See the instructions on the reverse.
Please print or type in the unshaded areas only.

EPA I.D. NUMBER *(copy from Item 1 of Form 1)*

Form Approved.
OMB No. 2040-0086.
Approval expires 8-31-98.

FORM **2B** NPDES

# EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY
APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER
## CONCENTRATED ANIMAL FEEDING OPERATIONS AND AQUATIC ANIMAL PRODUCTION FACILITIES
*Consolidated Permits Program*

## I. GENERAL INFORMATION

| A. TYPE OF BUSINESS | B. LEGAL DESCRITION OF FACILITY LOCATION | C. FACILITY OPERATION STATUS |
|---|---|---|
| ☐ 1. CONCENTRATED ANIMAL FEEDING OPERATION *(complete items B, C, and Section II)*.<br>☐ 2. CONCENTRATED AQUATIC ANIMAL PRODUCTION FACILITY *(complete items B,C, and Section III)* | | ☐ 1. EXISTING FACILITY<br>☐ 2. PROPOSED FACILITY |

## II. CONCENTRATED ANIMAL FEEDING OPERATION CHARACTERISTICS

| A. TYPE & NUMBER OF ANIMALS IN OPEN CONFINEMENT & HOUSED UNDER ROOF | | |
|---|---|---|
| 1. TYPE | 2. NO. IN OPEN CONFINEMENT | 3. NO. HOUSED UNDER ROOF |
| | | |

B. NO. OF ACRES FOR CONFINEMENT FEEDING

C. If there is open confinement, has a runoff diversion and control system been constructed?

☐ YES *(complete items 1, 2, & 3 below)*

☐ NO *(go to Section IV)*

1. What is the design basis for the control system?

| | INCHES | | INCHES | | INCHES | TYPE |
|---|---|---|---|---|---|---|
| ☐ a. 10 YEAR, 24 - HOUR STORM *(specify inches)* | | ☐ b. 25 YEAR, 24 — HOUR STORM *(specify inches)* | | ☐ c. OTHER *(specify inches & type)* | | |

| 2. Report the number of acres of contributing drainage. | ACRES | 3. Report the design safety factor. | SAFETY FACTOR |
|---|---|---|---|
| | | | |

## III. CONCENTRATED AQUATIC ANIMAL PRODUCTION FACILITY CHARACTERISTICS

A. For each outfall give the maximum daily flow, maximum 30 day flow, and the long term average flow.

| 1. OUTFALL NO. | 2. FLOW *(gallons per day)* | | |
|---|---|---|---|
| | a. MAXIMUM DAILY | b. MAXIMUM 30 DAY | c. LONG TERM AVERAGE |
| | | | |

B. Indicate the total number of ponds, raceways, and similar structures in your facility.

| 1. PONDS | 2. RACEWAYS | 3. OTHER |
|---|---|---|
| | | |

C. Provide the name of the receiving water and the source of water used by your facility.

| 1. RECEIVING WATER | 2. WATER SOURCE |
|---|---|
| | |

D. List the species of fish or aquatic animals held and fed at your facility. For each species, give the total weight produced by your facility per year in pounds of harvestable weight, and also give the maximum weight present at any one time.

| 1. COLD WATER SPECIES | | | 2. WARM WATER SPECIES | | |
|---|---|---|---|---|---|
| a. SPECIES | b. HARVESTABLE WEIGHT *(pounds)* | | a. SPECIES | b. HARVESTABLE WEIGHT *(pounds)* | |
| | (1) TOTAL YEARLY | (2) MAXIMUM | | (1) TOTAL YEARLY | (2) MAXIMUM |
| | | | | | |

| E. Report the total pounds of food fed during the calendar month of maximum feeding. | 1. MONTH | 2. POUNDS OF FOOD |
|---|---|---|
| | | |

## IV. CERTIFICATION

*I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.*

| A. NAME & OFFICIAL TITLE *(print or type)* | B. PHONE NO. *(area code & no.)* |
|---|---|
| C. SIGNATURE | D. DATE SIGNED |

THIS FORM REPLACES EPA FORMS 7550-7 & 7550-7A WHICH ARE OBSOLETE

## INSTRUCTIONS

### General

**This form must be completed by all applicants who check "yes" to Item II-B in Form 1.** Not all animal feeding operations or fish farms are required to obtain NPDES permits. Exclusions are based on size and occurrence of discharge. See the description of these statutory and regulatory exclusions in the General Instructions which accompany Form 1. In particular, for animal feeding operations, the size cutoffs depend on whether or not pollutants are discharged through a manmade device or by direct contact with the facility or animals. A facility for laying hens or broilers is not required to have a permit unless it has a liquid manure handling system or continuous overflow watering. Also, facilities which discharge only in the case of a 25 year, 24 hour storm event are not required to have a permit.

For aquatic animal production facilities, the size cutoffs are based on whether the species are warm water or cold water, on the production weight per year in harvestable pounds, and on the amount of feeding in pounds of food *(for cold water species)*. Also, facilities which discharge less than 30 days per year, or only during periods of excess runoff *(for warm water fish)* are not required to have a permit.

Refer to the Form 1 instructions to determine where to file this form.

### Item I-A

See the note above and the General Instructions which accompany Form 1 to be sure that your facility is "concentrated."

### Item I-B

If your answer to Item VI of Form 1 does not give a complete legal description of your facility's location, use this space to provide a complete description, such as quarter, section, township, and range.

### Item I-C

Check "proposed" if your facility is not now in operation, or not now "concentrated" under the definition in the glossary found in the General Instructions which accompany Form 1.

### Item II

Supply all information in Item II if you checked *(1)* in Item I-A.

### ITEM II-A

Give the maximum number of each type of animal in open confinement or housed under roof *(either partially or totally)* which are held at your facility for a total of 45 days or more in any 12 month period.

Use the following categories for types of animal:

Slaughter Cattle; Feeder Cattle; Mature Dairy Cattle *(milked or dry)*; Swine *(each weighing over 55 pounds)*; Horses; Sheep; Lambs; Turkeys; Laying Hens[1]; Broilers[1]; Ducks.

[1]A permit is not required unless the facility has a liquid manure handling system or continuous overflow watering.

### Item II-B

Give only the area used for the animal confinement or feeding facility. Do not include any area used for growing or operating feed.

### Item II-C

Check "yes" if any system for collection of runoff has been constructed. Supply the information under *(1)*, *(2)*, and *(3)* to the best of your knowledge.

### Item III

Supply all information in Item III if you checked *(2)* in Item I-A.

### Item III-A

Outfalls should be numbered to correspond with the map submitted in Item XI of Form 1. Values given for flow should be representative of your normal operation. The maximum daily flow is the maximum measured flow occurring over a calendar day. The maximum 30 day flow is the average of measured daily flows over the calendar month of highest flow. The long term average flow is the average of measured daily flows over a calendar year.

### Item III-B

Give the total number of discrete ponds or raceways in your facility. Under "other," give a descriptive name of any structure which is not a pond or a raceway but which results in discharge to waters of the United States.

### Item III-C

Use names for the receiving water and source of water which correspond to the map submitted in Item XI of Form 1.

### Item III-D

The names of fish species should be proper, common, or scientific names as given in special Publication No. 6 of the American Fisheries Society, "A List of Common and Scientific Names of Fishes from the United States and Canada." The values given for total weight produced by your facility per year and the maximum weight present at any one time should be representative of your normal operation.

### Item III-E

The value given for maximum monthly pounds of food should be representative of your normal operation.

### Item IV

The Clean Water Act provides for severe penalties for submitting false information on this application form.

Section 309(c)(2) of the Clean Water Act provides that "Any person who knowingly makes any false statement, representation, or certification in any application, . . . shall upon conviction, be punished by a fine of no more than $10,000 or by imprisonment for not more than six months, or both,"

**Federal regulations require the certification to be signed as follows:**

A. For corporation, by a principal executive officer of at least the level of vice president;

B. For a partnership or sole proprietorship, by a general partner or the proprietor, respectively; or

C. For a municipality, State, Federal, or other public facility, by either a principal executive officer or ranking elected official.

### Paper Reduction Act Notice

**The Public reporting burden for this collection of information estimated to average 6 hours per response. This estimate includes time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information to the chief, Information Policy Branch (PM-223), US Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460, and the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503, marked Attention : Desk Officer for EPA**

***Consulting Engineers in Georgia EPD* CAFO Stakeholder List***
***02/12/01***

| | | |
|---|---|---|
| Mr. L.M. Safley, Jr., Ph.D., P.E. | Agri-Waste Technology, Inc.<br>5400 Etta Burke Court<br>Raleigh, NC 27606 | 919-859-0669<br>FAX: 919-233-1970 |
| Brian Rindt, P.E. | Rindt-McDuff Associates<br>334 Cherokee Street<br>Marietta, GA 30060 | 770-427-8123 |
| T. Halliburton "Hal" Wood, P.E. | Agricultural and Environmental Engineering<br>2033 Lee Road 165<br>Salem, AL 36874 | 334-742-1266 |
| Mr. Joseph G. Martin III, P.E., M.S. | Agricultural Engineer<br>6024 S.W. 89th Terrace<br>Gainesville, FL 32608 | 352-371-4655<br>FAX: 352-371-1677 |
| Mr. Michael Holloway, P.E. | Consulting Engineers<br>4241 S.W. 6th Avenue<br>Ocala, FL 34474 | 352-861-1172<br>FAX: 352-861-1173 |
| Mr. Fenton Nash, P.E. | Nash Engineering and Surveying, LLC<br>128 Greer Lane<br>Albany, GA 31707 | 229-435-6186 |
| Mr. N. Ray Archer, P.E. | Arrow Technology and Engineering Co.<br>Post Office Box 3336<br>Gainesville, GA 30503 | 770-536-8617<br>FAX: 770-536-8618 |
| Steven R. Woodruff, P.E.<br>President | Woodruff and Howe Environmental Engineering, Inc.<br>192 Spring Lake Lane<br>Canton, GA 30115 | 770-844-0037<br>Mobile: 404-408-0903<br>FAX: 678-513-3860<br>swoodruff@wheeinc.com |

*This is a list of individuals whom have indicated an interest in performing design work for animal feeding operations. No endorsement by the Georgia Environmental Protection Division is expressed or implied.

Adopted June 1, 2001

# RULES
# OF
# GEORGIA DEPARTMENT OF AGRICULTURE
# ANIMAL INDUSTRY DIVISION

## CHAPTER 40-16-5
## ANIMAL FEEDING OPERATOR TRAINING AND CERTIFICATION

TABLE OF CONTENTS



### 40-16-5-.01 Definitions.

(1) A Swine Feeding Operator means a person who is designated as such by the owner of a swine feeding operation which is permitted by the Georgia Department of Natural Resources Environmental Protection Division.

(2) An Animal (Non-Swine) Feeding Operator means a person who is designated as such by the owner of a non-swine (i.e dairy, layer) feeding operation which handles liquid manure and is permitted by the Georgia Department of Natural Resources Environmental Protection Division.

(3) Animal Feeding Operators will include Swine Feeding Operators and Animal (Non-Swine) Feeding Operators as herein defined.

### 40-16-5-.02 Application for Animal Feeding Operator Training and Certification

Application for Animal Feeding Operator Training and Certification shall be made to the Department of Agriculture on a form approved by the Department.

### 40-16-5-.03 Animal Feeding Operator Training

(1) An Animal Feeding Operator shall be considered trained when the applicant successfully completes a minimum of 2 days instruction on the following:

(a) Understanding state regulations and water quality laws,
(b) Comprehensive nutrient management planning,
(c) Best management practices for manure storage, treatment and land application,
(d) Monitoring and record keeping,
(e) Pollution prevention and alternative treatment systems, and
(f) Odor and atmospheric emissions.

(2) Training will be developed and delivered by the Georgia Cooperative Extension Service or other subject matter experts as deemed appropriate by the Department. Training will be structured to address the needs of operators of differing sizes and various waste management technologies. The Department shall approve the use of all training materials and methods.

**40-16-5-.04 Animal Feeding Operator Certification**

(1) An Animal Feeding Operator shall be considered certified when the applicant demonstrates competency in all of the above listed modules including passing a written examination with a minimum score of 70%. Examinations will be structured to address the needs of operators of various production sizes and waste management technologies. The Department will administer and grade the examinations. The Department shall issue a certificate to the operator upon the successful completion of training and certification.

(a) An Animal Feeding Operator who fails to make a minimum score of 70% on the initial examination may retake an exam up to three (3) times within a twelve (12) month period, after which he or she must complete an instructional course approved by the Department before taking another exam.

(2) Animal Feeding Operators must receive a minimum of 4 hours continuing education every two years from the date of the original certification. The Department shall approve all continuing education instruction and materials and will issue certificates of completion indicating the course topic and hours of instruction.

(3) Failure of an Animal Feeding Operator to receive continued education will result in suspension of certification and require recertification.

(4) The Department has final authority over all training, certification, and continuing education.

(5) The Department shall provide the Department of Natural Resources Environmental Protection Division with a current list of Certified Animal Feeding Operators upon request.

Authority O.C.G.A. Section 12-5-20, as amended; DNR Rule 391-3-6-.20 and 391-3-6-.21.

## *Animal (Non-Swine) Feeding Operations - State of Georgia*
## *The Rules and Regulations for Water Quality Control, Chapter 391-3-6*

***Rule 391-3-6-.21, □Animal (Non-Swine) Feeding Operation Permit Requirements,□is added as follows:***

**391-3-6-.21 Animal (Non-Swine) Feeding Operation Permit Requirements**

**(1) Purpose.**

The purpose of this paragraph 391-3-6-.21 is to provide for the uniform procedures and practices to be followed relating to the application for and the issuance or revocation of permits for animal (non-swine) feeding operations. Nothing in this paragraph shall be construed to preclude the modification of any requirement of this paragraph when the Division determines that the requirement is not protective of the environment.

**(2) Definitions.**

All terms used in this paragraph shall be interpreted in accordance with the definitions as set forth in the Act unless otherwise defined in this paragraph or in any other paragraph of these Rules:

(a) □Act□ means the Georgia Water Quality Control Act, as amended.

