ENVIRONMENTAL QUALITY

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Sizing Soil-Plant Filters for Conservative Manure Management

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Approval of an animal manure management system by the Missouri Department of Natural Resources (DNR) requires that sufficient land be available to receive the generated manure. If you do not own suitable land, a legally binding agreement must be reached with neighboring landowners to allow spreading the manure on their land. A specific form (M121-F, Spreading Agreement) is available from DNR outlining the requirements.

DNR currently accepts two approaches for estimating land-area requirements for the soil-plant filter receiving the spread manure. They are the "conservative management" and the "plant-available nitrogen" approaches.

These approaches differ in the degree of detail required for estimating land-area requirements. The conservative management approach generally results in the greatest land-area requirement and the plant-available nitrogen approach requires the least land area.

Conservative management

The conservative approach to sizing the soil-plant filter for animal manure application is based on the annual application of 100 pounds of nitrogen per acre with no allowance for application loss. This approach is intended as a conservative application rate that is suitable for all soils and crops.

This method is used in Missouri when land area available for manure application is not limited. By contrast, the plant-available nitrogen approach is usually used when the land area available for manure application is limited. The plant-available nitrogen approach to sizing the soil-plant filter closely matches the manure nutrient application to crop nitrogen needs. In some situations, the operator may choose to base manure application limits on phosphorous or potassium, because of excessive amounts of phosphorus or potassium in the soil, rather than on nitrogen removal. However, DNR currently uses nitrogen rather than phosphorous and potassium to size the minimum soil-plant filter area.

Figure 1. The conservative management approach is based on the annual application of 100 lb of manure nitrogen per acre.

In estimating the land-area requirements under the conservative management approach, the adjusted thousand-weights of animals is multiplied by an index figure for the type of operation. The result is the acres of soil-plant filter area required for a permit under this approach. Table 1 gives index figures for various species of animals.

How to determine land-area requirements

The following example, along with Worksheets 1 and 2, illustrates how to determine land-area require-

Approval permits

Present regulations are primarily concerned with concentrated animal feeding operations. In general, a concentrated animal feeding operation with 1,000 animal units (AU) or more is required by Missouri state law to obtain a permit from the Missouri Department of Natural Resources (DNR). For details see *Guide to Animal Feeding Operations,* published by the Water Pollution Control Program, Division of Water Protection and Soil Conservation (WPSC), DNR, or contact the Outreach and Assistance Center at DNR (Phone 1-800-361-4827). However, any livestock manure management system, regardless of size, should be designed and operated in a manner that will not pollute surface or ground water.

ments using the conservative management approach.

Example: Estimate the land-area requirement using the conservative management approach for a beef feeding operation with 250 feeders averaging 800 pounds per head in a combination confined feeding and pasture situation, such that 80 percent of the total manure production will occur in confinement and 20 percent will be dropped on pasture. Compare the land-area requirement for the manure from the confinement facilities if handled as a liquid or solid with the land-area required if the manure is treated in a lagoon.

For this example, the conservative management approach requires that 80 acres of soil-plant filter be available for land application of liquid or solid manure, versus only 16 acres if manure is treated in a lagoon. This procedure is primarily intended to ensure that sufficient land is available to receive the manure from a given size animal feeding operation. Spreading the manure on the noted acreage for the given size operation may not meet the nutrient needs of the crop. For example, nitrogen losses following land application and before incorporation may be substantial. In some cases, the phosphorus and potassium applied using this approach may exceed the requirements of the crop.

Table 2 gives land-area requirements for various species and selected size animal feeding operations, assuming 100 percent of the manure is removed from a concentrated or confined feeding operation.

Table 1. Index number, or land area in acres required per 1,000 lb of animal live weight under the conservative management approach.

Animal type	Anaerobic lagoon effluent	Manure storage liquid/solids	Manure & litter	Compost
Swine	0.200	1.000		0.200
Beef cattle	0.100	0.500		0.100
Dairy cows	0.143	0.833		0.143
Poultry layers	0.263	1.667		0.263
broilers	0.435	2.500	2.000	0.435
Turkey	0.370	2.000	1.667	0.370
Horse	0.100	0.500		0.100
Sheep	0.167	1.000		0.167
Dog	0.556	3.333		0.556

Note: Index figures based on applying 100 pounds nitrogen per acre per year. Does not include losses during land application. Assumes 100 percent of annual manure production to the soil/plant filter. The thousand-pound units should be adjusted downward for percent of time facilities are empty between cycles or animals are on pasture, because their manure will not be directed to the concentrated feeding facility.

