient application = tons/acre x pounds of nutrient per ton
or gallons/acre x pounds of nutrient per gallon

Worksheet 13A-3—Weight-Area Calibration

1. Select a manure collection surface.

- a. Determine collection area

Ground sheet:

width _____ ft x length _____ ft = area _____ ft²

Pans:

pan width _____ inch x pan length _____ inch ÷ 144 = pan area _____ ft²pan area _____ x number of pans _____ = collection area _____ ft²

2. Secure ground sheet or pans.

3. Spread manure over the collection area.

| | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 |
|---|---------|---------|---------|---------|---------|
| Forward speed, gear or throttle setting | _____ | _____ | _____ | _____ | _____ |
| PTO speed | _____ | _____ | _____ | _____ | _____ |
| Spreader setting | _____ | _____ | _____ | _____ | _____ |

4. Collect and weigh the manure and compute the application rate.

- | | | | | | |
|--|-------|-------|-------|-------|--------------------------|
| a. Tare weight of sheet or pan and weighing container | _____ | _____ | _____ | _____ | _____ lb |
| b. Gross weight of sheet or pan, collected manure and weighing container | _____ | _____ | _____ | _____ | _____ lb |
| c. Net weight of manure (b - a) | _____ | _____ | _____ | _____ | _____ lb |
| d. Area of sheet or pans | _____ | _____ | _____ | _____ | _____ ft ² |
| e. Application rate (c ÷ d) | _____ | _____ | _____ | _____ | _____ lb/ft ² |

Ground sheet or pans to tons per acre.

- | | | | | | |
|--|-------|-------|-------|-------|--------------|
| f. Application rate [(e x 43,560) ÷ 2,000] | _____ | _____ | _____ | _____ | _____ ton/ac |
|--|-------|-------|-------|-------|--------------|

Pans to gallons per acre.

- | | | | | | |
|---|-------|-------|-------|-------|--------------|
| g. Tare weight of a 5-gallon bucket | _____ | _____ | _____ | _____ | _____ lb |
| h. Weight of a 5-gallon bucket full of manure | _____ | _____ | _____ | _____ | _____ lb |
| i. Net weight of 1 gallon of manure [(h - g) - 5] | _____ | _____ | _____ | _____ | _____ lb/gal |
| j. Application rate [(e x 43,560) ÷ g] | _____ | _____ | _____ | _____ | _____ gal/ac |

Nutrient application = tons/acre x pounds of nutrient per ton
or gallons/acre x pounds of nutrient per gallon.

Worksheet 13A-4—Uniformity Testing

1. Layout a line of small ground sheet sheets or pans of equal size, equally spaced across two spreader path widths

a. Determine the pan or sheet area.

width _____ inch x length _____ inch ÷ 144 = area _____ ft²

2. Spread manure over the collection area.

Forward speed, gear or throttle setting _____

PTO speed _____

Spreader setting _____

| | Area 1 | Area 2 | Area 3 | Area 4 | Area 5 | Area 6 | Area 7 | |
|--|--------|--------|--------|--------|--------|--------|--------|--------------------|
| a. Tare weight of sheet or pan and weighing container | _____ | _____ | _____ | _____ | _____ | _____ | _____ | lb |
| b. Gross weight of sheet or pan, collected manure and weighing container | _____ | _____ | _____ | _____ | _____ | _____ | _____ | lb |
| c. Net weight of manure (b - a) | _____ | _____ | _____ | _____ | _____ | _____ | _____ | lb |
| d. Area of sheet or pans | _____ | _____ | _____ | _____ | _____ | _____ | _____ | ft ² |
| e. Application rate (c ÷ d) | _____ | _____ | _____ | _____ | _____ | _____ | _____ | lb/ft ² |

Uniformity is achieved when all pans or sheets collect the same amount of manure. To improve uniformity, adjust spreader paths to increase or decrease overlap.

Published 1985-86
Revised 1990-91

**651.1360 Appendix 13B—Manure,
Soil, and Plant Testing**

Manure testing

(Source—Adapted from Manure Testing, Fact Sheet 430, Cooperative Extension Service, University of Maryland System, H.L. Brodia, extension agricultural engineer, Department of Agricultural Engineering, and V. Allan Bandel, extension soil specialist, Department of Agronomy, University of Maryland at College Park, published 1986-87, revised 1986-87, reprinted 1990, 1991.)

Manure analysis is a vital part of nutrient management planning for farms, which can save producers money and protect water quality.

Benefits

Agricultural waste must not be viewed as merely a disposal problem, but as a valuable resource. Applied at proper rates to cropland, manure improves the physical condition of the soil and reduces the need for commercial fertilizers.

Agricultural wastes, such as manure, are rich in plant nutrients. A recent report by Cornell University showed that approximately 75 percent of the nitrogen, 60 percent of the phosphorus, and 80 percent of the potassium fed to dairy cattle is excreted in manure (poultry and swine have higher values for phosphorus and potassium). In addition, manure supplies calcium, manganese, magnesium, zinc, copper, sulfur and other micronutrients.

Manure produced

Livestock produce valuable amounts of fertilizer. Chapter 4, Waste Characteristics, shows just how much fertilizer beef and dairy cows and broilers produce daily. Actual nutrient content of manure varies with type of animal, feed, manure storage system, and method of manure application.

The bottom line

Assuming no nutrient loss during handling and a value of \$0.22 per pound for nitrogen, \$0.20 per pound for phosphoric acid (P_2O_5), and \$0.10 per pound for potash (K_2O) (based on 1991 pricing data):

- A 100-head beef herd produces \$4,410 worth of fertilizer per year.
- A 100-head dairy herd produces \$4,810 worth of fertilizer per year.
- A 100,000-bird broiler operation produces \$3,485 worth of fertilizer per year.

Costs of not testing

Without manure analysis, farmers may be buying more commercial fertilizer than is needed or spreading too much manure on their fields. Either practice can result in overfertilization, which, in turn, may depress crop yields and cut profits. Improper spreading of manure also can pollute surface and ground water. Additionally, contamination of wells by nitrates and bacteria may increase health risks.

Manure analysis

To get an analysis of manure, take the following steps:

1. Contact the county Extension agent or your local testing laboratory for a Nutrient Management Kit. The kit may contain a manure sampling jar, soil test bags, record sheets and instructions. A fee may be charged with each soil sample.
2. Collect a *representative* manure sample. For daily spreading, take many small samples over a representative period. In a manure pack, collect samples from a variety of locations in the pile. Be sure to collect both manure and bedding materials. Agitate liquid manure systems before you collect samples.
3. Follow the specific instructions included in the kit for collecting samples from your liquid, solid or semisolid system with a minimum of mess and effort. The small samples collected should be mixed together in a clean bucket. Place a portion of the mixture in the sample jar.
4. Keep samples cool and deliver them to the county Extension agent early in the week to avoid storage over weekends or holidays.

Collect samples well in advance of the date manure is plan to be spread so the test results can be used to calibrate the manure spreader. With liquid waste systems it may be easiest to collect samples when the manure is pumped into the spreader. Use these test results to calibrate the spreader for future applications of manure, or to determine if additional chemical fertilizer is needed.