(b) □Animal feeding operation,□ □operation,□ or □AFO□ means a lot or facility (other than an aquatic animal production facility or swine feeding operation) where animals have been, are, or will be stabled or confined and fed or maintained for a total of at least 45 days in any 12-month period, and the confinement areas do not sustain crops, vegetation, forage growth, or post-harvest residues in the normal growing season.

(c) □Animal Unit□ (AU) is a unit of measurement for any AFO calculated by adding the following numbers: the number of slaughter and feeder cattle multiplied by 1.0, plus the number of mature dairy cattle multiplied by 1.4, plus the number of sheep multiplied by 0.1, plus the number of horses multiplied by 2.0.

(d) "Barn" means a structure where confinement feeding (feeding in limited quarters, often under a roof and over slotted floors) occurs. Structures where confinement feeding does not occur are not considered "barns" for the purposes of this rule.

(e) "Certified operator" means any person who has been trained and certified by the Georgia Department of Agriculture and has direct general charge of the day-to-day field operation of an AFO waste storage and disposal system , and who is responsible for the quality of the treated waste.

(f) □Closure plan□ means the plan approved by the Division for clean up and closure of the AFO and associated waste storage and disposal facilities.

(g) "Comprehensive Nutrient Management Plan" (CNMP) is a plan which identifies actions or priorities that will be followed to meet clearly defined nutrient management goals at an agricultural operation. Defining nutrient management goals and identifying measures and schedules for attaining the goals are critical to reducing threats to water quality and public health. The CNMP should address, at a minimum, manure handling and storage, land application of manure and wastewater, site management, record keeping, and management of other utilization options. The CNMP must be developed or modified by a "certified specialist" defined by the Division. The Division will specify the requirements for certification. The CNMP is submitted to the Division for review and approval. It should include emergency response planning and a closure plan for abandonment of any facility used for the treatment or storage of animal waste.

(h) "Existing" applies to that which existed prior to the effective date of this rule. "Existing operation" means an AFO that was in operation prior to the effective date of this rule.

(i) "Natural Resources Conservation Service" (NRCS) is an agency within the United States Department of Agriculture.

(j) "New or expanding operation" or "new AFO" means an AFO the construction or expansion of which is commenced on or after the effective date of this rule.

(k) "NRCS guidance" means the latest editions of the Natural Resources Conservation Service (NRCS) Agricultural Waste Management Field Handbook, Part 651, FOTG Section IV Georgia, and other applicable publications of the NRCS. NRCS guidance is used by a certified specialist to develop or modify a CNMP.

(l) (Reserved)

(m) "Owner" means any person owning any system for waste treatment and disposal at an AFO.

(n) "Permit" means a permit applied for and issued in accordance with the terms and conditions for paragraphs 391-3-6-.06, Waste Treatment and Permit Requirements (individual NPDES permits), or 391-3-6-.11, Land Disposal and Permit Requirements (non-NPDES individual land application system or "LAS" permit), or 391-3-6-.15, Non-Storm Water General Permit Requirements (general NPDES permit), or 391-3-6-.19, General Permit - Land Application System Requirements (non-NPDES general LAS permit), of this Chapter.

(o) "Wetted area" or "disposal area" is the land area where AFO waste is sprayed, spread, incorporated, or injected so that the waste can either condition the soil or fertilize crops or vegetation grown in the soil.

(p) "25-year, 24-hour storm event" is the maximum 24-hour precipitation event expressed in inches with a probable recurrence interval of once in 25 years, as defined by the National Weather Service of the United States Department of Commerce in Technical Paper Number

40, "Rainfall Frequency Atlas of the United States," May 1961, and subsequent amendments.

(q) □100-year flood plain□ is the land inundated from a flood whose peak magnitude would be experienced on an average of once every 100 years. The 100-year flood has a 1% probability of occurring in one given year.

(r) □300 AU□ means three hundred animal units. Paragraph 391-3-6-.21 (2) (c) notwithstanding, the numbers of animals in any of the following categories are equivalent to 300 AU:

- 300 slaughter and feeder cattle,
- 200 mature dairy cattle (whether milked or dry cows),
- 150 horses,
- 3,000 sheep or lambs,
- 16,000 turkeys,
- 30,000 laying hens or broilers (if the facility has continuous overflow watering),
- 9,000 laying hens or broilers (if the facility has a liquid manure handling system),
- 1,500 ducks

(s) □1000 AU□ means one thousand animal units. Paragraph 391-3-6-.21 (2) (c) notwithstanding, the numbers of animals in any of the following categories are equivalent to 1000 AU:

- 1,000 slaughter and feeder cattle,
- 700 mature dairy cattle (whether milked or dry cows),
- 500 horses,
- 10,000 sheep or lambs,
- 55,000 turkeys,
- 100,000 laying hens or broilers (if the facility has continuous overflow watering),
- 30,000 laying hens or broilers (if the facility has a liquid manure handling system),
- 5,000 ducks

(t) □3000 AU□ means three thousand animal units. Paragraph 391-3-6-.21 (2) (c) notwithstanding, the numbers of animals in any of the following categories are equivalent to 3000 AU:

- 3,000 slaughter and feeder cattle,
- 2,100 mature dairy cattle (whether milked or dry cows),
- 1,500 horses,
- 30,000 sheep or lambs,
- 165,000 turkeys,
- 300,000 laying hens or broilers (if the facility has continuous overflow watering),
- 90,000 laying hens or broilers (if the facility has a liquid manure handling system),
- 15,000 ducks

**(3) Permit Requirement.**

(a) Any person who is the owner of an AFO with more than 300 AU shall obtain a permit from the Division in accordance with this paragraph corresponding to the age and size of the AFO.

(b) Any person who is the owner of an AFO with 300 AU or less is not required to obtain a permit unless the AFO is defined as a concentrated animal feeding operation per 40 CFR 122, Appendix B or the Division has made a case-by-case designation as a concentrated animal feeding operation, in which case NPDES permitting is required by 40 CFR 122.23. The owner of an AFO with 300 AU or less remains subject to applicable sections of the Act, including civil liability, civil penalty, and criminal penalty, □ O.C.G.A. 12-5-51, et seq.

(c) Two or more AFOs under common ownership are considered to be a single operation subject to this paragraph if they adjoin each other (are contiguous) or if they use a common area or system for the disposal of wastes.

(d) Exclusions from all permit requirements of this paragraph are made for the following facilities unless they are defined as a concentrated animal feeding operation per 40 CFR 122, Appendix B, or the Division has made a case-by-case designation as a concentrated animal feeding operation, or the Division has determined that they have potential to discharge, in which cases NPDES permitting is required by 40 CFR 122.23:

1. A livestock market, sale barn, stockyard, or auction house where animals are assembled from at least two sources to be publicly auctioned or privately sold on a commission basis and that is under state or federal supervision. However, these facilities are defined as AFOs if they meet the definition of an AFO in subparagraph (2)(b).

2. A poultry operation that properly stores and disposes of dry litter waste and does not have continuous overflow watering or a liquid manure handling system.

**(4) Permit for Existing or New Operations with more than 300 but equal to or less than 1000 AU.**

(a) Any person who is the owner of an existing AFO with more than 300 but equal to or less than 1000 AU must apply for an LAS permit from the Division by October 31, 2001. The Division may issue an individual or general permit. New or expanding AFOs must obtain an LAS permit from the Division prior to beginning the AFO with more than 300 but equal to or less than 1000 AU. Permit applications for new or expanding AFOs should be submitted 180 days prior to beginning the AFO with more than 300 but equal to or less than 1000 AU. Any person who owns or operates an existing or new AFO must have waste storage and disposal systems pursuant to this rule and meet the conditions in subparagraphs (b) through (i) below. Any person who is the owner of an AFO with more than 300 AU but equal to or less than 1000 AU is not required to obtain an NPDES permit unless the AFO is defined as a concentrated animal feeding operation per 40 CFR 122, Appendix B or the

Division has made a case-by-case designation as a concentrated animal feeding operation, in which case NPDES permitting is required by 40 CFR 122.23.

(b) There shall be no discharge of pollutants from the operation into surface waters of the State unless a catastrophic rainfall event (25-year, 24-hour storm) occurs.

(c) Prior to beginning operation of the AFO, new operations must have waste storage and disposal systems in operation that have been designed and constructed in accordance with NRCS guidance.

(d) By October 31, 2002, the owner of an existing AFO shall submit to the Division a CNMP for the AFO. The CNMP shall be of sufficient substance and quality as to be approvable by the Division. The owner should receive the Division's approval of the CNMP by July 1, 2003, and shall begin implementing the approved CNMP not later than October 31, 2003. The owner of a new operation should submit to the Division a CNMP prior to beginning operation of the AFO.

(e) Existing operations should have a certified operator by October 31, 2002. New operations should have a certified operator prior to beginning the AFO. The certified operator should be trained and certified in accordance with 391-3-6-.21(9).

(f) New operations must be designed and constructed to contain all process generated wastewaters plus the runoff from a 25-year, 24-hour storm event without an overflow from the waste storage lagoon.

(g) New waste storage lagoons located within significant ground water recharge areas which fall within the categories defined in the Georgia Department of Natural Resources Rules for Environmental Planning Criteria, Chapter 391-3-15-.02, Paragraph 3(e) must be provided with either a compacted clay or synthetic liner such that the vertical hydraulic conductivity does not exceed $5 \times 10^{-7}$ cm/sec or other criteria as determined by the Division. If it is determined that an existing waste storage lagoon is creating a ground water contamination problem, the Division may require the lagoon to be repaired.

(h) New barns and new waste storage lagoons for new AFOs started after the effective date of this rule with more than 300 but equal to or less than 1000 AU, or for existing AFOs that are expanding production so that they will have more than 300 but equal to or less than 1000 AU after the effective date of this rule, shall not be located within a 100-year flood plain.

(i) Any failure to comply with any condition of (a) through (h) above shall be deemed a violation of the Act and may be punishable in accordance with the penalties provided for in the Act.

(5) **Permit for Existing Operations with more than 1000 but equal to or less than 3000 AU.**

(a) Any person who is the owner of an existing AFO with more than 1000 but equal to or less than 3000 AU must apply for an NPDES permit from the Division by October 31, 2001. The Division may issue an individual or general permit. Any person who expands an existing operation to include more than 1000 but equal to or less than 3000 AU becomes subject to the requirements of subparagraph (6), Permit for New or Expanding Operations with more than 1000 but equal to or less than 3000 AU.

(b) There shall be no discharge of process wastewater pollutants per 40 CFR Part 412 from the feedlot(s) or manure storage areas to waters of the United States except when catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain all process generated wastewater resulting from the operation of the AFO plus all runoff from a 25 year, 24-hour rainfall event for the location of the AFO.

(c) By October 31, 2002, the owner shall submit to the Division a CNMP for the AFO. The CNMP shall be of sufficient substance and quality as to be approvable by the Division. The owner should receive the Division's approval of the CNMP by July 1, 2003, and shall begin implementing the approved CNMP not later than October 31, 2003.

(d) The operation should have a certified operator by October 31, 2002. The certified operator should be trained and certified in accordance with 391-3-6-.21(9).

(e) Public notice of the proposed draft permit will be prepared and circulated in accordance with 391-3-6-.06(7) or 391-3-6-.15(7).

(f) If it is determined that an existing waste storage lagoon is creating a ground water contamination problem, the Division shall require the owner to repair the lagoon, to close the lagoon, or to take other actions to protect the ground water.

(g) The waste disposal system shall be designed and operated such that it does not cause Nitrate Nitrogen ($NO_3$-N) in the ground water at the operation's property line to exceed 10 mg/l. The Division will require the owner to implement corrective actions if the permitted waste disposal system has caused the Nitrate Nitrogen ($NO_3$-N) to exceed 10 mg/l as described.

(h) Representative samples shall be collected from each major soil series present within the waste disposal field areas in a manner to be specified in the permit. One down gradient ground water monitoring well shall be installed for each waste storage lagoon or series of lagoons. The number, location, design and construction specifications of the monitoring wells shall be submitted to the Division prior to issuance of a permit. Existing wells that are approved by the Division can be used for testing. Monitoring wells shall be properly installed within 24 months of permit issuance.

(i) The permit will contain specific requirements for monitoring the waste storage lagoon effluent to be land applied and for the ground water monitoring wells. This will usually consist, at a minimum, of semiannual monitoring of the effluent for Total Kjeldahl Nitrogen (TKN) and Nitrate Nitrogen ($NO_3$-N) as well as semiannual monitoring of the wells for TKN and $NO_3$- N.

(j) When the owner ceases operation of the AFO, he must notify the Division of that fact within three months, and he must properly close all waste storage lagoons within eighteen months. In the case of voluntary closure, a period of twenty-four months from notification is allowed. Proper closure of a lagoon entails removing all waste from the lagoon and land applying it at agronomic rates, and in a manner so as not to discharge to any surface water.

(k) Any failure to comply with any condition of (a) through (j) above or any condition of any individual permit issued for the operation shall be deemed a violation of the Act and may be punishable in accordance with the penalties provided in the Act.

**(6) Permit for New or Expanding Operations with more than 1000 but equal to or less than 3000 AU.**

(a) Any person who proposes to commence operation of a new AFO with more than 1000 but equal to or less than 3000 AU after the effective date of this paragraph, or any person who proposes to expand an existing AFO to more than 1000 but equal to or less than 3000 AU after the effective date of this paragraph, must obtain an NPDES permit in accordance with this subparagraph. The Division may issue an individual or general permit. Permit applications should be submitted 180 days in advance.

(b) There shall be no discharge of process wastewater pollutants per 40 CFR Part 412 from the feedlot(s) or manure storage areas to waters of the United States except when catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain all process generated wastewater resulting from the operation of the AFO plus all runoff from a 25 year, 24-hour rainfall event for the location of the AFO. There shall be no discharge of pollutants into ground water which would cause ground water quality not to comply with the primary maximum contaminant levels established in Georgia's Rules for Safe Drinking Water, Chapter 391-3-5.

(c) Prior to beginning operation of the AFO, the operation must have waste storage and disposal systems in operation that have been designed and constructed in accordance with NRCS guidance.

(d) Prior to beginning operation of the AFO, the owner shall submit to the Division a CNMP for the AFO. The CNMP shall be of sufficient substance and quality as to be approvable by the Division.