Worksheet 1: Estimating the land area for lagoon effluent	
Example	**Your farm**
1. Calculate thousand-weights of animals: 250 feeders × 800 pounds per feeder ÷ 1,000 pounds = 200	
2. Adjust the thousand-pound units for time on pasture: Adjustment factor = 1.0 − 0.2 = 0.8 200 × 0.8 = 160	
3. Multiply the adjusted animal weight from (2) by the index number from Table 2. 160 × 0.10 = 16 acres	

Worksheet 2: Estimating the land area for liquid or solid manure	
Example	**Your farm**
1. Calculate thousand-weights of animals: 250 feeders × 800 pounds per feeder ÷ 1,000 pounds = 200	
2. Adjust the thousand-pound units for time on pasture: Adjustment factor = 1.0 − 0.2 = 0.8 200 × 0.8 = 160	
3. Multiply the adjusted animal weight from (2) by the index number from Table 2. 160 × 0.50 = 80 acres	

Percent loading worksheet for dairy operations

Form M121-G, available from the Water Pollution Control Program, Division of Water Protection and Soil Conservation, Missouri Department of Natural Resources, contains a procedure for determining the percent loading to a lagoon or basin, to pasture, or hauled for various manure handling scenarios. University of Missouri Extension Agricultural Engineering specialists, staff from the Natural Resources Conservation Service (NRCS), and many consulting engineers have a computer program that performs the calculations to determine the required land application area for animal manure.

Land application & comprehensive nutrient management planning

Under the Unified National Strategy for Animal Feeding Operations, the desired outcome is for all concentrated animal feeding operations (AFOs) to develop and implement a comprehensive nutrient management plan (CNMP). The development of CNMPs should take into account manure and wastewater handling and storage, land treatment practices, nutrient management, record keeping, feed management and processes such as composting and methane generation as alternatives to land application of manure.

Table 2. Soil/plant filter land area required by Missouri Department of Natural Resources for approval of operations under the conservative management approach for various species.

Number of animals	Acres required			
	For lagoon effluent	For liquid/ solid manure	For manure & litter	Compost
100 dairy cows @ 1,400 lb average	20	117		20
1,000 swine @ 150 lb average	30	150		30
100 beef feeders @ 1,000 lb average	10	50		10
10,000 layers @ 4 lb average	10.4	66.7		10.4
30,000 broilers @ 2 lb average	25.6	150	120	25.6
15,000 turkeys @ 12 lb average	66.6	360	300.6	66.6

In addition to nutrients, the plan should address other pollutants, such as pathogens, to minimize adverse effects of animal feeding operations on water quality and public health.

At a minimum, the nutrient management plan should prevent the application of nutrients at rates that exceed the capacity of the soil and planned crop needs and should also prevent pollution. Soils, crop removal and manure should be tested to determine nutrient needs and content.

To keep the addition of nutrients from manure and fertilizer in balance with the nutrient removal by crops requires a record-keeping system. To prevent applying an excess of plant nutrients (N, P and K), records should be kept on the amount applied to each field. Use laboratory tests showing the nutrient content of the manure that was applied. The quantities of manure added and crops removed should be measured or estimated as accurately as possible. Manure application equipment should be calibrated regularly to ensure that the quantity of material being applied is what is planned. Records of crops removed annually and the total amount of manure applied should be kept to maintain the desired nutrient balance. Electronic totalizing flow-rate meters in liquid / slurry pumping systems are frequently used by custom applicators to calibrate the equipment and record the amount applied per acre. These meters are also a component in variable-rate application systems using global positioning system (GPS) technology to record site-specific application amounts.

Agitation before and during pumpdown is recommended to remove settled solids and achieve maximum nutrient recovery in liquid / slurry systems. Reliable nutrient data requires that the manure be kept well mixed during the loading, sampling, transport, and land application process. See EQ 215, *Laboratory Analysis of Manure,* for details on sampling and tests.

To have value, manure must be used in a manner that results in a salable product. For example, if the phosphate level in the soil is already extremely high, the P_2O_5 in applied manure may have a negative value, which should be deducted from the value of the N and K_2O in the manure. This adjustment may be significant when regulations are changed to include phosphorous limits in addition to nitrogen limits. Environmental Protection Agency regulations are expected to change in December 2002.