The manure sample should be analyzed for nitrogen, phosphorus, potassium, moisture content, calcium, manganese, magnesium, sulfur, zinc and copper. A copy of the results will be sent directly to the applicant and the county Extension agent. The agent will be able to answer questions and help plan fertilization and nutrient management programs.

Soil testing

Soil testing is an important agronomic tool for determining crop nutrient needs. Soil testing evaluates the fertility of the soil to determine the basic amounts of fertilizer and lime to apply. The following sections describe how to use soil testing to evaluate crop nutrient needs.

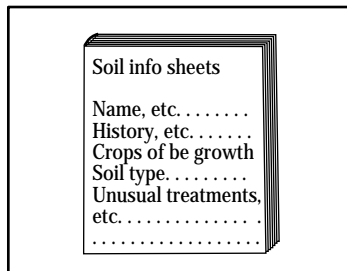
Sampling instructions

Collecting the sample is one of the most important steps in the soil testing program. When one considers that the 2-pound soil sample must adequately represent 10 million or more pounds of soil in the area being sampled, the importance of doing a good job of sampling becomes apparent. Instructions for collecting a good representative soil sample follow.

Using the soil test report

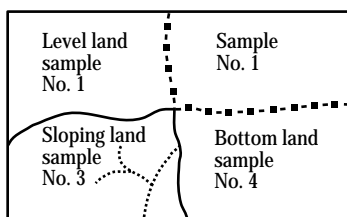
The soil test report generally contains the laboratory test results plus fertilizer and lime recommendations for the next two crops in the rotation. Additional information regarding time and method of fertilizer and lime application will also be provided in the form of a soil test note which will accompany the report. When several samples have been collected from the same field, the Soil Test Reports should be compared to determine the best rates of fertilizer and lime to use for the field. Large differences in the reports may call for fertilizer and/or lime at two or more different rates.

Sampling soil



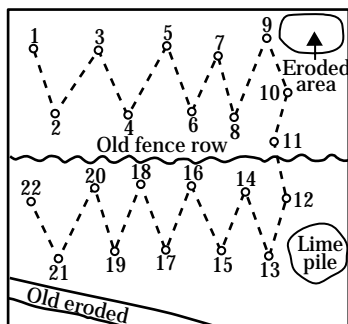
1. Obtain soil samples information sheet and soil boxes

A laboratory must be located that can provide appropriate soil testing. These laboratories can often be accessed through Extension Service agents and fertilizer dealers. The laboratory will provide directions to follow for soil sampling.



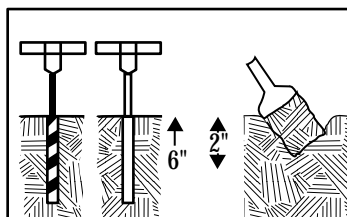
2. Divide farm into areas or fields

If the field is uniform, one sample will do. But most fields will have been treated differently, or the slope, drainage, or soil type will make it desirable to divide the field into small areas of 5 to 10 acres each.



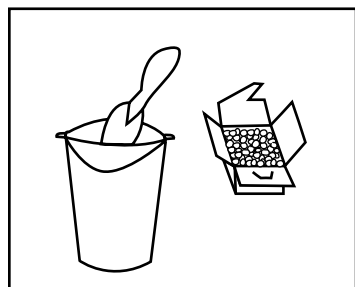
3. Obtain a good sample of soil

The soil test can be no better than the sample. Take the sample from 20 or more places in the field. Zig-zag across the field or area as shown in the diagram. When taking sample, avoid unusual places such as old fence row, old roadbeds, eroded spots, where lime or manure have been piled, or in the fertilizer band of row crops.



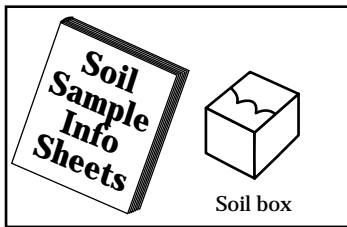
4. Use proper sampling tools

Sampling may be made with a soil auger, soil tube, or spade. The desired depth for cropland is plow depth (6 to 8 inches or more), and for pasture land, 2 to 4 inches. Place sample in clean container.



5. Mix well in clean plastic pail

From the 20 or more stops you have made, you now have 1/2 gallon or more of soil. Mix it thoroughly, then send about 1/2 pint of the mixed soil for analysis.

**6. Fill out sample information sheet for each sample**

It is essential that your name, address, and sample number be plainly written on the sheet you send with each sample. As a guide in making recommendations for each of your numbered areas, it is important that the history of treatments and any unusual treatments be stated.

7. Mail to soil testing and plant analysis laboratory

Place completed the Soil Sample Information Sheet inside the flap of the soil sample box and mail to the laboratory. Generally, the laboratory will make a routine test of seven analyses (soil pH, phosphorus, potassium, calcium, magnesium, zinc, and manganese) on all samples. Special tests on organic matter, nitrate-nitrogen, and soluble salts can be requested if needed.

Plant testing

Plant testing is also an important agronomic tool for determining crop nutrient needs. It is used as a monitoring tool to determine if the fertilization and liming program, as determined by the soil test, is providing the nutrients at the necessary levels for top yields. Plant analysis is the ultimate test; i.e., is the plant obtaining, from the soil, ample nutrients for good growth and development. If not, nutrients can be added during the existing growing season to improve yields, or the fertilization program can be modified for next year's crop.

Plant testing procedure

- 1. Submit clean sample**
Avoid submitting sample tissue that is contaminated with dust or soil. If tissue is dusty or dirty, remove as much of it as you can by shaking, brushing, or washing the tissue in gently-flowing water.
- 2. Sample healthy plant**
Do not sample disease, insect, or mechanically damaged plant tissue.
- 3. Place in clean bag**
Place the plant tissue in a clean paper bag. Do not use plastic bags. If the sample is wet or succulent, let it air-dry in the open for one day before sending it to the laboratory. Identify each sample by number and crop name.
- 4. Take two samples**
When using tissue analysis in the diagnosis of crop production problems, take one sample from the problem area in the field and one from an area where plants appear normal.
- 5. Sample proper plant part at proper time**
When sampling, both the time (growth stage) and plant part collected are important. Be sure to sample at the recommended time and collect the proper plant part.
- 6. Follow sampling instructions**
If there are no specific sampling instructions for the crop to be analyzed, a good rule of thumb is to sample mature leaves that are representative of the current season's growth during the mid period of the growth cycle or just prior to seed set.

7. Fill out a Plant Analysis Information Sheet

The plant analysis laboratory will provide the information sheet. The completed sheet should indicate where the results should be mailed and record each sample number along with crop name. Send the sample and completed information sheet to the laboratory.

8. Analyses performed

Sample should be analyzed for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), manganese (Mn), zinc (Zn), copper (Cu), iron (Fe), boron (B), and aluminum (Al). In addition, a sulfur (S) test can be run if needed.

(Source—A Handbook of Agronomy, Virginia Cooperative Extension Service, Publication 424-100, Revised December 1987.)