(e) The operation should have a certified operator for the waste storage and disposal system prior to beginning the AFO. The certified operator should be trained and certified in accordance with 391-3-6-.21(9).

(f) Public notice of the proposed draft permit will be prepared and circulated in accordance with 391-3-6-.06(7) or 391-3-.15(7).

(g) The waste storage and disposal system must be designed to contain all process generated wastewaters plus the runoff from a 25-year, 24-hour storm event without an overflow from the waste storage lagoon.

(h) Any waste storage lagoon must be constructed to ensure that seepage is limited to a maximum of 1/8 inch per day ($3.67 \times 10^{-6}$ cm/sec). For waste storage lagoons located within significant ground water recharge areas which fall within the categories defined in the Georgia Department of Natural Resources Rules for Environmental Planning Criteria, Chapter 391-3-15-.02, Paragraph 3(e), the lagoons must be provided with either a compacted clay or a synthetic liner such that the vertical hydraulic conductivity does not exceed $5 \times 10^{-7}$ cm/sec or other criteria as determined by the Division. Individual waste storage lagoons shall not exceed 100 acre-feet in volume.

(i) It is required that a minimum of 2 feet of freeboard be maintained in the waste storage lagoons at all times.

(j) Barns and waste storage lagoons shall not be located within a 100-year flood plain.

(k) The following buffers shall be maintained:

1. 100 feet between wetted areas and water wells;

2. 100 feet between waste storage lagoons or barns or wetted areas and drainage ditches, surface water bodies, or wetlands;

3. 500 feet between waste storage lagoons or barns and any existing wells that supply water to a public water system, or any other existing well off the owner's property that supplies water for human consumption.

(l) Representative samples shall be collected from each major soil series present within the waste disposal field areas in a manner to be specified in the permit. One down gradient ground water monitoring well shall be installed for each waste storage lagoon or series of lagoons. The number, location, design and construction specifications of the monitoring wells shall be submitted to the Division prior to issuance of a permit. Existing wells that are approved by the Division can be used for testing. Monitoring wells shall be properly installed prior to the beginning of operation of the AFO.

(m) The permit will contain specific requirements for monitoring the waste storage lagoon effluent to be land applied, and for the ground water monitoring wells. This will usually consist, at a minimum, of semiannual monitoring of the effluent for Total Kjeldahl Nitrogen (TKN) and Nitrate Nitrogen ($NO_3$-N) as well as semiannual monitoring of the wells for TKN and $NO_3$- N.

(n) When the owner ceases operation of the AFO, he must notify the Division of that fact within three months, and he must properly close all waste storage lagoons within eighteen months. In the case of voluntary closure, a period of twenty-four months from notification is allowed. Proper closure of a lagoon entails removing all waste from the lagoon and land applying it at agronomic rates, and in a manner so as not to discharge to any surface water.

(o) Any failure to comply with any condition of (a) through (n) above or any condition of any individual permit issued for the operation may be deemed a violation of the Act and may be punishable in accordance with the penalties provided in the Act.

(7) **Permit for Existing Operations with more than 3000 AU.**

(a) Any person who owns an existing AFO with more than 3000 AU must apply for an NPDES permit from the Division by October 31, 2001. The Division may issue an individual or general permit. Any person who expands an existing operation to more than 3000 AU becomes subject to the requirements of subparagraph (8), Permit for New or Expanding Operations with more than 3000 AU.

(b) There shall be no discharge of process wastewater pollutants per 40 CFR Part 412 from the feedlot(s) or manure storage areas to waters of the United States except when catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain all process generated wastewater resulting from the operation of the AFO plus all runoff from a 25 year, 24-hour rainfall event for the location of the AFO.

(c) By October 31, 2002, the owner shall submit to the Division a CNMP for the AFO. The CNMP shall be of sufficient substance and quality as to be approvable by the Division. The owner should receive the Division's approval of the CNMP by July 1, 2003, and shall begin implementing the approved CNMP not later than October 31, 2003.

(d) The operation should have a certified operator by October 31, 2002. The certified operator should be trained and certified in accordance with 391-3-6-.21(9).

(e) Public notice of applications and proposed draft permits will be prepared and circulated in accordance with 391-3-6-.06(7) or 391-3-6-.15(7). Furthermore, a proposed determination to issue an individual permit requires that the applicant shall post the public notice on a three feet by five feet sign at the entrance of the applicant's premises and publish the public notice in one or more newspapers of general circulation in the area affected by the AFO.

(f) If it is determined that an existing waste storage lagoon is creating a ground water contamination problem, the Division shall require the owner to repair the lagoon, to close the lagoon, or to take other actions to protect the ground water.

(g) The waste disposal system shall be designed and operated such that it does not cause Nitrate Nitrogen ($NO_3$-N) in the ground water at the operation's property line to exceed 10 mg/l. The Division will require the owner to implement corrective actions if the permitted waste disposal system has caused the Nitrate Nitrogen ($NO_3$-N) to exceed 10 mg/l as described.

(h) Representative samples shall be collected from each major soil series present within the waste disposal field areas in a manner to be specified in the permit. One down gradient ground water monitoring well shall be installed for each waste storage lagoon or series of lagoons. The number, location, design and construction specifications of the monitoring wells shall be submitted to the Division prior to issuance of a permit. Existing wells that are approved by the Division can be used for testing. Monitoring wells shall be properly installed within 24 months of permit issuance.

(i) The permit will contain specific requirements for monitoring the waste storage lagoon effluent to be land applied, and for the ground water monitoring wells. This will usually consist, at a minimum, of semiannual monitoring of the effluent for Total Kjeldahl Nitrogen (TKN) and Nitrate Nitrogen ($NO_3$-N) as well as semiannual monitoring of the wells for TKN and $NO_3$- N.

(j) When the owner ceases operation of the AFO, he must notify the Division of that fact within three months, and he must properly close all waste storage lagoons within eighteen months. In the case of voluntary closure, a period of twenty-four months from notification is allowed. Proper closure of a lagoon entails removing all waste from the lagoon and land applying it at agronomic rates, and in a manner so as not to discharge to any surface water.

(k) Any failure to comply with any condition of (a) through (j) above or any condition of any individual permit issued for the operation shall be deemed a violation of the Act and may be punishable in accordance with the penalties provided in the Act.

**(8) Permit for New or Expanding Operations with more than 3000 AU.**

(a) Any person who proposes to be the owner or operator of a new AFO with more than 3000 AU, and any person who is the owner or operator of an existing operation that is expanding production so that it will have more than 3000 AU, which proposes to commence operation after the effective date of this rule must obtain an individual NPDES permit in accordance with this paragraph prior to commencing construction for the operation.

1. Permit applications should be submitted 180 days in advance.

2. (Reserved)

3. The owner of an existing operation that is expanding production so that it will have more than 3000 AU after the effective date of this rule must obtain an individual NPDES permit.

(b) There shall be no discharge of process wastewater pollutants per 40 CFR Part 412 from the feedlot(s) or manure storage areas to waters of the United States except when catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain all process generated wastewater resulting from the operation of the AFO plus all runoff from a 25 year, 24-hour rainfall event for the location of the AFO. There shall be no discharge of pollutants into ground water which would cause ground water quality not to comply with the primary maximum contaminant levels established in Georgia's Rules for Safe Drinking Water, Chapter 391-3-5.

(c) Prior to beginning operation of the AFO, the operation must have waste storage and disposal systems in operation that have been designed and constructed in accordance with NRCS guidance.

(d) Prior to beginning operation of the AFO, the owner and operator if co-permitted, shall submit to the Division a CNMP for the AFO. The CNMP shall be of sufficient substance and quality as to be approvable by the Division.

(e) The operation should have a certified operator for the waste storage and disposal system prior to beginning the AFO. The certified operator should be trained and certified in accordance with 391-3-6-.21(9).

(f) Public notice of the completed application and proposed draft permit will be prepared and circulated in accordance with 391-3-6-.06(7). Furthermore, a proposed determination to issue an individual permit requires that the applicant shall post the public notice on a three feet by five feet sign at the entrance of the applicant's premises and publish the public notice in one or more newspapers of general circulation in the area affected by the AFO.

(g) The waste storage and disposal system must be designed to contain all process generated wastewaters plus the runoff from a 25-year, 24-hour storm event without an overflow from the waste storage lagoon.

(h) Any waste storage lagoon must be constructed to ensure that seepage is limited to a maximum of 1/8 inch per day ($3.67 \times 10^{-6}$ cm/sec). For waste storage lagoons located within significant ground water recharge areas which fall within the categories defined in the Georgia Department of Natural Resources Rules for Environmental Planning Criteria, Chapter 391-3-15-.02, Paragraph 3(e), the lagoons must be provided with either a compacted clay or a synthetic liner such that the vertical hydraulic conductivity does not exceed $5 \times 10^{-7}$ cm/sec or other criteria as determined by the Division. Individual waste storage lagoons shall not exceed 100 acre-feet in volume.

(i) It is required that a minimum of 2 feet of freeboard be maintained in the waste storage lagoons at all times.

(j) Barns and waste storage lagoons shall not be located within a 100-year flood plain.

(k) The following buffers shall be maintained:

1. 100 feet between wetted areas and water wells;

2. 100 feet between waste storage lagoons or barns or wetted areas and drainage ditches, surface water bodies, or wetlands;

3. 500 feet between waste storage lagoons or barns and any existing wells that supply water to a public water system, or any other existing well off the owner's property that supplies water for human consumption.

(l) Representative samples shall be collected from each major soil series present within the waste disposal field areas in a manner to be specified in the permit. One down gradient ground water monitoring well shall be installed for each waste storage lagoon or series of lagoons. The number, location, design and construction specifications of the monitoring wells shall be submitted to the Division prior to issuance of a permit. Existing wells that are approved by the Division can be used for testing. Monitoring wells shall be properly installed prior to the beginning of operation of the AFO.

(m) The permit will contain specific requirements for monitoring the waste storage lagoon effluent to be land applied, and for the ground water monitoring wells. This will usually consist, at a minimum, of semiannual monitoring of the effluent for Total Kjeldahl Nitrogen (TKN) and Nitrate Nitrogen ($NO_3$-N) as well as semiannual monitoring of the wells for TKN and $NO_3$- N.

(n) When the owner or operator ceases operation of the AFO, he must notify the Division of that fact within three months, and he must properly close all waste storage lagoons within eighteen months. In the case of voluntary closure, a period of twenty-four months from notification is allowed. Proper closure of a lagoon entails removing all waste from the lagoon and land applying it at agronomic rates, and in a manner so as not to discharge to any surface water.

(o) Any failure to comply with any condition of (a) through (n) above or any condition of any individual permit issued for the operation may be deemed a violation of the Act and may be punishable in accordance with the penalties provided in the Act.

(9) **Certified Operator - Training and Certification Requirements.**

(a) AFOs should have certified operators according to the following schedule:

1. Existing operations with 301 to 1000 AU, 1001 to 3000 AU, and more than 3000 AU: October 31, 2002.

2. New or expanding AFOs with 301 to 1000 AU, 1001 to 3000 AU, and more than 3000 AU: Prior to beginning the AFO.

(b) AFO certified operators should be trained and certified by the Georgia Department of Agriculture. Proof of such training, certification and continuing education may be maintained by the Department of Agriculture and records provided to the Georgia Environmental Protection Division.

(c) Certification training, agenda and topics will be determined by the Georgia Department of Agriculture; but will include, at a minimum, best management practices, comprehensive nutrient management planning, understanding regulations and water quality laws, standards and practices, siting, pollution prevention, monitoring and record keeping. Training programs will be structured to address the needs of the certified operators of differing sizes and various waste management technologies. Continuing education will be required to maintain this certification.

Authority: O.C.G.A. Section 12-5-20, et. seq.

# *The Rules and Regulations for Water Quality Control*
# *Chapter 391-3-6*

*Rule 391-3-6-.20, "Swine Feeding Operation Permit Requirements," is proposed to be amended as follows:*

**[Note: underlined text is proposed to be added; lined-through text is proposed to be deleted.]**

**391-3-6-.20 Swine Feeding Operation Permit Requirements**

**(1) Purpose.**

The purpose of this paragraph 391-3-6-.20 is to provide for the uniform procedures and practices to be followed relating to the application for and the issuance or revocation of permits for swine feeding operations. Nothing in this paragraph shall be construed to preclude the modification of any requirement of this paragraph when the Division determines that the requirement is not protective of the environment.

**(2) Definitions.**

All terms used in this paragraph shall be interpreted in accordance with the definitions as set forth in the Act unless otherwise defined in this paragraph or in any other paragraph of these Rules:

(a) “Act” means the Georgia Water Quality Control Act, as amended;

(b) “Swine feeding operation” or “operation” means a lot or facility where swine have been, are, or will be stabled or confined or fed or maintained for a total of at least 45 days in any 12-month period, and the confinement areas do not sustain crops, vegetation, forage growth, or post-harvest residues in the normal growing season.

(c) ~~“Animal Unit” (AU) is a unit of measurement for any swine feeding operation calculated by the number of swine weighing over 25 kilograms (approximately 55 pounds) multiplied by 0.4.~~ "Animal Unit" (AU) is a unit of measurement for any swine feeding operation calculated by adding the following numbers: the number of slaughter and feeder cattle multiplied by 1.0, plus the number of mature dairy cattle multiplied by 1.4, plus the number of swine weighing over 25 kilograms (approximately 55 pounds) multiplied by 0.4, plus the number of sheep multiplied by 0.1, plus the number of horses multiplied by 2.0.

(d) "Barn" means a structure where confinement feeding (feeding in limited quarters, often under a roof and over slotted floors) occurs. Structures where confinement feeding does not occur are not considered "barns" for the purposes of this rule.

(e) "Certified operator" means any person who has been trained and certified by the Georgia Department of Agriculture and has direct general charge of the day-to-day field operation of an swine feeding operation waste storage and disposal system, and who is responsible for the quality of the treated waste.

~~(d)~~(f) “Closure plan” means the plan approved by the Division for clean up and closure of the swine feeding operation and associated waste storage and disposal facilities.