Land application is the most desirable method for making use of the nutrients and organic matter in animal manure. To minimize pollution potential (both air and water) and to maximize nutrient recovery, manure should be incorporated into the soil as soon as possible after application. See MU publication EQ 201 *Reduce Environmental Problems with Proper Land Application of Animal Manure*; and EQ 202, *Land Application Considerations for Animal Manure*; for information on land application and fertilizer value of manure. For additional information, see EQ 327, *Calibration of Lagoon Irrigating Equipment;* EQ 351, *Fertilizer Nutrients in Livestock and Poultry Manure; and* EQ 383, *Land Application Equipment for Livestock and Poultry Manure Management.*

Land area requirements based on phosphorous

There is much discussion on how to determine the land area requirements for application of animal manure based on phosphorous instead of nitrogen. In Missouri, three approaches are being considered: (1) a phosphorus index (PI) rating; (2) soil phosphorus threshold values; and (3) soil test values.

Phosphorus index (PI) rating

Phosphorus index ratings, to be developed by University of Missouri and NRCS, will identify the need for management decisions that reduce the potential for phosphorus movement to surface water. If the field is rated as a low- to medium-risk site, the application of organic nutrients may be made based on the nitrogen needs of the crop. If the field is rated as a high-risk site, organic nutrients may be applied to meet the needs of the crop rotation for phosphorus removal. If the field is rated as a very high-risk site, phosphorus applications will not be recommended for the field (Table 3).

Table 3. Phosphorus index.

Phosphorus index rating	Phosphorus application
Low risk	Nitrogen based
Medium risk	Nitrogen based
High risk	Phosphorus based on crop removal
Very high risk	Phosphorus not recommended

Soil phosphorus threshold values

Soil phosphorus threshold values will be investigated for the different soil series in Missouri. These values will be used to determine the maximum phosphorus that may be applied to a soil series without causing environmental damage. When soil test phosphorus levels are below the threshold value, applications of organic nutrients may be based on the nitrogen needs of the crop. As the soil test phosphorus level approaches the soil phosphorus threshold value, organic nutrient applications are to be based on the crop removal rate of phosphorus. When the soil test phosphorus level exceeds the threshold by less than a factor of 2, organic nutrient applications are to be based on one-half the crop removal rate. When the soil test phosphorus level exceeds the threshold by a factor of 2 or more, phosphorus applications will not be recommended for the field (Table 4).

Table 4. Phosphorus threshold values.

Phosphorus threshold values	Phosphorus application
< 3/4 of value	Nitrogen based
> 3/4 to < 1-1/4 of value	Phosphorus based on crop removal
> 1-1/4 to < 2 of value	Phosphorus based on 1/2 crop removal
> 2 of value	Phosphorus not recommended

Soil test values

Based on agronomic crop needs, organic nutrients may be applied based on a nitrogen recommendation when additional phosphorus is needed for buildup and is likely to increase crop yield. A soil test phosphorus rating of *very low*, *low* or *medium* would allow organic nutrients to be applied at the nitrogen rate. When soil test phosphorus is *high* (adequate for crop production and no buildup is necessary), organic nutrients may be applied based on a phosphorus maintenance rate of one and one-half times the crop removal rate. When soil test phosphorus is *very high*, organic nutrients may be applied to replace the phosphorus removed in crop production. When soil test phosphorus is *extremely high* (exceeds crop needs), phosphorus applications will not be recommended for the field (Table 5).

Table 5. Soil test levels.

Soil test phosphorus level	Phosphorus application
Very low	Nitrogen based
Low	Nitrogen based
Medium	Nitrogen based
High	Phosphorus based on 1-1/2 crop removal
Very high	Phosphorus based on crop removal
Excess	Phosphorus not recommended

In many situations, where large quantities of manure have been applied over a period of several years, a phosphorous-based approach may preclude the use of additional animal manure for several years into the future, depending on the amount of phosphorous removal by future crops. A phosphorous-based approach could have a significant impact in the areas of Missouri where there are intensive poultry operations and relatively few crop acres available to use manure. Some of these areas have runoff into the southwest Missouri lakes where phosphorous levels are high.

For further information

USDA-Natural Resources Conservation Service. 1992. *Agricultural Waste Management Field handbook*, Part 651. USDA-NRCS, Washington, D.C.

Available from Extension Publications 1-800-292-0969

MU publications

EQ 201 *Reduce Environmental Problems with Proper Land Application of Animal Manure*
EQ 202 *Land Application Considerations for Animal Manure*
WQ 203 *Estimated Land Area Requirements for Poultry Operations: Conservative Litter Management Approach*

Midwest Plan Service Publications

MWPS-6 *Beef Housing and Equipment Handbook*
MWPS-18 *Livestock Waste Facilities Handbook*

Published with funds provided to the Missouri Department of Natural Resources and the Environmental Protection Agency, Region VII. To learn more about water quality and other natural resource issues, contact the Missouri Department of Natural Resources, P.O. Box 176, Jefferson City, MO 65102. Toll free 1-800-361-4827.