**651.1370 Appendix 13C—Operation,
Maintenance, and Safety Guidelines**

Appendix 13C

Operation, Maintenance, and Safety Inspection Guidelines

Production Function

| Element to check | How to check | Recommended action |
|-----------------------|--|--|
| Nutrients produced | Compare feed ration, number of animals, and weights of animals assumed in design. | Make appropriate adjustments to the nutrient management plan if nutrients are significantly different from those assumed. |
| Volume produced | Compare actual number of animals, weights of animals, bedding used, areas producing polluted runoff, and other sources of wastewater to those assumed in design. | If actual volume produced is greater and will result in early filling of storage/treatment facilities, see the Troubleshooting Guide for recommended action. |
| Clean water exclusion | See that clean water exclusion practices, such as diversion channels, roof gutters and downspouts, and curbs, are functional and in good condition. | Maintenance should be performed to correct deficiencies found. |

Collection Function

| Element to check | How to check | Recommended action |
|-------------------|--|---|
| Alley scrape | Observe that alleys are relatively clean after being scraped and that animals are not being interfered with during scraping. Note areas that are not being cleaned during scraping. Observe that mechanical scrapers are operating properly. | Evaluate consequences, such as odor, that may result because of lack of cleanliness. Make suggestion on how to achieve more cleanliness if consequence for not doing so would be significant. Tractor scrapers and other related equipment needed should be available, maintained, and equipped with adequate safety devices, such as roll over bars and shields. Equipment that is not properly equipped with safety devices should not be used until it has been so equipped. |
| Alley flush | See that alleys are relatively clean after being flushed, particularly along curbs and at the end of alleys. | Adjust flow rate and/or duration of flush as necessary to achieve necessary cleanliness. See that safety precautions are taken in use of flush tanks that tip or otherwise present a hazard. |
| Gutter scrap | Observe cleanliness after scraping. | Suggest adjusting travel speed of scraping mechanism if satisfactory cleanliness is not being achieved. |
| Reception hoppers | See that dry material is not being placed in hopper. Observe whether ice is forming in hopper. | Blend wet material with dry material before placing in hopper. Hopper should be protected from freezing. |
| Slatted floors | See that ventilation is provided beneath slatted floors. Check structural integrity of slats. | Provide ventilation if not found. |

Storage Function

| Element to check | How to check | Recommended action |
|---------------------------|--|---|
| Waste storage pond | | |
| Rate of filling | Observe availability and readability of staff gage in pond with marks or cross-bars at intervals that will permit calculation of volume of waste added per unit of time, i.e., month. Use gage readings in conjunction with pond's stage-storage relationships to determine rate of filling. | A staff gage should be installed if one is not present. If rate of filling will result in an early filling of storage facilities, see Troubleshooting Guide for recommended action. |
| | Determine waste and wastewater contribution. | Examine records kept of how often and what amounts of waste are added to the pond. |
| | Determine precipitation contribution to filling. Examine onsite or nearby weather station rain/snow gage readings. Compare with precipitation assumed in design. | If determined that precipitation has been excessive, reduce waste production to offset excess precipitation in storage or do emergency pumping to allow for future storm events. |
| | Determine amount of evaporation. Examine onsite or nearby weather station evaporation records. Compare actual evaporation with the amount assumed in design. Recognize that crusts formed on pond surfaces may reduce evaporation. | Reduce amount of waste produced or make adjustment in pumping schedule if evaporation is less than assumed in design. |
| Agitation | Observe that pond contents are agitated properly. | Assure that agitation is according to the agitation equipment manufacturer owner's manual recommendation for time and spacing. |
| | Observe that bank protection at agitation points is adequate. | If erosion is present, install bank protection or make adjustment of agitation point so erosion will not occur. |

Storage Function—Continued

| Element to check | How to check | Recommended action |
|---------------------------------------|---|---|
| Waste storage pond (Continued) | | |
| Pump intake | Observe that intake is located at a depth that will minimize intake of solids material that will clog land application equipment, such as nozzles and orifices. | Make appropriate revision to pump intake to minimize clogging of land application equipment. Check adequacy of agitation equipment. |
| | Observe that sides and bottom are protected or intake is far enough away to avoid erosion during pumping. | Install protection or move pump intake if erosion is occurring. |
| | Observe that intake screens with appropriate size opening are in place. Observe frequency of clogging of screens and method for cleaning screens. | Make adjustments to minimize clogging. |
| Safety measures | Observe that fences and gates are maintained and that warning signs are visible and in good condition. | |
| | Assure that access ramps have appropriate guard rails and safety curbs in place and cleaned so traction surfaces are exposed. | |
| | Ascertain that a life ring, life line, or pole is readily available in case of an emergency. | |

Waste storage structure—tank

| | | |
|-----------------|--|--|
| Rate of filling | Use established method for determining depth of waste in the tank that will permit determination of volume of waste and allow calculation of volume per unit of time, e.g., cubic feet per month. This rate can be compared to rate of filling assumed in design. The rate can also be used as a basis for planning/design of subsequent AWMS's. | Make adjustment to reduce filling rate if it exceeds assumed rate. |
|-----------------|--|--|

Storage Function—Continued

| Element to check | How to check | Recommended action |
|---|--|--|
| Waste storage structure—tank (Continued) | | |
| Agitation | During agitation observe that dry crusts that may have formed on the surface and heavy solids that may have settled to the tank are put into suspension. | Improve methods used in agitation if it is inadequate. |
| Emptying | Confirm that tank is pumped out in accordance with established utilization plan and that records are kept of when and how much is removed from the tank. | |
| Structural integrity | For reinforced concrete structures, inspect for excessive cracking and concrete deterioration. | Consult with concrete repair specialist for recommended repairs. |
| | For steel tanks check for corrosion around bolts and deterioration of protective coatings. | Repair, if found. |
| | Observe differential or excessive settlement. | If found, consult an engineer for action needed. |
| Water table control drains | See that drains are properly functioning to maintain water table to level required for structure loadings assumed in design. | |
| Safety measure | Assure that warning signs are visible and in good condition, and that protective grates and covers are in place. Confirm that an emergency action plan is in place to deal with accidental tank entry or other crisis. | Assist in development of a plan if one has not been developed. |

Storage Function—Continued

| Element to check | How to check | Recommended action |
|--|--|--|
| Waste storage structure—Stacking facility | | |
| Rate of filling | Make an estimate of volume based on measurement of stack. Divide the volume estimate by the number of days waste has been stored in the facility. Compare actual daily rate with that assumed in design. | If found to be excessive, make adjustments to reduce the daily volume of waste produced, such as using less bedding. |
| Structural integrity | For reinforced concrete structures, inspect for excessive cracking and concrete deterioration. | Consult with concrete repair specialist for recommended repairs. |
| | Check wood portions of structure for damage. | Replace as appropriate. |
| Roofing | Check trusses and rafters for damage. | Repair as necessary. Repair roofing if leaks are noted. See that fasteners are tight and in good repair. |