~~(e) Comprehensive Nutrient Management Plan (CNMP) is a plan which identifies actions or priorities that will be followed to meet clearly defined nutrient management goals at an agricultural operation. Defining nutrient management goals and identifying measures and schedules for attaining the goals is critical to reducing threats to water quality and public health. CNMPs should address, at a minimum, feed management, manure handling and storage, land application of manure, land management, record keeping, and management of other utilization options. The Natural Resources Conservation Services (NRCS) Field Office Technical Guide (FOTG) is the primary technical reference for the development of CNMPs. It contains technical information about utilization and conservation of soil, water, air, plant, and animal resources. The FOTG used in an individual field office is localized to consider particular characteristics for the geographic area for which it is prepared. CNMPs are submitted to the Division for review and approval. They include emergency response planning and a closure plan for abandonment of any facility used for the treatment or storage of swine waste.~~

(g) "Comprehensive Nutrient Management Plan" (CNMP) is a plan which identifies actions or priorities that will be followed to meet clearly defined nutrient management goals at an agricultural operation. Defining nutrient management goals and identifying measures and schedules for attaining the goals are critical to reducing threats to water quality and public health. The CNMP should address, at a minimum, manure handling and storage, land application of manure and wastewater, site management, record keeping, and management of other utilization options. The CNMP must be developed or modified by a "certified specialist" defined by the Division. The Division will specify the requirements for certification. The CNMP is submitted to the Division for review and approval. It should include emergency response planning and a closure plan for abandonment of any facility used for the treatment or storage of animal waste.

~~(f) Existing operation means a swine feeding operation which was in operation prior to the effective date of this rule.~~

(h) "Existing" applies to that which existed prior to the effective date of this rule. "Existing operation" means a swine feeding operation that was in operation prior to the effective date of this rule.

~~(g) Individual permit means an NPDES permit applied for and issued in accordance with paragraph 391-3-6-.06 of this Chapter.~~

~~(h)~~(i) Natural Resources Conservation Services (NRCS) is an agency within the United States Department of Agriculture.

(j) "New or expanding operation" or "new swine feeding operation" means a swine feeding operation the construction or expansion of which is commenced on or after the effective date of this rule.

~~(i) NRCS guidance means the latest editions of the NRCS Agricultural Waste Management Field Handbook, Part 651, FOTG Section IV Georgia, and other applicable publications of the NRCS.~~

(k) "NRCS guidance" means the latest editions of the Natural Resources Conservation Service (NRCS) Agricultural Waste Management Field Handbook, Part 651, Field Office Technical Guide Section IV Georgia, and other applicable publications of the NRCS. NRCS guidance is used by a certified specialist to develop or modify a CNMP.

~~(j) "New operation" means a swine feeding operation the construction or expansion of which is commenced on or after the effective date of this rule.~~

~~(k)~~(l) "Owner" means any person owning any system for waste treatment and disposal at a swine feeding operation. "Owner or operator" means any person who owns, leases, controls, or supervises a swine feeding operation. For the purpose of paragraph 391-3-6-.20 (8) of these rules, if a person intends to operate a swine feeding operation with another entity that owns the swine, directs the manner in which the swine will be housed, or controls the inputs or the other material aspects of the operation, this person shall be the operator and the owner shall be the entity that owns the swine, directs the manner in which the swine will be housed, or controls the inputs or the other material aspects of the operation.

~~(l) "Permit by rule" or "deemed to be permitted" means an issued non-NPDES permit in accordance with Division paragraph 391-3-.06.20 (4).~~

(m) "Permit" means a permit applied for and issued in accordance with the terms and conditions for paragraphs 391-3-6-.06, Waste Treatment and Permit Requirements (individual NPDES permits), or 391-3-6-.11, Land Disposal and Permit Requirements (non-NPDES individual land application system or "LAS" permit), or 391-3-6-.15, Non-Storm Water General Permit Requirements (general NPDES permit), or 391-3-6-.19, General Permit - Land Application System Requirements (non-NPDES general LAS permit), of this Chapter.

~~(m)~~(n) "Removed from service" means:

1. The waste storage and disposal facilities no longer receive swine wastes and the facilities are not being serviced or maintained; or

2. The owner or operator informs the Division that the swine feeding operation has been closed and removed from service; or

3. The Division has ordered the facilities closed; or

4. An order has been issued by a court to cease operation and close the facilities.

~~(n) "25-year, 24-hour storm event" is the maximum 24-hour precipitation event expressed in inches with a probable recurrence interval of once in 25 years, as defined by the National Weather Service.~~

(o) "Wetted area" or "disposal area" is the land area where swine waste is sprayed, spread, incorporated, or injected so that the waste can either condition the soil or fertilize crops or vegetation grown in the soil.

(p) "25-year, 24-hour storm event" is the maximum 24-hour precipitation event expressed in inches with a probable recurrence interval of once in 25 years, as defined by the National Weather Service of the United States Department of Commerce in Technical Paper Number 40, "Rainfall Frequency Atlas of the United States," May 1961, and subsequent amendments.

~~(o)~~(q) "50-year, 24-hour storm event" is the maximum 24-hour precipitation event expressed in inches with a probable recurrence interval of once in 50 years, as defined by the National Weather Service~~.~~ of the United States Department of Commerce in Technical Paper Number 40, "Rainfall Frequency Atlas of the United States," May 1961, and subsequent amendments.

~~(p)~~(r) "100-year flood plain" is the land inundated from a flood whose peak magnitude would be experienced on an average of once every 100 years. The 100-year flood has a 1% probability of occurring in one given year.

~~(q) "Wetted area" or "disposal area" is the land area where swine feeding operation waste is sprayed, spread, incorporated, or injected so that the waste can either condition the soil or fertilize crops or vegetation grown in the soil.~~

(s) "300 AU" means three hundred animal units. Paragraph 391-3-6-.20 (2) (c) notwithstanding, the numbers of animals in any of the following categories are equivalent to 300 AU:

1. 300 slaughter and feeder cattle,

2. 200 mature dairy cattle (whether milked or dry cows),
3. 150 horses,
4. 750 swine each weighing over 25 kilograms (approximately 55 pounds),
5. 3,000 sheep or lambs,
6. 16,000 turkeys,
7. 30,000 laying hens or broilers (if the facility has continuous overflow watering),
8. 9,000 laying hens or broilers (if the facility has a liquid manure handling system),
9. 1,500 ducks

(t) "1000 AU" means one thousand animal units. Paragraph 391-3-6-.20 (2) (c) notwithstanding, the numbers of animals in any of the following categories are equivalent to 1000 AU:

1. 1,000 slaughter and feeder cattle,
2. 700 mature dairy cattle (whether milked or dry cows),
3. 2,500 swine each weighing over 25 kilograms (approximately 55 pounds),
4. 500 horses,
5. 10,000 sheep or lambs,
6. 55,000 turkeys,
7. 100,000 laying hens or broilers (if the facility has continuous overflow watering),
8. 30,000 laying hens or broilers (if the facility has a liquid manure handling system),
9. 5,000 ducks

(u) "3000 AU" means three thousand animal units. Paragraph 391-3-6-.20 (2) (c) notwithstanding, the numbers of animals in any of the following categories are equivalent to 3000 AU:

1. 3,000 slaughter and feeder cattle,
2. 2,100 mature dairy cattle (whether milked or dry cows),
3. 7,500 swine each weighing over 25 kilograms (approximately 55 pounds),
4. 1,500 horses,
5. 30,000 sheep or lambs,
6. 165,000 turkeys,
7. 300,000 laying hens or broilers (if the facility has continuous overflow watering),
8. 90,000 laying hens or broilers (if the facility has a liquid manure handling system)
9. 15,000 ducks

**(3) Permit Requirement.**

(a) Any person who owns or operates a swine feeding operation with greater than 300 AU shall obtain a permit from the Division in accordance with this paragraph.

~~(b) Any person who owns or operates a swine feeding operation with 300 AU or less is not required to obtain a permit, but remains subject to applicable sections of the Act, including civil liability, civil penalty, and criminal penalty, § O.C.G.A. 12-5-51, et seq.~~

(b) Any person who is the owner of a swine feeding operation with 300 AU or less is not required to obtain a permit unless the swine feeding operation is defined as a concentrated animal feeding operation per 40 CFR 122, Appendix B or the Division has made a case-by-case designation as a concentrated animal feeding operation, in which case NPDES permitting is required by 40 CFR 122.23. The owner of a swine feeding operation with 300 AU or less remains subject to applicable sections of the Act, including civil liability, civil penalty, and criminal penalty, O.C.G.A. 12-5-51, et seq.

(c) Two or more swine feeding operations under common ownership are considered to be a single operation subject to this paragraph if they adjoin each other (are contiguous) or if they use a common area system for the disposal of wastes.

(d) The sale, lease, or other transfer of ownership or operating control of any swine feeding operation with greater than 3000 AU to any other corporate or partnership entity or to any individual person or persons unrelated by blood, marriage, or adoption to the existing operator shall require that a new permit be applied for, in accordance with the applicable paragraph or paragraphs of this rule.

(e) Exclusions from all permit requirements of this paragraph are made for the following facilities unless they are defined as a concentrated animal feeding operation per 40 CFR 122, Appendix B, or the Division has made a case-by-case designation as a concentrated animal feeding operation, or the Division has determined that they have potential to discharge, in which cases NPDES permitting is required by 40 CFR 122.23:

1. A livestock market, sale barn, stockyard, or auction house where animals are assembled from at least two sources to be publicly auctioned or privately sold on a commission basis and that is under state or federal supervision. However, these facilities are defined as swine feeding operations if they meet the definition of a swine feeding operation in subparagraph (2)(b).

**~~(4) Permit by Rule for 301 to 1000 AU.~~**

~~(a) Any person who owns or operates a swine feeding operation with 301 to 1000 AU in conformance with all provisions of this subparagraph is deemed to be permitted pursuant to this paragraph and shall not be required to obtain an individual permit from the Division.~~

~~(b) There shall be no discharge of pollutants from the operation into surface waters of the State.~~

~~(c) By October 31, 2002, new operations must have waste storage and disposal systems in operation that have been designed and constructed in accordance with NRCS guidance.~~

~~(d) By October 31 2001, the owner or operator shall submit to the Division a CNMP for the swine feeding operation. The CNMP shall be of sufficient substance and quality as to be approvable by the Division. The owner or operator shall receive the Division's approval of the CNMP by July 1, 2002, and shall begin implementing the approved CNMP not later than October 31, 2002.~~

~~(e) The operation must have a certified operator by October 31, 2001. The operator must be trained and certified, in accordance with 391-3-6-.20(13).~~

~~(f) New operations must be designed and constructed to handle the runoff from a 25-year, 24-hour storm event without an overflow from the storage lagoon.~~

~~(g) New operations located within significant ground water recharge areas which fall within the categories defined in the Georgia Department of Natural Resources Rules for Environmental Planning Criteria, Chapter 391-3-15-.02, Paragraph 3.(e) must be provided with either a compacted clay or synthetic liner such that the vertical hydraulic conductivity does not exceed~~ ~~$5 \times 10^{-7}$ cm/sec or other criteria as determined by the Division. If it is determined that an existing lagoon is creating a ground water contamination problem, the Division may require the lagoon to be repaired.~~

~~(h) New barns, new lagoons, and new waste disposal systems for new swine feeding operations started after the effective date of this rule with 301 to 1000 AU, or for existing swine feeding operations that are expanding production so that they will have 301 to 1000 AU after the effective date of this rule, shall not be located within a 100-year flood plain.~~

(i) ~~All existing, new, or expanding swine feeding operations with 301 to 1000 AU, must submit a registration form to the Division, on or before October 31, 2000.~~

(j) ~~Any failure to comply with any condition of (a) through (h) above shall be deemed a violation of the Act and may be punishable in accordance with the penalties provided for in the Act.~~

**(4) Permit for Existing or New Operations with more than 300 but equal to or less than 1000 AU.**

(a) Any person who is the owner of an existing swine feeding operation with more than 300 but equal to or less than 1000 AU must apply for an LAS permit from the Division within 90 days from the effective date of this paragraph. The Division may issue an individual or general permit. New or expanding swine feeding operations must obtain an LAS permit from the Division prior to beginning the swine feeding operation with more than 300 but equal to or less than 1000 AU. Permit applications for new or expanding swine feeding operations should be submitted 180 days prior to beginning the swine feeding operation with more than 300 but equal to or less than 1000 AU. Any person who owns or operates an existing or new swine feeding operation must have waste storage and disposal systems pursuant to this rule and meet the conditions in subparagraphs (b) through (i) below. Any person who is the owner of a swine feeding operation with more than 300 AU but equal to or less than 1000 AU is not required to obtain an NPDES permit unless the swine feeding operation is defined as a concentrated animal feeding operation per 40 CFR 122, Appendix B or the Division has made a case-by-case designation as a concentrated animal feeding operation, in which case NPDES permitting is required by 40 CFR 122.23.

(b) There shall be no discharge of pollutants from the operation into surface waters of the State unless a catastrophic rainfall event (25-year, 24-hour storm) occurs.

(c) Prior to beginning operation of the swine feeding operation, new operations must have waste storage and disposal systems in operation that have been designed and constructed in accordance with NRCS guidance.

(d) Within 90 days from the effective date of this paragraph, the owner of an existing swine feeding operation shall submit to the Division a CNMP for the swine feeding operation. The CNMP shall be of sufficient substance and quality as to be approvable by the Division. The owner should receive the Division's approval of the CNMP by July 1, 2002, and shall begin implementing the approved CNMP not later than October 31, 2002. The owner of a new operation should submit to the Division a CNMP prior to beginning operation of the swine feeding operation.

(e) Existing operations should have a certified operator by October 31, 2002. New operations should have a certified operator prior to beginning the swine feeding operation. The certified operator should be trained and certified in accordance with 391-3-6-.20(13).

(f) New operations must be designed and constructed to contain all process generated wastewaters plus the runoff from a 25-year, 24-hour storm event without an overflow from the waste storage lagoon.

(g) New waste storage lagoons located within significant ground water recharge areas which fall within the categories defined in the Georgia Department of Natural Resources Rules for Environmental Planning Criteria, Chapter 391-3-15-.02, Paragraph 3(e) must be provided with either a compacted clay or synthetic liner such that the vertical hydraulic conductivity does not exceed $5 \times 10^{-7}$ cm/sec or other criteria as determined by the Division. If it is determined that an existing waste storage lagoon is creating a ground water contamination problem, the Division may require the lagoon to be repaired.

(h) New barns and new waste storage lagoons for new swine feeding operations started after the effective date of this rule with more than 300 but equal to or less than 1000 AU, or for existing swine feeding operations that are expanding production so that they will have more than 300 but equal to or less than 1000 AU after the effective date of this rule, shall not be located within a 100-year flood plain.

(i) Any failure to comply with any condition of (a) through (h) above shall be deemed a violation of the Act and may be punishable in accordance with the penalties provided for in the Act.

**~~(5) Permit for Existing Operations 1001 to 3000 AU.~~**

~~(a) Any person who owns or operates an existing swine feeding operation with 1001 to 3000 AU must obtain an individual permit from the Division by October 31, 2000, in accordance with this paragraph. Permit applications should be submitted 180 days in advance. Any person who expands an existing operation to include 1001 to 3000 AU becomes subject to the requirements of paragraph (6), □Permit for New or Expanding Operations 1001 to 3000 AU□.~~

~~(b) There shall be no discharge of pollutants from the operation into surface waters of the State.~~

~~(c) By October 31 2001, the owner or operator shall submit to the Division a CNMP for the swine feeding operation. The CNMP shall be of sufficient substance and quality as to be approvable by the Division. The owner or operator shall receive the Division□s approval of the CNMP by July 1, 2002, and shall begin implementing the approved CNMP not later than October 31, 2002.~~

~~(d) The operation must have a certified operator by October 31, 2001. The operator must be trained and certified, in accordance with 391-3-6-.20(13).~~

~~(e) Prior public notice of the completed application and proposed draft permit will be prepared and circulated in accordance with 391-3-6-.06(7).~~

~~(f) If it is determined that an existing lagoon is creating a ground water contamination problem, the Division shall require the owner or operator to repair the lagoon, to close the lagoon, or to take other actions to protect the ground water.~~

~~(g) The wastewater disposal system shall be designed and operated such that nitrates in the ground water at the operation□s property line do not exceed 10 mg/1. The Division will require the owner or operator to implement corrective actions if the nitrates exceed 10 mg/1.~~

~~(h) At least one up-gradient and at least two down-gradient ground water monitoring wells shall be installed for the spray irrigation fields and one down gradient ground water monitoring well shall be installed for each lagoon or series of lagoons. The number, location, design and construction specifications of the monitoring wells shall be reviewed and approved by the Division, prior to issuance of a permit. Existing wells that are approved by the Division can be used for testing. Monitoring wells shall be properly installed within 24 months of permit issuance.~~

~~(i) The permit will contain specific requirements for monitoring the storage lagoon effluent to be land applied, and for the ground water monitoring wells. This will usually consist of semiannual monitoring of the effluent for 5-day Biochemical Oxygen Demand ($BOD_5$), Total Suspended Solids (TSS), Total Kjeldahl Nitrogen (TKN), Ammonia Nitrogen ($NH_3$), Nitrate Nitrogen ($NO_3$), and pH, as well as semiannual monitoring of the wells for specific conductivity, $NO_3$, pH and depth to ground water. Monitoring may be required to determine soil phosphorus adsorption, sodium adsorption ratio, cation exchange capacity, and cumulative loading of copper and zinc.~~

~~(j) When the owner or operator ceases raising swine, he must notify the Division of that fact within three months, and he must properly close all wastewater lagoons within eighteen months. Proper closure of a lagoon entails removing all wastewater from the lagoon and land applying~~

~~it on the owner or operator□s fields at agronomic rates, and in a manner so as not discharge to any surface water stream.~~

~~(k) Any failure to comply with any condition of (a) through (j) above or any condition of any individual permit issued for the operation shall be deemed a violation of the Act and may be punishable in accordance with the penalties provided in the Act.~~

**(5) Permit for Existing Operations with more than 1000 but equal to or less than 3000 AU.**

(a) Any person who is the owner of an existing swine feeding operation with more than 1000 but equal to or less than 3000 AU must apply for an NPDES permit from the Division by October 31, 2000. The Division may issue an individual or general permit. Any person who expands an existing operation to include more than 1000 but equal to or less than 3000 AU becomes subject to the requirements of subparagraph (6), "Permit for New or Expanding Operations with more than 1000 but equal to or less than 3000 AU."

(b) There shall be no discharge of process wastewater pollutants per 40 CFR Part 412 from the feedlot(s) or manure storage areas to waters of the United States except when catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain all process generated wastewater resulting from the operation of the swine feeding operation plus all runoff from a 25 year, 24-hour rainfall event for the location of the swine feeding operation.

(c) Within 90 days from the effective date of this paragraph, the owner shall submit to the Division a CNMP for the swine feeding operation. The CNMP shall be of sufficient substance and quality as to be approvable by the Division. The owner should receive the Division's approval of the CNMP by July 1, 2002, and shall begin implementing the approved CNMP not later than October 31, 2002.

(d) The operation should have a certified operator by October 31, 2002. The certified operator should be trained and certified in accordance with 391-3-6-.20(13).

(e) Public notice of the proposed draft permit will be prepared and circulated in accordance with 391-3-6-.06(7) or 391-3-6-.15(7).

(f) If it is determined that an existing waste storage lagoon is creating a ground water contamination problem, the Division shall require the owner to repair the lagoon, to close the lagoon, or to take other actions to protect the ground water.

(g) The waste disposal system shall be designed and operated such that it does not cause Nitrate Nitrogen ($NO_3$-N) in the ground water at the operation's property line to exceed 10 mg/l. The Division will require the owner to implement corrective actions if the permitted waste disposal system has caused the Nitrate Nitrogen ($NO_3$-N) to exceed 10 mg/l as described.

(h) Representative samples shall be collected from each major soil series present within the waste disposal field areas in a manner to be specified in the permit. One down gradient ground water monitoring well shall be installed for each waste storage lagoon or series of lagoons. The number, location, design and construction specifications of the monitoring wells shall be submitted to the Division prior to issuance of a permit. Existing wells that are approved by the Division can be used for testing. Monitoring wells shall be properly installed within 24 months of permit issuance.

(i) The permit will contain specific requirements for monitoring the waste storage lagoon effluent to be land applied and for the ground water monitoring wells. This will usually consist, at a

minimum, of semiannual monitoring of the effluent for Total Kjeldahl Nitrogen (TKN) and Nitrate Nitrogen ($NO_3$-N) as well as semiannual monitoring of the wells for TKN and $NO_3$- N.

(j) When the owner ceases operation of the swine feeding operation, he must notify the Division of that fact within three months, and he must properly close all waste storage lagoons within eighteen months. In the case of voluntary closure, a period of twenty-four months from notification is allowed. Proper closure of a lagoon entails removing all waste from the lagoon and land applying it at agronomic rates, and in a manner so as not to discharge to any surface water.

(k) Any failure to comply with any condition of (a) through (j) above or any condition of any individual permit issued for the operation shall be deemed a violation of the Act and may be punishable in accordance with the penalties provided in the Act.

~~**(6) Permit for New or Expanding Operations 1001 to 3000 AU.**~~

~~(a) New swine feeding operations with 1001 to 3000 AU which propose to commence operation after the effective date of this rule, or existing swine feeding operations which propose to expand to 1001 to 3000 AU after the effective date of this rule, must obtain an individual permit in accordance with this paragraph. Permit applications should be submitted 180 days in advance.~~

~~(b) There shall be no discharge of pollutants from the operation into the surface waters of the State, as defined in the Act, § O.C.G.A. 12-5-22(13). There shall be no discharge of pollutants into ground water which would cause ground water quality not to comply with the maximum contaminant levels established in Georgia's Rules for Safe Drinking Water 391-3-5.~~

~~(c) Prior to beginning the feeding of swine, the operation must have waste storage and disposal systems in operation that have been designed and constructed in accordance with NRCS guidance.~~

~~(d) Prior to beginning the feeding of swine, the owner or operator shall submit to the Division a CNMP for the swine feeding operation. The CNMP shall be of sufficient substance and quality as to be approvable by the Division.~~

~~(e) The operation must have a certified operator for the waste storage and disposal system prior to beginning the feeding of swine. The operator must be trained and certified, in accordance with 391-3-6-.20(13).~~

~~(f) Public notice of the completed application and proposed draft permit will be prepared and circulated in accordance with 391-3-6-.06(7)~~

~~(g) The system must be designed to handle the runoff from a 25-year, 24-hour storm event without an overflow from the storage lagoon.~~

~~(h) Any storage lagoon must be constructed to ensure that seepage is limited to a maximum of 1/8 inch per day ($3.67 \times 10^{-6}$ cm/sec). For lagoons located within significant ground water recharge areas which fall within the categories defined in the Georgia Department of Natural Resources Rules for Environmental Planning Criteria, Chapter 391-3-15-.02, Paragraph 3.(e), the waste impoundments must be provided with either a compacted clay or a synthetic liner such that the vertical hydraulic conductivity does not exceed $5 \times 10^{-7}$ cm/sec or other criteria as determined by the Division.~~

~~(i) It is required that a minimum of 2 feet of freeboard be maintained in the lagoons at all times.~~

~~(j) Barns, lagoons, and waste disposal systems shall not be located within a 100-year flood plain.~~

~~(k) The following buffers shall be maintained:~~

~~1. 300 feet between wetted area and any residence or places of public assembly under separate ownership, or 100 feet if subsurface injection is utilized for waste disposal.~~

~~2. 150 feet between wetted area and property lines, or 50 feet if subsurface injection is utilized for waste disposal~~

~~3. 100 feet between wetted area and water wells,~~

~~4. 100 feet between lagoons or barns or wetted area and drainage ditches, surface water bodies, or wetlands.~~

~~5. 700 feet between lagoons or barns and any occupied residence off of the applicant's property,~~

~~6. 700 feet between lagoons or barns and any public use area, church, picnic area, playground, school, hospital, outdoor recreational facility, national park, state park, historic property, or child care center,~~

~~7. 150 feet between lagoons or barns and any property boundary, and~~

~~8. 500 feet between lagoons or barns and any wells that supply water to a public water system, or any other well off the applicant's property that supplies water for human consumption.~~

~~(l) At least one up gradient and at least two down gradient ground water monitoring wells shall be installed for the spray irrigation fields and one down gradient ground water monitoring well shall be installed for each lagoon or series of lagoons. The number, location, design and construction specifications of the monitoring wells shall be reviewed and approved by the Division, prior to issuance of a permit. Existing wells that are approved by the Division can be used for testing. Monitoring wells shall be properly installed prior to the beginning of feeding of swine.~~

~~(m) The permit will contain specific requirements for monitoring the effluent and ground water monitoring wells. This will usually consist of semiannual monitoring of the effluent for~~ ~~$BOD_5$~~ ~~TSS, TKN,~~ ~~$NH_3$,~~ ~~$NO_3$~~ ~~and pH, as well as semiannual monitoring of the wells for specific conductivity,~~ ~~$NO_3$,~~ ~~pH and depth to ground water. Monitoring may also be required to determine soil phosphorus adsorption, sodium adsorption ratio, cation exchange capacity, and cumulative loading of copper and zinc.~~

~~(n) When the owner or operator ceases raising swine, he must notify the Division of that fact within three months, and he must properly close all wastewater lagoons within eighteen months. Proper closure of a lagoon entails removing all wastewater from the lagoon and land applying it on the owner or operator's fields at agronomic rates, and in a manner so as not discharge to any surface water stream.~~

~~(o) Any failure to comply with any condition of (a) through (n) above or any condition of any individual permit issued for the operation shall be deemed a violation of the Act and may be punishable in accordance with the penalties provided in the Act.~~

## (6) Permit for New or Expanding Operations with more than 1000 but equal to or less than 3000 AU.

(a) Any person who proposes to commence operation of a new swine feeding operation with more than 1000 but equal to or less than 3000 AU after the effective date of this paragraph, or any person who proposes to expand an existing AFO to more than 1000 but equal to or less than 3000 AU after the effective date of this paragraph, must obtain an NPDES permit in accordance with this subparagraph. The Division will issue an individual permit. Permit applications should be submitted 180 days in advance.

(b) There shall be no discharge of process wastewater pollutants per 40 CFR Part 412 from the feedlot(s) or manure storage areas to waters of the United States except when catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain all process generated wastewater resulting from the operation of the swine feeding operation plus all runoff from a 25 year, 24-hour rainfall event for the location of the swine feeding operation. There shall be no discharge of pollutants into ground water which would cause ground water quality not to comply with the primary maximum contaminant levels established in Georgia's Rules for Safe Drinking Water, Chapter 391-3-5.

(c) Prior to beginning operation of the swine feeding operation, the operation must have waste storage and disposal systems in operation that have been designed and constructed in accordance with NRCS guidance.

(d) Prior to beginning operation of the swine feeding operation, the owner shall submit to the Division a CNMP for the swine feeding operation. The CNMP shall be of sufficient substance and quality as to be approvable by the Division.

(e) The operation should have a certified operator for the waste storage and disposal system prior to beginning the swine feeding operation. The certified operator should be trained and certified in accordance with 391-3-6-.20(13).

(f) Public notice of the proposed draft permit will be prepared and circulated in accordance with 391-3-6-.06(7).

(g) The waste storage and disposal system must be designed to contain all process generated wastewaters plus the runoff from a 25-year, 24-hour storm event without an overflow from the waste storage lagoon.

(h) Any waste storage lagoon must be constructed to ensure that seepage is limited to a maximum of 1/8 inch per day ($3.67 \times 10^{-6}$ cm/sec). For waste storage lagoons located within significant ground water recharge areas which fall within the categories defined in the Georgia Department of Natural Resources Rules for Environmental Planning Criteria, Chapter 391-3-15-.02, Paragraph 3(e), the lagoons must be provided with either a compacted clay or a synthetic liner such that the vertical hydraulic conductivity does not exceed $5 \times 10^{-7}$ cm/sec or other criteria as determined by the Division. Individual waste storage lagoons shall not exceed 100 acre-feet in volume.

(i) It is required that a minimum of 2 feet of freeboard be maintained in the waste storage lagoons at all times.

(j) Barns and waste storage lagoons shall not be located within a 100-year flood plain.