Treatment Function

| Element to check | How to check | Recommended action |
|------------------------------------|---|---|
| Waste treatment lagoon | | |
| Operating depth/treatment depth | Observe availability and readability of staff gage in lagoon marked to show minimum depth; maximum depth (depth above which insufficient storage remains for the 24-hour, 25-year storm event); and elevation of top of embankment or spillway. | Install staff gage if one is not present. |
| Loading rate | Compare wastewater sources being discharged in lagoon with those assumed in design. | If loading rates exceed those in design, suggest ways to reduce loading rates or changes in operation of the lagoon to accommodate the additional loading. |
| | Take wastewater samples, have them tested for VS or BOD ₅ and compare results with the values assumed in design. | If loading rates exceed those in design, suggest ways to reduce loading rates or changes in operation of the lagoon to accommodate the additional loading. |
| Performance in reducing pollutants | Test lagoon contents periodically to determine changes in ammonia (NH ₃), total phosphorus (TP), total nitrogen (TN), total dissolved solids (TDS), and bacteria. | Excessive ammonia and TDS (salts) can effect lagoon function. High TP and TN concentrations can create land application problems. If above parameters are suspected of being excessive, dilution, reduction in loading rates, increase in residence time, or some other appropriate measure should be considered to improve the lagoon's performance. |
| Agitation | Observe that lagoon contents are agitated properly. | Assure that agitation is according to agitation equipment manufacturer owner's manual recommendation for time and spacing. |
| | Observe that bank protection at agitation points is adequate. | If erosion is present, install bank protection or make adjustment of agitation point so erosion will not occur. |

Treatment Function—Continued

| Element to check | How to check | Recommended action |
|---|---|--|
| Waste treatment lagoon (Continued) | | |
| Bottom sludge | Determine depth of the bottom sludge and compare the depth with that reserved for its acclimation in design. | If it exceeds the amount assumed in design, it will infringe on the minimum treatment volume and, as such, it should be removed from the lagoon. Consistency of the sludge determines how its thickness is measured and how it may be removed. If the bottom sludge has a solid consistency, determine top elevation of sludge and compare with "as built" lagoon bottom elevation to determine its thickness. Generally, some sort of excavating equipment must be used to remove solid sludge. If the bottom sludge has a liquid consistency, its thickness and total solids must also be determined. The depth is used to determine if the sludge volume infringes on the minimum design volume and total solids is used to decide if the sludge can be pumped. A light and light sensor apparatus can be used to determine the depth. A rigid translucent pipe driven into bottom of lagoon and retrieved with a soil plug can be used to obtain a sample for determining total solids. Generally, wastewater with less than 5% solids can be pumped. If the sludge has total solids of more than 5%, it may be necessary to agitate the bottom sludge before pumping. |
| Aeration | Assure that operation of aeration equipment is consistent with recommendations in manufacturer owner's manual(s) and conforms to design requirements. | If undesirable odor is present, take sample of lagoon contents from within the top 2 feet of lagoon water surface and test for dissolved oxygen at the detectable level, 0.1 mg/L. If aeration operation needs to be changed, a manufacture representative should be consulted. |
| | Observe that none to very few organic solids are present on the lagoon surface. | A few solids on the surface for a newly installed aeration system does not necessarily indicate a problem. |

 Treatment Function—Continued

| Element to check | How to check | Recommended action |
|---|--|---|
| Waste treatment lagoon (Continued) | | |
| Safety measures | Inspect fence and gates to see that they are in good repair. See that warning signs are visible and in good condition. | Correct deficiencies as appropriate. |
| Mechanical separation | | |
| Volume of solids separated | Compare the volume of solids being separated with the volume assumed to be separated in planning/design. | If not to expectations, check that total solids of the wastewater is within the range recommended by the manufacturer. |
| | Make sure wastewater is agitated so that all solids are in suspension prior to separation. Check flow rate to see that it does not exceed manufacturer's recommendation. | Reduce flow rate if found to be excessive. |
| Safety measures | Check to see that moving parts are guarded. See that warning signs, ladders, and handrails are in good condition. Also see that access to separation equipment towers and pits is denied to unauthorized people. | Safety deficiencies must be repaired or installed if hazards are found. |
| Settling basins | | |
| Volume of solids settled out | Compare the volume of solids being settled out with the volume assumed to be settled in planning/design. | If found to be less, check detention time assumed in design. If found inadequate, increase detention time by reducing inflow and/or outflow from the settling basin or increasing volume of settling basin. |

Treatment Function—Continued

| Element to check | How to check | Recommended action |
|--|--|--|
| Dilution | | |
| Adequacy of dilution | Test diluted wastewater for total solids. Compare with the desired total solids for the treated wastewater assumed in design. | If significantly different than assumed, evaluate the consequence of it being different on the basis of the purpose for dilution. Either reduce amount of dilution water added or add additional water with a lesser amount of total solids to achieve desired total solids. |
| Vegetative filters | | |
| Performance of vegetative filter (infiltration area) | See that wastewater is not leaving filter area. | Lengthen filter if wastewater exits filter area. |
| | Assure that filter is given a minimum 2-day rest period each week. | |
| | Assure that wastewater is uniformly distributed over the width of the filter. | Regrade and revegetate filter as necessary. |
| Composting | | |
| Pile temperature | Using thermometer probe, check internal temperature of compost pile. The pile temperature should be checked at a point one-third the distance from the outside of the pile to the center of the mass. Compost temperatures should peak between 130 and 140 degrees F in 5 to 7 days. | See the troubleshooting guide if piles fail to heat or exceed 150 degrees F. |
| Carbon:nitrogen ratio of compost mix | Take a representative sample of the raw compost mixture and have a laboratory determine the carbon and nitrogen content. The carbon to nitrogen ratio should range between 25 and 40 to 1. | Make adjustments to the ingredients of the recipe as necessary to achieve a carbon to nitrogen ratio within the range of 25 to 40 to 1. |
| Moisture of compost mix | Take sample and check moisture content. The moisture content should range between 40 and 60 percent. | Add water or drier material to adjust moisture content. If drier material is added, care must be taken to see that the carbon to nitrogen ratio of the mix is still in the 25 to 40 to 1 range. |

Treatment Function—Continued

| Element to check | How to check | Recommended action |
|------------------|--------------|--------------------|
|------------------|--------------|--------------------|

Composting (Continued)

pH of compost mix

Check pH of compost mix. The pH preferably should range between 6.5 and 8. Composting may be adequate between a pH of 5.5 and 9.0

Finished compost

Observe that compost has little or no trace of the original raw material and has little odor. The material should be black to brown in color. Particle size should be consistent and soil-like in texture.