(k) The following buffers shall be maintained:

1. 100 feet between wetted areas and water wells;

2. 100 feet between waste storage lagoons or barns or wetted areas and drainage ditches, surface water bodies, or wetlands;

3. 500 feet between waste storage lagoons or barns and any existing wells that supply water to a public water system, or any other existing well off the owner's property that supplies water for human consumption.

(l) Representative samples shall be collected from each major soil series present within the waste disposal field areas in a manner to be specified in the permit. One down gradient ground water monitoring well shall be installed for each waste storage lagoon or series of lagoons. The number, location, design and construction specifications of the monitoring wells shall be submitted to the Division prior to issuance of a permit. Existing wells that are approved by the Division can be used for testing. Monitoring wells shall be properly installed prior to the beginning of operation of the swine feeding operation.

(m) The permit will contain specific requirements for monitoring the waste storage lagoon effluent to be land applied, and for the ground water monitoring wells. This will usually consist, at a minimum, of semiannual monitoring of the effluent for Total Kjeldahl Nitrogen (TKN) and Nitrate Nitrogen ($NO_3$-N) as well as semiannual monitoring of the wells for TKN and $NO_3$- N.

(n) When the owner ceases operation of the swine feeding operation, he must notify the Division of that fact within three months, and he must properly close all waste storage lagoons within eighteen months. In the case of voluntary closure, a period of twenty-four months from notification is allowed. Proper closure of a lagoon entails removing all waste from the lagoon and land applying it at agronomic rates, and in a manner so as not to discharge to any surface water.

(o) Any failure to comply with any condition of (a) through (n) above or any condition of any individual permit issued for the operation may be deemed a violation of the Act and may be punishable in accordance with the penalties provided in the Act.

**(7) Permit for Existing Operations with more than 3000 AU.**

(a) Any person who owns or operates an existing swine feeding operation with more than 3000 AU must obtain an individual permit from the Division by October 31, 2000, in accordance with this paragraph. Permit applications should be submitted 180 days in advance. If the individual permit has not been obtained by October 31, 2000, the operation shall be closed, or the operation shall be reduced to 1000 AU or less and shall be in compliance with 391-3-6-.20(4).

(b) There shall be no discharge of pollutants from the operation into the surface waters of the State, as defined in the Act, O.C.G.A. 12-5-22(13). There shall be no discharge of pollutants into ground water which would cause ground water quality not to comply with the maximum contaminant levels established in Georgia's Rules for Safe Drinking Water 391-3-5.

(c) By October 31, 2002, the operation must have waste storage and disposal systems in operation that have been designed and constructed in accordance with NRCS guidance, or as otherwise determined by the Division.

(d) By October 31 2001, the owner or operator shall submit to the Division a CNMP for the swine feeding operation. The CNMP shall be of sufficient substance and quality as to be approvable

by the Division. The owner or operator shall receive the Division□s approval of the CNMP by July 1, 2002, and shall begin implementing the approved CNMP not later than October 31, 2002.

(e) The operation must have a certified operator by October 31, 2001. The operator must be trained and certified, in accordance with 391-3-6-.20(13).

(f) Public notice of the completed application and proposed draft permit will be prepared and circulated in accordance with 391-3-6-.06(7).

(g) The system must be designed to handle the runoff from a 25-year, 24-hour storm event without an overflow from the storage lagoon.

(h) If it is determined that an existing lagoon is creating a ground water contamination problem, the Division may require owner or operator to repair the lagoon to meet NRCS standards, to close the lagoon, or to take other actions to protect the ground water.

(i) It is required that a minimum of 2 feet of freeboard be maintained in the lagoons at all times.

(j) The wastewater disposal system shall not be located within a flood plain unless it protected from inundation or damage from a 25-year, 24-hour storm event.

(k) The wastewater disposal system shall be designed and operated such that nitrates in the ground water at the operation□s property line do not exceed 10 mg/1. The Division will require the owner or operator to implement corrective actions if the nitrates exceed 10 mg/1.

(l) At least one up-gradient and at least two down-gradient ground water monitoring wells shall be installed for the spray irrigation fields and one down gradient ground water monitoring well shall be installed for each lagoon or series of lagoons. The number, location, design and construction specifications of the monitoring wells shall be reviewed and approved by the Division, prior to issuance of a permit. Existing wells that are approved by the Division can be used for testing. Monitoring wells shall be properly installed within 24 months of permit issuance.

(m) The permit will contain specific requirements for monitoring the storage lagoon effluent to be land applied, and for the ground water monitoring wells. This will usually consist of semiannual monitoring of the effluent for 5-day Biochemical Oxygen Demand ($BOD_5$), Total Suspended Solids (TSS), Total Kjeldahl Nitrogen (TKN), Ammonia Nitrogen ($NH_3$), Nitrate Nitrogen ($NO_3$), and pH, as well as semiannual monitoring of the wells for specific conductivity, $NO_3$, pH and depth to ground water. Monitoring may be required to determine soil phosphorus adsorption, sodium adsorption ratio, cation exchange capacity, and cumulative loading of copper and zinc

(n) The permit may require periodic monitoring of any wet weather ditches or perennial streams which are in close proximity to spray irrigation fields.

(o) When the owner or operator ceases raising swine, he must notify the Division of that fact within three months, and he must properly close all wastewater lagoons within eighteen months. Proper closure of a lagoon entails removing all wastewater from the lagoon and land applying it on the owner or operator□s fields at agronomic rates, and in a manner so as not discharge to any surface water stream.

(p) Any failure to comply with any condition of (a) through (o) above or any condition of any individual permit issued for the operation shall be deemed a violation of the Act and may be punishable in accordance with the penalties provided in the Act.

(q) In the event of any expansion of an existing operation with more than 3000 AU which expansion requires the construction or use of new lagoons and/or disposal areas, or the expansion of existing lagoons and/or disposal areas, the operator shall comply with the requirements of paragraph (8), (e), (f), (g), (i), (j), (k), (o), and (p), with respect to such new or expanded lagoons or disposal areas. In the event of an expansion sufficient to necessitate the construction of new

lagoons or disposal areas, or the expansion of existing lagoons or disposal areas, the entire operation shall comply with paragraph (8) (n) and (q) and (9), (10), (11), and (12).

**(8) Permit for New or Expanding Operations with more than 3000 AU.**

(a) New swine feeding operations with more than 3000 AU, or existing operations that are expanding production so that they will have more than 3000 AU which propose to commence operation after the effective date of this rule must obtain an individual permit in accordance with this paragraph prior to commencing construction for the operation. Permit applications should be submitted 180 days in advance. Any existing swine feeding operation which proposes to expand to more than 3000 AU must obtain an individual permit and comply with the requirements of this paragraph prior to any such expansion or operation of such an expanded facility.

(b) There shall be no discharge of pollutants from the operation into the surface waters of the State, as defined in the Act, O.C.G.A. 12-5-22(13). There shall be no discharge of pollutants into ground water which would cause ground water quality not to comply with the maximum contaminant levels established in Georgia's Rules for Safe Drinking Water 391-3-5.

(c) The permit applicant shall have waste storage and disposal systems designed by a professional engineer registered in Georgia, at least as stringently as NRCS guidance, and shall implement a CNMP approved by the Division prior to startup. The permittee shall not start feeding any swine at the permitted operation before obtaining written approval from the Division for startup, subsequent to a final construction inspection by the Division.

(d) The operation must have a certified operator prior to startup. The operator must be trained and certified in accordance with 391-3-6-.20(13).

(e) The owner or operator shall, after completing a site evaluation and before any site preparation or construction commences, notify all adjoining property owners and all property owners who own property located within one mile of any boundary of the swine feeding operation of that person's intent to construct the swine feeding operation. This notice shall be by certified mail sent to the address on record at the property tax office in the county in which the land is located. The written notice shall include all of the following:

1. The name and address of the person intending to construct a swine feeding operation.

2. The type of swine feeding operation and the design capacity (in number of swine) of the proposed swine waste management system.

3. The name and address of the technical specialist preparing the waste management plan.

4. The address of the local Soil and Water Conservation District office.

5. A statement informing the adjoining property owners and the property owners who own property located within one mile of the proposed swine feeding operation that they may submit written comments or questions to the Division.

In addition, the owner or operator must conduct a minimum of one public meeting to present to the public the proposed project, its purpose, design, and environmental impacts. The meeting date and time must be advertised at least 30 days in advance in local newspapers with circulation covering all areas impacted by the project. Provisions to receive written comments should also be made. Evidence of notification of adjoining property owners, minutes of the public meeting, proof of advertisement, and opinions derived from the meeting must be submitted to the Division. Prior to making a decision on whether to issue a permit, the Division will require the permit applicant to run a notice in the largest newspaper of general circulation

in the affected county and will provide a 30-day public comment period. Furthermore, the Division may conduct a public hearing on the application prior to making any final decision.

(f) The system must be designed to handle the runoff from a 50-year, 24-hour storm event without an overflow from the storage lagoon or storm water runoff from the disposal fields.

(g) Any storage lagoon shall be provided with a synthetic liner such that the vertical hydraulic conductivity does not exceed $5 \times 10^{-7}$ cm/sec. Individual waste storage lagoons shall not exceed 100 acre-feet in volume.

(h) It is required that a minimum of 2 feet of freeboard be maintained in the lagoons at all times.

(i) Barns, lagoons, and wastewater disposal systems shall not be located within a 100-year flood plain.

(j) The following buffers shall be maintained:

1. 750 feet between disposal area and any residence or places of public assembly under separate ownership,
2. 200 feet between disposal area and property lines,
3. 200 feet between disposal area and water wells,
4. 150 feet between disposal area and drainage ditches, surface water bodies, or wetlands,
5. 1,750 feet between lagoons or barns and any occupied residence,
6. 1,750 feet between lagoons or barns and any public use area, church, picnic area, playground, school, hospital, outdoor recreational facility, national park, state park, historic property or child care center,
7. 1,750 feet between lagoons or barns and any property boundary,
8. 1,750 feet between lagoons or barns and any wells that supply water to a public water system, or any other well that supplies water for human consumption, and
9. 2,640 feet between lagoons or barns and waters of the State (not including ephemeral and intermittent streams).

(k) At least one up-gradient and at least two down-gradient ground water monitoring wells shall be installed for each drainage basin intersected by the disposal field and for each lagoon. The number, location, design, and construction specifications of the monitoring wells shall be reviewed and approved by the Division prior to permit issuance. The wells must be properly installed prior to the beginning of feeding of swine.

(l) The permit will contain specific requirements for monitoring the effluent and ground water monitoring wells. This will usually consist of quarterly monitoring of the effluent for $BOD_5$, TSS, TKN, $NH_3$, $NO_3$ and pH, as well as quarterly monitoring of the wells for specific conductivity, $NO_3$, pH and depth to ground water. Monitoring will also be required to determine soil phosphorus adsorption, sodium adsorption ratio, cation exchange capacity, and cumulative loading of copper and zinc.

(m) The permit may require periodic monitoring of any wet weather ditches or perennial streams which are in close proximity to disposal fields.

(n) The owner or operator shall provide the evidence of financial responsibility in accordance with paragraph 391-3-6-.20 (11) prior to permit issuance. A closure plan in accordance with

paragraph 391-3-6-.20(12) shall be provided with the permit application. The sum of the following costs must also be included in the evidence of financial responsibility:

1. Ten percent of the initial capital costs for construction of the entire hog-growing facility swine feeding operation ( barns, pens, feed storage, waste management, etc.)

2. $100,000 to cover the costs of any fines that may be imposed by the Division for violations of the laws, rules, regulations, and permits associated with the facility.

(o) These operations are prohibited from using open lagoons. Lagoons and waste storage facilities must be provided with airtight covers. Air pollution control devices using best available technology must be installed on all lagoon cover vents and openings to remove ammonia, hydrogen sulfide, methane, formaldehyde, and any other organic and inorganic air pollutants which may be required by the Division. Such air pollution control devices must meet all requirements of the Division and Georgia□s Rules for Air Quality Control (391-3-1), and no swine feeding operation NPDES permit for new or expanding operations with more than 3000 AU shall be issued by the Division unless an appropriate air quality control permit can be issued simultaneously.

(p) These operations are prohibited from using spray irrigation of lagoon effluent. Lagoon effluent must be incorporated into the disposal fields using subsurface injection at a depth not less than 6 inches.

(q) These operations shall be assessed penalties for failure to comply with the terms of this paragraph, the Act or the individual permit according to the following schedule:

1. Lagoon breach or loss of containment, $50,000 for the first day and $100,000 per day for each day within a 12 month period thereafter during which a release occurs.

2. Land disposal field runoff, $25,000 per day.

3. Discharge to ground water on site causing ground water to exceed any maximum contaminant limits in Georgia□s Rules for Safe Drinking Water, $5,000 per day.
4. Discharge to ground water causing increases of pollutant concentrations at the property line above ambient levels, $5,000 per day and immediate cessation of land disposal.

5. Second occurrence of any of the failures to comply specified above in paragraph 391-3-6-.20 8. (s) (1), (2), (3), or (4), immediate revocation of the individual permit and assessment of the appropriate penalty.

(r) These operations shall submit a compliance history and other information with the permit application in accordance with paragraph (10) of this rule.

**(9) Degree of Pollutant Treatment Required and Alternative Technology**

(a) The owner or operator of any swine feeding operation covered by rule 391-3-6-.20 shall ensure that all wastes from a swine feeding operation shall receive such treatment or corrective action so as to ensure compliance with the terms and conditions of the permit~~ by rule or individual permit~~.