Transfer Function

| Element to check | How to check | Recommended action |
|--------------------------|--|--|
| Reception pits | | |
| Structural integrity | For concrete and concrete block structures, inspect for excessive cracking and concrete deterioration. | Consult with concrete repair specialist for recommended repairs. |
| Foreign material | Check for excessive debris that will impair function of pit. | Remove debris remotely from outside the pit. |
| Safety | Assure that protective grates are installed in good condition. Assure that pits enclosed in buildings are properly vented to prevent accumulation of gases. | |
| Gravity pipelines | | |
| Outlet | See that outlet is free flowing and is not causing erosion. | |
| Safety | Note that pipeline inlets located within buildings are properly vented so gases do not accumulate. | |
| Pushoff ramps | | |
| Safety | Assure that restraints to prevent equipment from accidentally going off the end are in place and in good repair. Assure that traction surfaces are exposed. | |

Transfer Function—Continued

| Element to check | How to check | Recommended action |
|-------------------------|---|---|
| Picket fences | | |
| Function | Assure that water has a clear drainage path from the face (leading edge) of the manure pile to the picket dam. | |
| Structural integrity | Inspect lumber and hardware elements for deterioration. | Replace as necessary. |
| Pumps | | |
| Operation | <p>Ascertain that pump and motor are receiving regularly scheduled lubrication.</p> <p>Note that intake is properly protected to screen out oversized material and is not plugged.</p> <p>Notice that wastewater to be pumped is adequately agitated prior to pumping to assure that all solids are in suspension.</p> <p>During periods of non-use see that pump is drained or otherwise protected from freezing, if appropriate for climate.</p> <p>Listen to operation of pump and motor for abnormal noise.</p> | The pump and motor should be serviced by a qualified technician if abnormal noise is heard or excessive vibration is noted. |
| Suction and discharge | See that supports to bear weight of suction pipe and discharge pipes are in place and adequate. | |
| Pump and switch housing | Observe that housing for motor and switches is adequate for protection from sun and rain. | |

 Transfer Function—Continued

| Element to check | How to check | Recommended action |
|----------------------------------|--|--|
| Pumps (Continued) | | |
| Safety | <p>Determine that adequate safety devices, such as guards and shields, are in place.</p> <p>Check that motors and switches are properly grounded and that exposed wiring is both insulated and protected against accidental contact.</p> | |
| Equipment | | |
| Proper operation and maintenance | Verify that equipment is operated and maintained in accordance with manufacturer's recommendations. Records of use should be kept. | Perform maintenance at recommended intervals. |
| Safety | <p>Assure that safety devices and equipment is in good repair and being used as appropriate.</p> <p>Assure that tractors are matched with hauling equipment being pulled.</p> | |
| | Assure that public safety is protected when hauling equipment uses public roads. | Use proper signage and clean up spilled materials. |

Utilization Function

| Element to check | How to check | Recommended action |
|-------------------------|--|---|
| Land application | | |
| Amount applied | <p>Measure the amount of waste actually being applied. Estimate the amount of nutrients being applied by considering nutrient losses involved to the point of application. A laboratory analysis to determine nutrient content of the waste applied allows a more precise estimate. Compare actual amount of waste and nutrients being applied to the recommendations in the nutrient management plan.</p> <p>Observe the condition of the crop. For example, yellowing might indicate that not enough nutrients are being applied. On the other hand, burned leaves might indicate that too many nutrients are being applied.</p> | <p>If nutrients being applied are found excessive or crop condition indicates overapplication, reduce future application amounts. This may require that additional fields receive waste or that waste treatment be included in the AWMS to reduce nutrient content of the waste.</p> <p>If nutrients being applied are found insufficient for optimum production or the crop condition indicates under-application of nutrients, consider supplementing with commercial fertilizer.</p> <p>Recommend calibrating application equipment.</p> |
| Method of application | <p>Observe method being used to apply waste. Compare method being used with the method assumed in computing nutrient losses for the nutrient management plan.</p> | <p>If a different method is being used, it may be necessary to adjust to the amount of the waste applied. For example, if the nutrient management plan it was assumed a surface application method and an injection method is being used, nitrogen loss may be less than assumed, so more nutrient are actually being applied to the crop than planned. This may make the nutrient application excessive.</p> |
| Placement of waste | <p>Observe how the waste is being placed and its distribution on the farm. Check for field runoff during application.</p> | <p>Compare fields to which waste is being distributed to those planned to receive waste in the nutrient management plan. Recommend appropriate modification if they are found different. If waste application is not evenly distributed or is causing runoff, recommend adjustment to equipment itself or in the way equipment is being used.</p> |

Utilization Function—Continued

| Element to check | How to check | Recommended action |
|-------------------------------------|--|--|
| Land application (Continued) | | |
| Timing of application | Observe when waste is being applied. | Compare actual timing with timing recommended in the nutrient management plan. Consider the environmental consequences if actual timing of application and recommended timing differ. Consequences, such as increased runoff and leaching losses, and inability of crop to use available nutrients should be considered. Recommend modification to timing of application if appropriate. |
| Safety | Observe unsafe actions or conditions, such as unshielded moving parts that could be injurious. | Recommend appropriate modification to unsafe activities or correct unsafe conditions (see 651.1303). |
| Biogas production | | |
| Overall system | Evaluate daily operating temperatures and gas production records. | If gas production is not to the level anticipated, check volatile solid loading rates. Make appropriate adjustments. |
| Covered lagoon | Check cover visually for rainwater accumulation, tearing, wear holes, and proper tensioning. | Make appropriate repairs or adjustments to the cover. |
| Complete mix digester | Check operating temperature. Check cover visually for rainwater accumulation, tearing, wear holes, and proper tensioning. Evaluate mixer and heat exchanger maintenance records for proper lubrication. | Make appropriate repairs or adjustments to the operation of the digester system. |
| Plug flow digester | Check operating temperature. Check the effluent outlet and digester gas relief valves for proper operation. Check cover visually for rainwater accumulation, tearing, wear holes, and proper tensioning. Evaluate heat exchanger pump maintenance record for proper lubrication. | Make appropriate repairs or adjustments to the digester system. |

Utilization Function—Continued

| Element to check | How to check | Recommended action |
|------------------|--------------|--------------------|
|------------------|--------------|--------------------|

Biogas production (Continued)

| | | |
|--------|--|----------------------------|
| Safety | Visually check to see that safety fencing and warning signs are in good condition. | Correct unsafe conditions. |
|--------|--|----------------------------|

651.1380 Appendix 13D—Agricultural Waste Management System Troubleshooting Guidelines

Production function

Observed problem

Recommended actions

An unusually strong odor is present where animals are kept

Check for manure covered animals and excess manure. Animals should be cleaned and adjustments made to keep them separate from their manure.

Look for evidence of poor drainage in lot areas. If noted, improve lot drainage and consider such things as installing concrete pavement around feeders and waterers to keep lot drier.

Collection Function

Observed problem

Recommended actions

An unusually strong odor is present in animal housing area

Check for spilled feed that is being allowed to ferment or areas where manure is not being routinely collected and removed. Remove these materials as a measure to reduce odors.

Check the frequency of collection. Suggest consideration be given to more frequent collection to reduce odors.

Check for manure covered animals.

Check for soiled or wet bedding. If found in excessive amounts, a more frequent removal schedule should be considered.

Consider providing additional ventilation.

Storage Function

Observed problem

Recommended actions

Waste storage pond

Pond is filled at or near capacity too early

Activate the contingency plan for emptying a portion of pond's contents to allow for future waste storage and storm events.

Undesired material in pond

Initiate removal prior to pumping. Take remedial measures to exclude undesired material from pond.