(b) If retrofitting the waste handling storage and disposal system of any swine feeding operation covered by 391-3-6-.20 with alternative technology becomes economically achievable, the Director may require any swine feeding operation to eliminate lagoons or spray fields. Alternative technologies may include, but are not limited to:

1. Drying/dewatering in greenhouse - type facilities

2. Composting by in-vessel method

3. Mechanical separation

4. Biogas production

5. Soil incorporation

6. Soil injection

**(10) Refusal to Grant Certain Permits in accordance with  O.C.G.A. 12-5-23 (d), (e), (f), and (g).**

(a) An applicant for a permit for a new or expanding swine feeding operation with more than 3000 AU shall submit the following information to the Director as it pertains to the applicant and, in the case of a corporation or partnership, to the corporation, partnership, officer, director, manager, partner and each shareholder of five percent or more of the stock or financial interest in the corporation or partnership:

1. The name, social security number, taxpayer identification number and business address.

2. Background information and a three-year environmental compliance history of any facility associated with any of the above individuals in any state. The information and compliance history shall be sufficient to address the following:

(i) intentionally misrepresented or concealed any material fact in permit application submitted;

(ii) obtained or attempted to obtain another permit by misrepresentation or concealment;

(iii) pleaded guilty or been convicted by final judgment, and all appeals have been exhausted, in this state or any other state or federal court of any felony involving moral turpitude;

(iv) pleaded guilty or been convicted by final judgment and all appeals have been exhausted to a third or subsequent material violation of any federal environmental law or any environmental law of this state or of any other state that presented a substantial endangerment to human health or the environment;

(v) adjudicated in contempt of any court order enforcing any federal environmental laws or any environmental laws of this state or of any other state;

(vi) the holder of any permit required for the discharge of pollutants as defined by this article, under the laws of this state, any other state, or the Federal Water Pollution Control Act Amendments of 1972, as amended, which permit has been revoked for reasons of noncompliance;

(vii) denied for reasons of noncompliance the issue of any permit required for the discharge of pollutants, as defined by this article, under the laws of this state, any other state, or the Federal Water Pollution Control Act Amendments of 1972, as amended, which permit has been revoked for reasons of noncompliance;

(viii) fish kills caused by any facility;

(ix) facility compliance status for the past three years including all violations of environmental permits, rules or statutes.

(x) other information determined by the Director.

(b) The Director shall deny a permit application for a new or expanding swine feeding operation if the applicant or any person identified in (a) above:

1. intentionally misrepresented or concealed any material fact in the application submitted to the Director or an environmental permit application in any other state;

2. has obtained or attempted to obtain another permit from the Director or from any other state by misrepresentation or concealment;

3. has pleaded guilty or been convicted by final judgment and all appeals have been exhausted, in this state or any other state or federal court of any felony involving moral turpitude within the three years preceding the date of the application for such permit;

4. has pleaded guilty or been convicted by final judgment and all appeals have been exhausted to a third or subsequent material violation of any federal environmental law or any environmental law of this state or of any other state that presented a substantial endangerment to human health or the environment within three years preceding the date of the application for such a permit;

5. has been adjudicated in contempt of any court order enforcing any federal environmental laws or any environmental laws of this state or of any other state within three years preceding the date of the application for such permit;

6. was the holder of any permit required for the discharge of pollutants, as defined by this article, under the laws of this state, any other state, or the Federal Water Pollution Control Act Amendments of 1972, as amended, which permit has been revoked for reasons of noncompliance within three years preceding the date of the application for a permit under this article;

7. was denied for reasons of noncompliance the issuance of any permit required for the discharge of pollutants, as defined by this article, under the laws of this state, any other state, or the Federal Water Pollution Control Act Amendments of 1972, as amended, within three years preceding the date of the application for a permit.

(c) The Director shall deny a permit application for a new or expanding swine feeding operation if a facility operated by or associated with any person identified in (a) above has failed to operate in full compliance with applicable environmental permits, rules or statutes for less than eighty percent of the time during the three-year period preceding the date of the application for a permit or if the facility caused more than one fish kill during that period.

(d) The Director shall not deny a permit as stated in (b) above, if the Director finds that affirmative actions taken by the applicant mitigate the impact of any such material misrepresentations, concealment, convictions, adjudication or violations. Such affirmative actions to be considered by the Director as mitigating factors shall include, but not be limited to, information or documentation related to the following:

1. Implementation by the applicant of formal policies, training programs, or other management controls to minimize the occurrence of future unlawful activities;

2. Installation by the applicant of environmental auditing or compliance programs;

3. The discharge from employment of any individual who was convicted of a crime associated with environmental violations.

## (11) FINANCIAL REQUIREMENTS

Owners of new swine feeding operations with more than 3000 AU at any one time shall establish and maintain evidence of financial responsibility to provide for the closure of their waste treatment facilities and the proper disposal of their contents after closure of the facility.

(a) The owner must have a detailed written estimate, in current dollars, of the cost of hiring a third party to clean up and close the swine feeding operation. The owner must obtain a letter from the Division stating its concurrence that the owner's estimate of clean up and closure costs is reasonable. The owner must notify the Director that the estimate has been placed in the operating record.

1. During the active life of the facility, the owner must annually adjust the closure cost estimate for inflation.

2. The owner must increase the closure cost estimate and the amount of financial assurance provided under paragraph (b) of this section if changes to the closure plan increase the maximum cost of closure at any time during the remaining active life.

3. The owner may reduce the closure cost estimate and the amount of financial assurance provided under paragraph (b) of this section if the cost estimate exceeds the maximum cost of closure. The owner must notify the Director that the justification for the reduction of the closure cost estimate and the amount of financial assurance has been placed in the operating record.

(b) Financial assurance for closure: The owner of each swine feeding operation with an annual average of greater than 3000 AU must establish financial assurance for closure of the facility. The owner must provide continuous coverage for closure until released from financial assurance requirements by the Director. The owner must choose from the options as specified in paragraphs (c) through (f) of this section. The mechanism for financial assurance must be submitted to the Division for approval and must also allow the Director access to the funds in the event of failure of the owner to close the facility in accordance with 12 (c).

(c) Closure trust fund.

1. An owner may satisfy the requirements of this section by establishing a closure trust fund and submitting an originally signed duplicate of the trust agreement to the Director. The trustee must be an entity which has the authority to act as a trustee and whose trust operations are regulated and examined by a Federal or State agency.

2. After the trust fund is established, whenever the current closure cost estimate changes, the owner must compare the new estimate with the trustee's most recent annual valuation of the trust fund. If the value of the fund is less than the amount of the new estimate, the owner, within 60 days after the change in the cost estimate, must either deposit an amount into the fund so that its value after this deposit at least equals the amount of the current closure cost estimate, or obtain other financial assurance as specified in this section to cover the difference.

3. If the value of the trust fund is greater than the total amount of the current closure cost estimate, the owner may submit a written request to the Director for release of the amount in excess of the current closure cost estimate.

4. If an owner substitutes other financial assurance as specified in this section for all or part of the trust fund, he may submit a written request to the Director for release of the amount in excess of the current closure cost estimate covered by the trust fund.

5. After beginning partial or final closure, an owner or another person authorized to conduct partial or final closure may request reimbursements for partial or final closure expenditures by submitting itemized bills to the Director. The owner may request

reimbursements for partial closure only if sufficient funds are remaining in the trust fund to cover the maximum costs of closing the facility over its remaining operating life. No later than 60 days after receiving bills for partial or final closure activities, the Director will instruct the trustee to make reimbursements in those amounts as the Director specifies in writing, if the Director determines that the partial or final closure expenditures are in accordance with the approved closure plan, or otherwise justified. If the Director does not instruct the trustee to make such reimbursements, he will provide to the owner or operator a detailed written statement of reasons.

6. The Director will agree to termination of the trust when:

(i) An owner substitutes alternate financial assurance as specified in this section; or

(ii) The Director releases the owner from the requirements of this section.

(d) Closure letter of credit.

1. An owner may satisfy the requirements of this section by obtaining an irrevocable standby letter of credit and submitting the letter to the Director. The issuing institution must be an entity which has the authority to issue letters of credit and whose letter-of-credit operations are regulated and examined by a Federal or state agency.

2. The letter of credit must be accompanied by a letter from the owner referring to the letter of credit by number, issuing institution, and date, and providing the following information: The type of facility, name, and address of the facility, and the amount of funds assured for closure of the facility by the letter of credit.

3. The letter of credit must be irrevocable and issued for a period of at least 1 year. The letter of credit must provide that the expiration date will be automatically extended for a period of at least 1 year unless, at least 120 days before the current expiration date, the issuing institution notifies both the owner or operator and the Director by certified mail of a decision not to extend the expiration date. Under the terms of the letter of credit, the 120 days will begin on the date when both the owner or operator and the Director have received the notice, as evidenced by the return receipts.

4. The letter of credit must be issued in an amount at least equal to the current closure cost estimate.

5. Whenever the current closure cost estimate increases to an amount greater than the amount of the credit, the owner, within 60 days after the increase, must either cause the amount of the credit to be increased so that it at least equals the current closure cost estimate and submit evidence of such increase to the Director, or obtain other financial assurance as specified in this section to cover the increase. Whenever the current closure cost estimate decreases, the amount of the credit may be reduced to the amount of the current closure cost estimate following written approval by the Director.

6. Following a final administrative determination that the owner has failed to perform final closure in accordance with the approved closure plan when required to do so, the Director may draw on the letter of credit.

7. The Director will return the letter of credit to the issuing institution for termination when:

(i) An owner substitutes alternate financial assurance as specified in this section; or

(ii) The Director releases the owner from the requirements of this section.

(e) Closure insurance.

1. An owner may satisfy the requirements of this section by obtaining closure insurance which conforms to the requirements of this paragraph and submitting a certificate of such insurance to the Director. By the effective date of these rules the owner or operator must submit to the Director a letter from an insurer stating that the insurer is considering issuance of closure insurance conforming to the requirements of this paragraph to the owner or operator. Within 90 days after the effective date of these rules, the owner or operator must submit the certificate of insurance to the Director or establish other financial assurance as specified in this section. At a minimum, the insurer must be licensed to transact the business of insurance, or eligible to provide insurance as an excess or surplus lines insurer, in one or more States.

2. The closure insurance policy must be issued for a face amount at least equal to the current closure cost estimate. The term face amount means the total amount the insurer is obligated to pay under the policy. Actual payments by the insurer will not change the face amount, although the insurer's future liability will be lowered by the amount of the payments.

3. The closure insurance policy must guarantee that funds will be available to close the facility whenever final closure occurs. The policy must also guarantee that once final closure begins, the insurer will be responsible for paying out funds, up to an amount equal to the face amount of the policy, upon the direction of the Director, to such party or parties as the Director specifies.

4. After beginning final closure, an owner or any other person authorized to conduct closure may request reimbursements for closure expenditures by submitting itemized bills to the Director. Within 60 days after receiving bills for closure activities, the Director will instruct the insurer to make reimbursements in such amounts as the Director specifies in writing if the Director determines that the final closure expenditures are in accordance with the approved closure plan or otherwise justified. If the Director has reason to believe that the maximum cost of closure over the remaining life of the facility will be significantly greater than the face amount of the policy, he may withhold reimbursement of such amounts as he deems prudent until he determines that the owner is no longer required to maintain financial assurance for final closure of the particular facility. If the Director does not instruct the insurer to make such reimbursements, he will provide to the owner a detailed written statement of reasons.

5. The owner must maintain the policy in full force and effect until the Director consents to termination of the policy by the owner. Failure to pay the premium, without substitution of alternate financial assurance as specified in this section, will constitute a significant violation of these rules, warranting such remedy as the Director deems necessary. Such violation will be deemed to begin upon receipt by the Director of a notice of future cancellation, termination, or failure to renew due to nonpayment of the premium, rather than upon the date of expiration.

6. Each policy must contain a provision allowing assignment of the policy to a successor owner. Such assignment may be conditional upon consent of the insurer, provided such consent is not unreasonably refused.

7. The policy must provide that the insurer may not cancel, terminate, or fail to renew the policy except for failure to pay the premium. The automatic renewal of the policy must, at a minimum, provide the insured with the option of renewal at the face amount of the expiring policy. If there is a failure to pay the premium, the insurer may elect to cancel, terminate, or fail to renew the policy by sending notice by certified mail to the owner or operator and the Director. Cancellation, termination, or failure to renew may not occur, however, during the 120 days beginning with the date of receipt of the notice by both the Director and the owner, as evidenced by the return receipts.

Cancellation, termination, or failure to renew may not occur and the policy will remain in full force and effect in the event that on or before the date of expiration:

(i) The Director deems the facility abandoned; or

(ii) Closure is ordered by the Director or a U.S. district court or other court of competent jurisdiction; or

(iii) The owner is named as debtor in a voluntary or involuntary proceeding under Title 11 (Bankruptcy), U.S. Code; or

(iv) The premium due is paid.

8. Whenever the current closure cost estimate increases to an amount greater than the face amount of the policy, the owner, within 60 days after the increase, must either cause the face amount to be increased to an amount at least equal to the current closure cost estimate and submit evidence of such increase to the Director, or obtain other financial assurance as specified in this section to cover the increase. Whenever the current closure cost estimate decreases, the face amount may be reduced to the amount of the current closure cost estimate following written approval by the Director.

9. The Director will give written consent to the owner or operator that he may terminate the insurance policy when:

(i) An owner or operator substitutes alternate financial assurance; or

(ii) The Director releases the owner or operator from the requirements of this section.

(f) Surety Bond Guaranteeing Closure.

1. An owner or operator may demonstrate financial assurance for closure by obtaining a payment or performance surety bond which conforms to the requirements of this paragraph. The owner or operator must notify the Director that a copy of the bond has been placed in the operating record. The surety company issuing the bond must, at a minimum, be among those listed as acceptable sureties on Federal bonds in Circular 570 of the U.S. Department of the Treasury.

2. The penal sum of the bond must be in an amount at least equal to the current closure cost estimate.

3. Under the terms of the bond, the surety will become liable on the bond obligation when:

(i) The owner or operator fails to perform as guaranteed by the bond; or

(ii) The Director notifies the owner or operator that they have failed to meet the requirements of these rules.

4. Under the terms of the bond, the surety may cancel the bond by sending notice of cancellation by certified mail to the owner and operator and to the Director 120 days in advance of cancellation. If the surety cancels the bond, the owner or operator must obtain alternate financial assurance as specified in this section.

5. The Director will give written consent to the owner or operator that he may terminate the surety bond when:

(i) An owner or operator substitutes alternate financial assurance; or

(ii) The Director releases the owner or operator from the requirements of this section.

(g) Release of the owner from the requirements of this section: Within 60 days after receiving certifications from the owner and an independent registered professional engineer that final closure has been completed in accordance with the approved closure plan, the Director will notify the owner in writing that he is no longer required by this section to maintain financial assurance for final closure of the facility, unless the Director has reason to believe that final closure has not been in accordance with the approved closure plan. The Director shall provide the owner a detailed written statement of any such reason to believe that closure has not been in accordance with the approved closure plan.