Waste storage structure—Tank

Undesired material in tank

Assure that measures, such as sand traps and settling tanks, are in place to prevent mineral material from entering the tank. Install measures to remove undesired material if not in place.

If possible, exclude all foreign material, such as baling wire or twine, plastic bags, wood, and syringes, from the tank. Remove any materials that are found in the tank.

Waste storage structure—Stacking facility

Waste will not stack

Suggest ways that the total solids of the waste can be increased, such as using less water or increasing the amount of bedding used.

Treatment Function

Observed problem

Recommended actions

Waste treatment lagoon

An unusually strong odor is present

Check pH of lagoon water (should be between 5.5 and 8.0). The optimum pH is about 6.5. Testing for pH can be done in several ways. A meter with pH electrode provides a means of making a quick and accurate test. Tests should be taken at different locations and depths to assure a pH representative of the lagoon contents. If the pH falls below 6.5, add 1 pound of hydrated lime or lye per 1,000 square feet of lagoon surface daily until the pH reaches 7.0.

Observe color of water. Very black water is indicative of low or no desired biological activity. Other colors, such as purple or various shades of brown, are indicative of water having high suspended solids content, and they normally represent proper operation. Dilution or aeration should be considered as possible ways of reducing odor.

Test composition of water. Concentrations of ammonia should not exceed 600 mg/L, and TVS should not exceed recommended loading rates. Suggest reducing loading rates, dilution, or aeration as ways to reduce odor.

Undesired material in lagoon

Remove undesired material from lagoon if present.

Floating crust

Crust formation generally does not effect the treatment function of an anaerobic lagoon; however, it does reduce evaporation from the lagoon surface. If a crust forms and if design assumed a reduction in storage requirements because of normal evaporation, early filling may result. An adjustment, such as reducing the quantity of wastewater inflow, will be required to compensate for less evaporation losses.

Mechanical separation

Plugs with solids

Completely wash out the separator. Washing remaining solids from the separator after each use so solids will not dry in place may also reduce potential of plugging.

Vegetative filters

Excessive buildup of solids in vegetative filter

Consider solid separation prior to discharge into filter. Regrade and revegetate if buildup of solids is affecting performance of filter.

Vegetation is dying or has died

Revegetate as necessary. Consider dilution of the wastewater before discharge. An alternative treatment component to treat wastewater should also be considered.

Treatment Function—Continued

Observed problem

Recommended actions

Composting

Pile temperature—Temperature too low

Check moisture content of pile. Remedy is adding water or wet ingredient if pile is too dry. Add dry material and remix if too wet (moisture content of more than 60%).

Check C:N ratio of pile mix. Remedy is adding high nitrogen ingredient if the C:N ratio is greater than 50:1.

Check pH of pile. Remedy is adding lime or wood ash and remixing if pH is less than 5.5.

Observe pile structure evidenced by pile settling too quickly and few large particles. Remedy is adding bulking agent and remixing.

If weather is cold, remedy is to enlarge or combine piles or to add highly degradable ingredients.

Pile may fail to heat because of improper aeration. Aerate pile and check temperature frequently to see if it increases.

Pile temperature—Temperature prematurely falls consistently over several days

Indicates low oxygen. Remedy is to turn or aerate pile. Check moisture content. If low, the remedy is to add water.

Pile temperature—Temperature is uneven and has accompanying varying odor

Observe differences in pile's moisture content and materials. If observed the remedy is to turn or remix pile.

Pile temperature—Temperature gradually falls, and pile does not reheat after turning or aeration

Observe for completeness of composting as described in the O&M and Safety Inspection Guidelines, finished compost. If complete, no action is required. If composting is not complete, check for low moisture content. If low, add water.

Pile temperature—Pile overheating with temperatures greater than 165 °F and rising

Check the height of the composting material. It should never exceed the 5 to 7 feet range. Reducing the height will lessen the probability of spontaneous combustion.

Check for low moisture and a pile interior that looks or smells charred or if temperatures are even exceeding 180 °F. If any of these conditions are apparent, then the material should be removed from the composting bin. Do not add water to the compost as this may promote additional combustion. Avoid putting materials with dissimilar moisture contents next to each other.

 Treatment Function—Continued

Observed problem

Recommended actions

Composting (Continued)

Pile temperature—Pile is extremely overheating with temperatures greater than 170 °F

Check for low moisture and a pile interior that looks or smells charred. If these conditions exist, break pile down and re-pile to a reduced size.

Strong ammonia odor is present

Check C:N ratio and add amendment if less than 20:1.

Check pH. Add acidic ingredients and/or avoid alkaline ingredients if pH is greater than 8.0.

If large woody particles are being used as a carbon source and C:N ration is less than 30:1, use another carbon amendment or increase the carbon proportion.

Rotten-egg or putrid odors comes from pile continuously

Check for low pile temperature and too high moisture content. Add dry amendment if these conditions exist.

Check for low pile temperature and poor structure. Adding bulking agent is the remedy for this condition.

Check for low pile temperature and high compaction. The remedy for this condition is to remix the pile and add bulking agent.

Check for low pile temperature and insufficient aeration. Turning pile and increasing air flow are the options for improving this condition.

Check for low pile temperature and too large a pile. The pile size should be decreased to correct this problem.

Check for falling temperature and insufficient aeration. Turning the pile more frequently should improve this condition.

Flies or mosquitoes

Look for fresh manure or food material at pile surface and flies hovering around pile. Flies or mosquito problems can be reduced by turning the pile every 4 to 7 days and by covering a static pile with a 6-inch layer of compost.

Look for wet materials stored onsite for more than 4 days. Handling raw materials more promptly should reduce this problem.

Look for nearby standing puddles or nutrient-rich pond. Grade site to drain puddles and maintain pond in an aerobic condition.

Treatment Function—Continued

Observed problem

Recommended actions

Composting (Continued)

Compost contains clumps of materials and larger particles, and texture is not uniform

Check for discernible raw materials in compost. Screening compost and improving initial mixing achieve more complete composting.

Check for wet clumps of compost. Remedy is to screen or shred compost and improve air distribution.

Look for large, often woody particles in compost. Screening, grinding, and sorting of raw materials initially improve composting.

If composted materials heat or develop odors, lengthen composting time or improve composting conditions.

Transfer Function

Observed problem

Recommended actions

Reception pits

Foreign material in pit

Check for excessive debris, which will impair function of pit. Remove debris remotely from outside the pit.

Gravity pipelines

Plugging

Longer agitation, dilution, liquid/solid separation prior to transfer, and clean water flushes after transfer help reduce the potential of plugging. Installing cleanouts at locations of frequent plugging can be considered for ease of unplugging.

Utilization Function

Observed problem

Recommended actions

Land application

Crops are scum covered following application

Use a clean-water rinse following application to clean plants.

Soil is sealed following application

Reduce potential by lengthening drying cycle between applications, physically disturbing soil surface, or injecting waste.

Applied nutrients are excessive as determined by observed conditions, such as soil and leaf testing.

Change to a crop that uses a greater amount of nutrients. Use double cropping if appropriate.

Increase crop yield with improved management by such things as pretreating with lime, practicing water management, managing pests, splitting waste applications, and making timely harvest.

Take an action that would reduce the amount of nutrients produced.

Treat the waste or a portion of the waste before land application to reduce its nutrient content and to prepare if for refeeding or for use as bedding.

Locate an off-farm use for the waste.

Enlarge area on which waste is applied.

Health hazards

Isolate and treat infected animals to reduce the potential for high levels of pathogenic bacteria in waste material.

Apply waste on sunny days when temperatures are above 40 °F, ideally at higher temperatures, when bacterial and virus die-off is maximized.

Apply wastes to crops that will not be eaten raw or directly grazed unless adequate time is allowed for bacterial and virus die-off on the produce.

Apply wastes away from high density population area to reduce the possibility of disease transmittal by such factors as wind, insects, rodents, or flowing water.

Limit amount of waste applied to a single site to reduce the possibility of pathogenic bacterial build-up.

Apply waste when soil is not saturated and when rain is not forecast.

Runoff during or soon after application

Consider reducing rate at which waste is applied, applying waste only when rain is not forecast, not applying waste to snow or frozen ground, installing measures to capture runoff and return to AWMS for storage or treatment, and improving soil internal drainage by installing subsurface drainage.

**651.1390 Appendix 13E—Example
Agricultural Waste Management
System Plan**

Agricultural Waste Management System Plan for the Green Dairy

Decisionmaker: Joe Green

Address: P.O. Box 5000, Silverton, Oregon

Phone: (503) 555-1212

General

The agricultural waste management system for the Joe Green Dairy was planned and designed at the request and with the involvement of Mr. Joe Green. The plan is based on decisions and choices made by him. The system is planned to manage waste generated by the dairy in a manner that prevents or minimizes degradation of soil, water, air, plant, and animal resources and protects public health and safety. It is also planned to preclude discharge of pollutants to surface water from a 25-year, 24-hour storm event, to minimize ground water contamination, and to recycle the waste produced through soil and crops to the fullest extent possible.

The Natural Resources Conservation Service plans agricultural waste management systems viewed as having one or more of six functions. These functions are production, collection, transfer, storage, treatment, and utilization. Each of these functions is involved in the system planned for the Joe Green Dairy. The operation, maintenance, and safety requirements for the system presented in this plan are organized by these functions.

System description

The agricultural waste management system was planned to accommodate waste from a herd of 800 Holstein dairy livestock and wastewater from the milk parlor and milk house. The system is planned to divert clean water from the system with roof gutters and downspouts, to collect the manure from the freestall barn with flush alleys in a reception pit, to treat the wastewater with a solid/liquid separator, to store manure and wastewater in a waste storage pond, to transfer the wastewater in a pipeline from the waste storage pond to fields where it will be land applied, and to utilize the waste on 450 acres of pastures.

Decisionmaker's responsibilities

Mr. Green is responsible for the proper installation, operation, and maintenance of the waste management system. Although the system was designed by the Natural Resources Conservation Service using the best available technology, it needs to be inspected and properly operated and maintained in a safe manner if it is to operate as planned and designed.

Mr. Green is also responsible for obtaining a permit from the Oregon Department of Agriculture and all other necessary permits to operate the system. The system must be operated and maintained in accordance with

these permits and other laws and regulations that pertain to its operation including the Oregon Occupational Safety and Health Code for Agricultural Operations and Farming. All personnel must be trained or informed of the safety and the operation and maintenance requirements for the system.

An inventory of equipment related to each function will be made and checklists developed, as necessary, for preventive maintenance and inspection. A supply of spare parts necessary to keep the system operating will be kept on hand. Nameplate data, reference manuals, catalogs, drawings, and other manufacturers' information necessary to operate and maintain the equipment used in the system will be kept. A record will be kept of hours of operation for system equipment that is routinely maintained on a time-used basis.

Component installation schedule

The system components will be installed according to the following schedule:

| Component | Installation date |
|--|-------------------|
| Reception pit | 5/99 |
| Roof gutters and downspouts | 7/99 |
| Solid/liquid separator (including storage pad) | 10/99 |
| Waste storage pond | 6/00 |
| Transfer pipeline | 9/00 |

Production function requirements

The production function of an AWMS relates to the amount of waste produced within the system. The system design was based on waste production estimates for 800 Holstein dairy livestock, which includes 500 milk cows, 150 dry cows, and 150 heifers. Exceeding either the number or type of livestock may invalidate the design for the system. The system was designed based on a daily manure production of 1,336 cubic feet per day and milk house and milk parlor wastewater production of 420 cubic feet per day. The amount of manure and wastewater produced must be monitored to assure that it does not exceed these design volumes. These volumes can be estimated using the staff gauge readings and the stage storage curve for the waste storage pond. Production rates that exceed those estimated in design will result in premature filling of the waste storage pond.

The system was designed assuming that roof water would be excluded from the system. For this reason the roof gutter and downspout system on the barn must be maintained. The gutters and downspouts will be inspected during rainstorms to check for leaks and clogs. If found, the gutters and downspouts must be repaired. The gutters must be cleaned of debris annually. The protective coatings on the gutters should be inspected at this time and repaired if necessary.

Production function safety items include maintaining ventilation to prevent the buildup of gases within the freestall barn. Workers must be informed of the danger of gases and the necessity of keeping vents open at all times, even during cold weather.

Collection function requirements

The collection function pertains to the capture and gathering of manure and wastewater so it can be further managed. Manure is collected from a freestall barn with flush alleys. Temporary storage is provided by a below-ground, reinforced concrete reception pit. Flush water used in the system is recycled from the waste storage pond. Flush tanks are filled using a pump and pipeline. The pump enclosure will be maintained to prevent exposure to the elements. Pump maintenance will be according to the manufacturer's recommendations. Pump safety features will be maintained. The flushing operation will be monitored for effectiveness in moving the manure to the reception pit. The frequency and/or duration of flushing will be adjusted as necessary.

The grates and covers for the reception pit must remain secured in place except for maintenance purposes. During maintenance, temporary barriers must be positioned to prevent accidental entry. To prevent injury, caution shall be exercised when flush tanks are operated.

Treatment function requirements

The treatment function pertains to changing the characteristics of the waste by biological, chemical, or physical means. Manure and wastewater from the flush alleys, milk parlor, and milk house will be treated with a stationary, inclined-screen solid/liquid separator prior to discharge into the waste storage pond. Separated solids will be stored on an adjacent concrete pad. Manure and wastewater collected in the reception pit will be agitated and pumped to the separator once a day. Adequate ventilation must be provided before starting agitation. The rate of flow to the separator must be within the range recommended by the manufacturer. The flow must be adjusted for maximum solid separation efficiency. The screen will be given a clean-water rinse following each use to prevent solids from drying and adhering to the screen. The pump/agitator must be operated according to the manufacturer's recommendation.

The ladder attached to the tower for the solid/liquid separator shall be maintained. Workers using the ladder shall use the safety belt provided. Equipment used to move and stack the separated solids must be equipped with rollover protective structures, seat belts, and backup alarms. Equipment operators must be fully trained in safe use of the equipment.

Storage function requirements

The storage components for the system are a waste storage pond and a concrete slab for storage of separated solids. The 17 acre-foot waste storage pond was designed to provide 180 days of storage for manure and washwater. Also included in the design of the pond is a depth allowance of 2.6 feet. This allows for precipitation less evaporation anticipated for the storage period between October 15 and May 15 and for the 24-hour, 25-year storm event precipitation. The top of embankment elevation is 1.3 feet above the spillway crest, which is an allowance for the head to operate the spillway and freeboard.

The pond must be empty at the beginning of the rainy season, which is generally about October 15. The pond should fill to the elevation of the spillway crest (98.7) not sooner than April 15. To achieve this filling schedule, the approximate target elevations should be observed throughout the storage period according to the following schedule.

Filling Schedule

| Date | Target elevation | Average precipitation less evaporation |
|-------------|---------------------|--|
| October 15 | 90.0—Empty | 5.0 |
| November 15 | 91.6 | 6.0 |
| December 15 | 93.2 | 6.5 |
| January 15 | 94.7 | 5.9 |
| February 15 | 96.2 | 4.0 |
| March 15 | 97.7 | 2.0 |
| April 15 | 98.7—Spillway crest | |

Evaluation of the filling rate for the pond should consider actual precipitation less evaporation for the periods involved.

Removal of liquids before the end of the storage period may be necessary if above average precipitation has occurred and if future storms that may cause the spillway to operate are possible. Liquid must be removed to the extent necessary to allow for storage of these potential storm events. Applying liquids removed for this purpose to Pasture No. 2 during a period of good weather when soil conditions are not saturated or frozen is recommended.

The safety fence surrounding the pond shall be maintained. Entrance inside the fence must only be by those who are trained and have activities to perform. The hazard sign shall be kept in good condition. A boat will be moored and a life ring shall be placed near the pumping platform for emergency rescue.

The vegetative cover within the pond area shall be maintained by monthly mowing during the growing season. Weeds and woody vegetation will be controlled with herbicides, which must be applied according to label instructions.

The pond shall be inspected at least annually and after unusual storm events. The embankment will be inspected for leaks, slope failures, erosion, and excessive settlement. Excavated slopes will be inspected for slope failures and erosion. Repairs shall be made promptly. Assistance in planning the appropriate repairs may be requested from the Natural Resources Conservation Service.

The concrete slab for storage of separated solids will be inspected for cracking, and repairs will be made as necessary. Drains to the waste storage pond will be inspected regularly to see that they are operative.

Transfer function requirements

The transfer function applies to movement and transport of the waste throughout the system. Waste is pumped from the waste storage pond and transferred for land application using a 6-inch PVC pipeline that is buried. Valves, air vents, and other pipeline appurtenances will be inspected for proper operation prior to using the pipeline. The pipeline will be operated with a minimum pressure of 20 psi and a maximum pressure of 40 psi. To prevent solids accumulation, it will be flushed with clean water following each use. The pump must be operated and maintained according to the manufacturer's instructions. Heavy equipment will be allowed to cross the pipeline at established travelways where the pipeline has been designed for traffic loads. The pipeline will be drained at the end of each season to prevent cold weather damage.

Separated solids will be transferred using a solid manure spreader. The manure spreader must be maintained according to the manufacturer's recommendations. Equipment operated on the public road must have signs as required by local laws and regulations. Care shall be taken to minimize spillage on roadways.

Utilization function requirements

The utilization function is that part of the system that recycles reusable waste products. Wastewater from the waste storage pond and separated solids will be uniformly surface applied to 450 acres of pastures. The liquids will be applied using the sprinkler irrigation system. The separated solids will be applied using a manure spreader. Manure and wastewater will be applied only between May 15 and October 15 when the weather forecast is a high probability of 7 days without precipitation.

The nutrients available in the waste must not exceed the agronomic requirements for the yield goals of the pastures. The actual rates applied will be based on the nutrient content of the waste and soil fertility testing. See included job sheets for soil testing and manure testing.

Waste accumulated during the storage period will be applied to orchardgrass pastures beginning on or about May 15. Allowing for nitrogen losses in storage, application, and denitrification, and for the amount that will be mineralized, about 17,730 pounds of nitrogen, 7,750 pounds of phosphorus, and 31,495 pounds of potassium will be available for crop uptake from the waste storage pond. The separated solids during this same period will provide, after accounting for these same losses and for mineralization, about 6,000 pounds nitrogen, 1,940 pounds of phosphorus, and 7,870 pounds of potassium for crop uptake. The total nitrogen available for crop uptake from the waste storage pond and separated solids is 23,730 pounds or 52.7 pounds per acre for the 450 acres of pastures, 9,690 pounds or 21.5 pounds per acre of phosphorus, and 39,365 or 87.5 pounds per acre of potassium. Based on nitrogen, even application over the entire acreage will require that the wastewater from the waste storage pond be applied to 336 acres and the separated solids be applied to the remaining 114 acres.

The waste storage pond has a capacity of 17 acre-feet of wastewater. To apply this amount uniformly over 336 acres will require an application of about 0.6 inches of wastewater. The amount of solids accumulated over the storage period is estimated to weigh 2,840 tons. To apply this amount uniformly over 114 acres will require about 25 tons per acre. The attached worksheet will be used to calibrate the manure spreaders used.

Cattle will be grazed from about May 15 to October 15. It is estimated that the lactating cows will be on pasture about 50 percent of the time and the dry cows and heifers 100 percent of the time during this period. Allowing for application and denitrification losses and for the amount mineralized, it is estimated that about 21,810 pounds, or 48.5 pounds per acre of grazing applied nitrogen will be available for crop uptake. During this same period, wastewater and separated solids collected are estimated to provide, after losses and mineralization, another 8,192 pounds, or 18 pounds per acre of nitrogen uniformly applied on the 450 acres of pastures.

The total nutrients applied per acre available for plant uptake are estimated to be as follows:

| | Nitrogen | Phosphorus | Potassium |
|---|--------------|-------------|--------------|
| Winter stored wastewater and separated solids | 52.7 | 21.5 | 87.5 |
| Grazing applied | 48.5 | 14.1 | 60.4 |
| Summer stored wastewater and separated solids | 18.0 | 8.4 | 31.4 |
| Total from waste | 119.2 | 44.0 | 179.3 |

For a yield goal of 5 tons per acre, the orchardgrass pastures are estimated to uptake 147 pounds of nitrogen per acre, 20 pounds phosphorous per acre, and 216 pounds of potassium per acre. The waste will provide 119.2 pounds per acre of nitrogen. The deficit will require an additional 28 pounds per acre of commercial nitrogen be applied on or about July 1. No additional phosphorus is needed. An additional 37 pounds per acre of potassium will be applied with the nitrogen on or about July 1.

Guards and shields on moving parts of the pumps and manure spreader must be maintained at all times of operation. Other safety precautions must be as recommended by the equipment manufacturers.

Decisionmaker acknowledgment

I certify that this plan accurately represents my decisions for installation, operation, maintenance, and safety for my AWMS:

Joe Green, Decisionmaker

Date