(h) Failure of the owner to close the facility in accordance with section 12, (c) of this rule shall constitute forfeiture of the funds retained in the financial assurance mechanism and the Director shall be allowed access to the funds to close the facility.

**(12) Closure**

(a) Closure for new swine feeding operations with more than 3000 AU shall include, but may not be limited to the following:

1. The sampling, analysis, and reporting of results of all remaining livestock waste, including any sludge and the top 6 inches of any lagoon soil liner;

2. The removal of all remaining livestock waste, including sludge, and the removal of a minimum 6-inch thickness of soil throughout all lagoon interiors;

3. The application of all such wastes to crop land or pasture at agronomic rates;

4. The removal of all associated appurtenances, including but not limited to transfer lines, ramps, pumping ports, and any other waste conveyance structures;

5. The management of any impounded precipitation in any remaining excavations if the excavations are not immediately filled and returned to the preconstruction condition; and

6. Any monitoring wells will be filled, plugged and sealed in accordance with procedure approved by the Division.

(b) For new swine feeding operations with more than 3000 AU, the owner shall submit a detailed closure plan for clean up and closure of the swine management facility with the permit application. This plan shall include a schedule for completion of closure within six months after the facility is removed from service. This plan shall be updated with future subsequent renewals of the permit.

**(13) Operator Training and Certification Requirements.**

(a) Swine feeding operations are required to have certified operators. Operators should be certified according to the following schedule:

1. 301 to 1000 AU: ~~October 31, 2001.~~October 31, 2002.

2. Existing operations 1001 to 3000 AU: ~~October 31, 2001.~~October 31, 2002.

3. New or expanding operations 1001 to 3000 AU: Prior to beginning the feeding of swine.

4. Existing operations with more than 3000 AU: October 31, 2001.

5. New or expanding operations with more than 3000 AU: Prior to startup.

(b) Swine feeding operators shall be trained and certified by the Georgia Department of Agriculture. Proof of such training, certification and continuing education shall be maintained by the Department of Agriculture and records provided to the Georgia Environmental Protection Division.

(c) Certification training, agenda and topics will be determined by the Georgia Department of Agriculture; but will include, at a minimum, best management practices, comprehensive nutrient management planning, understanding regulations and water quality laws, standards and practices, siting, pollution prevention, monitoring and record keeping. Training programs will be structured to address the needs of the operators of differing sizes and various waste management technologies. Continuing education will be required to maintain this certification.

Authority: O.C.G.A. Section 12-5-20, et. seq.

# Module 1: Managing Manure for Environmental Protection

*By Mark Risse, University of Georgia, and Diana Rashash, North Carolina State University*

## Intended Outcomes

The participants will

- Understand key environmental issues facing the livestock and poultry industry.
- Recognize key principles of environmental stewardship.
- Recognize the importance of balancing nutrient inputs and managed outputs for a livestock or poultry operation.
- Be aware of fundamental strategies for addressing a whole farm nutrient imbalance.
- Review regulatory issues that are of national and local interest.

## Contents

## Reviewers

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**This module was adapted from the Livestock and Poultry Environmental Stewardship (LPES) curriculum, Lesson 1 and Lesson 2 authored by Rick Koelsch, University of Nebraska, courtesy of MidWest Plan Service, Iowa State University, Ames, Iowa, 50011-3080.**

# Introduction

Producers need to be aware of the impacts that manure can have on water and air quality. However, management of manure and other byproducts of livestock and poultry production is a complex environmental issue.

The purpose of this curriculum is to expand the awareness of producers not familiar with current environmental concerns and to encourage a pro-active stewardship response based on good science among those producers who recognize the seriousness of this environmental issue. This particular module will assist you in

- Assessing your operation's current environmental strengths and weaknesses.
- Identifying choices that minimize manure's risk as a pollutant and enhance its value as a resource.
- Reviewing your operation's compliance with environmental standards established by regulatory processes.

## How Can Manure Affect the Environment?

The livestock and poultry industry is facing growing scrutiny of its environmental stewardship. While emotion and limited information on the part of the general public contribute to this concern, problems also result from a few producers who have allowed highly visible impacts to occur on the environment. These situations create a negative and often biased public view about the impact of livestock and poultry on the environment.

If not carefully managed, manure and other byproducts of animal production such as mortality can have a significant negative impact on the environment. Animal production has the potential to negatively affect surface water quality (pathogens, phosphorus, nitrogen as ammonia and nitrate, and organic matter); groundwater quality (nitrate); soil quality (soluble salts, copper, arsenic, and zinc); and air quality (odors, dust and particulate matter emissions, pests, and aerial pathogens). In fact, the U.S. Environmental Protection Agency (EPA) has identified agricultural production as the largest single contributor to water quality impairment for rivers and lakes (Table 1-1). For nutrients in particular, livestock and poultry manures are a major contributor of total nitrogen (N) and phosphorus (P) inputs into U.S. watersheds (Figure 1-1). In some watersheds, manure nutrient inputs are substantially greater than those associated with more traditional sources of pollution (e.g., municipalities, industry).

Table 1-1. Five leading sources of water quality impairment.

| Rank | Rivers | Lakes | Estuaries |
|---|---|---|---|
| 1 | Agriculture | Agriculture | Municipal point sources |
| 2 | Municipal point sources | Urban runoff and storm sewers | Urban runoff and storm sewers |
| 3 | Urban runoff and storm sewers | Hydrologic/habitat modification | Agriculture |
| 4 | Resource extraction | Municipal point sources | Industrial point sources |
| 5 | Industrial point sources | Onsite wastewater disposal | Resource extraction |

Source: EPA 1998.

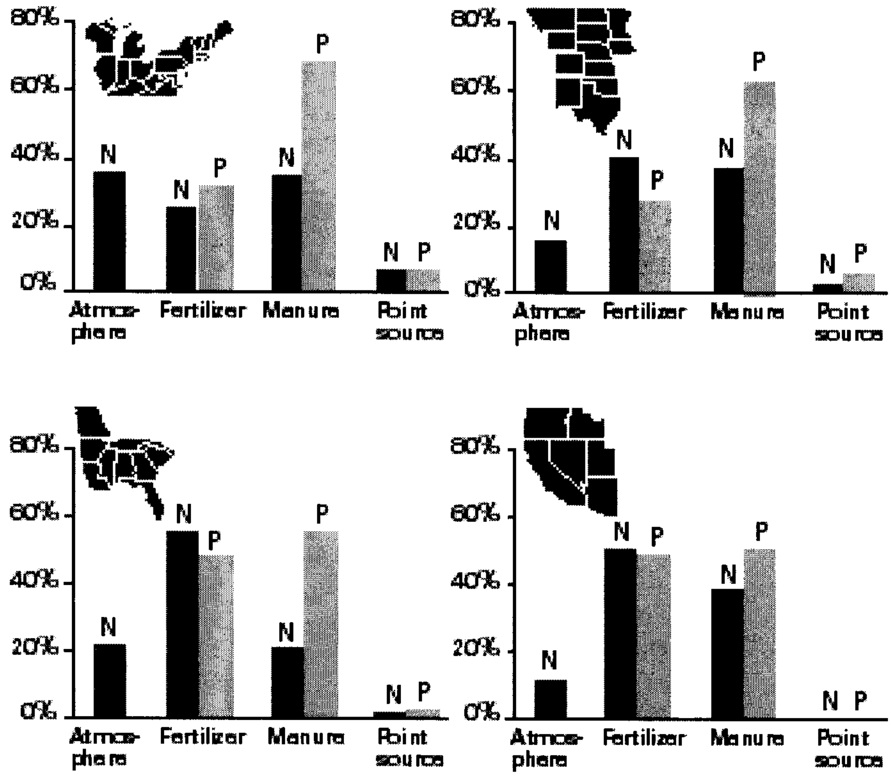


Figure 1-1. Sources of N and P inputs to watersheds in the four regions of the United States.
Source: USGAO 1995.

## Is Manure an Environmental Risk or Benefit?

How you manage your manure can determine if it is:

| | | |
|---|---|---|
| A source of nutrients and disease-causing organisms that degrade the quality of our water for drinking and recreational use. | OR | A source of organic matter that improves the quality and productivity of our soil resources. |
| One of our nation's largest sources of water pollution. | OR | A source of plant nutrients that can replace commercial fertilizers, saving time, energy, and money. |
| A source of gaseous emissions that reduces the quality of life in rural communities and contributes to possible neighbor health concerns. | OR | A means of recycling and adding carbon to the soils that contributes to a reduction in atmospheric carbon and global warming. |

Manure can produce both positive and negative results. The actual results often depend on choices that you make in managing this resource.

## Principles of Environmental Stewardship

As someone who manages animal manure on a livestock or poultry operation, you make the decisions that determine if manure will be a benefit or risk to the operation. Several fundamental principles of good environmental stewardship must be considered in the production of livestock and poultry.

### Awareness of environmental risks

The potential impact of an individual operation on the environment varies with animal concentration, weather, terrain, soils, and a host of other conditions. You must understand these risks and manage your operation's manure to minimize them.

### No point source discharge

Livestock and poultry production systems operate on the principle of "no discharge" of manure or wastewater to surface water from point sources such as animal housing, storage facilities, or treatment lagoons. Under EPA rules, the only time a discharge is allowed is in extreme rainfall events such as a 25-year, 24-hour storm (This is the amount of rain you would expect to fall in one day once every 25 years). The no discharge management standard for animal manure is distinctly different from the management of human and industrial waste, which is routinely discharged into surface waters following treatment. Avoiding manure or wastewater spills directly into surface waters is essential to being a good environmental steward. Minimizing runoff from nonpoint sources (NPSs) (e.g., land application) is also central to good environmental stewardship. Making proper decisions related to timing and site selection for land application should minimize the risk of these NPS discharges.

### Follow a nutrient management plan (NMP) for land application

A good stewardship program includes a plan for managing manure nutrients in crop production systems. The plan must maintain a balance between nutrient application and crop use as well as minimize the risk of runoff and leaching of nutrients. Proper nutrient management allows you to use the nutrients in manure as a resource for your operation.

### Be a good neighbor

The byproducts of animal production create several potential nuisances (including odors, flies, noise, and others) in rural communities. You must be fully aware of these potential issues and the degree of concern they cause neighbors. Where reasonable technologies and management strategies are available to reduce or eliminate these nuisances, such strategies should be implemented. Where such options do not exist, producers may need to consider alternatives such as separation distances and good communication to minimize these nuisances.

### Know the rules

Good stewardship requires knowledge of and compliance with current regulations established by federal, state, and local governments. Knowledge of these rules and careful planning of manure management systems to meet these requirements is essential. Good stewardship, however, goes beyond meeting the minimum requirements and includes reducing environmental risks whenever possible. While these environmental stewardship principles appear simple, they require knowledge, hard work, and commitment from everyone involved with the operation.

## Benefits of Manure Utilization

For centuries, animal manure has been used as a source of plant nutrients and as a soil "builder" because it improves soil quality. When compared to conventional fertilizer, properly applied manure can provide equivalent or superior plant growth while reducing environmental impacts. Scientific studies have documented that soils receiving manure tend to have:

- Reduced amounts of runoff and soil erosion.
- Higher levels of soil carbon (C).
- Higher levels of soil P and other micronutrients.

- Improved water-holding capacity.
- Higher productivity.

Manure contains most of the elements required for plant growth including N, P, potassium (K), and micronutrients. Many of these nutrients are available in both inorganic (like conventional fertilizers) as well as organic forms. The advantage of the organic form is that it is less prone to runoff or leaching and is slowly made available to plants throughout the growing season. It is more of a "timed-release" nutrient source.

Manure also contains organic C, which acts as the glue in soil, improving soil structure and holding nutrients until plants can use them. Tillage and crop removal reduce soil C levels. Over time, as soil C is removed, the soil becomes less productive and requires greater amounts of fertilizers, pesticides, and water. Adding C through manure can maintain or increase soil C levels, reversing this trend. In addition, soil C increases infiltration, reduces runoff and soil erosion, and improves soil water-holding capacity. Conventional fertilizers cannot claim these benefits.

## Understanding Water Quality Issues

While land application of manure provides many benefits, incorrect manure use can have negative impacts on water quality. Good stewards should be aware of the components of manure that are of greatest concern, their specific impact on water quality, and their common pathways to surface and groundwater.

### Water Quality Contaminants

Manure contains four primary components that impact water quality: N, P, pathogens (disease-causing organisms), and organic matter. These components, their environmental risk, and typical pathways to water are summarized in Table 1-2.

Table 1-2. Summary of manure components that can impact water quality, the associated environmental risk, and most common pathway to water.

| Potential Pollutant | Environmental Risk | Most Common Pathway to Water |
|---|---|---|
| Nitrate-N | Blue Baby Syndrome, algal blooms | Leaching to groundwater, subsurface flow to waterways |
| Ammonia-N | Fish kills | Surface water runoff |
| P | Eutrophication, algal blooms | Erosion and surface water runoff |
| Pathogens | Human health risk | Surface water runoff |
| Organic solids | Reduced oxygen level in water that results in fish kills | Surface water runoff |

### N

For growth and survival, all living things require N, the fundamental building block of protein. Livestock and poultry use only part of the protein in their feed for the production of meat or other animal products. The remaining protein is excreted as N in manure. Some of this N is quickly transformed into ammonia-N. When manure is applied to land, the soil's aerobic environment converts common manure-N forms to nitrate-N.

Nitrate contamination of drinking water supplies (primarily a groundwater issue) can present a health hazard. Infants and pregnant women are at greatest risk. The U.S. EPA has set a maximum contaminant level of 10 parts per million (ppm) for nitrate-N in public water supplies, and this is used as a groundwater quality standard in many states. Ammonia-N in surface water also represents an environmental risk. In most natural surface waters, low levels of ammonia-N (around 2 ppm) can cause fish kills.

Nitrogen is a very mobile element that has many different forms. Most N in manure exists in forms that are easily transported by surface runoff or shallow groundwater flow (Figure 1-2). The filtering ability of soil restricts movement of most forms to groundwater, but if sufficient oxygen is available, some forms can be transformed into nitrate-N and can leach through soils to groundwater. Some forms can also be transported through the atmosphere by volatilization and deposition processes.

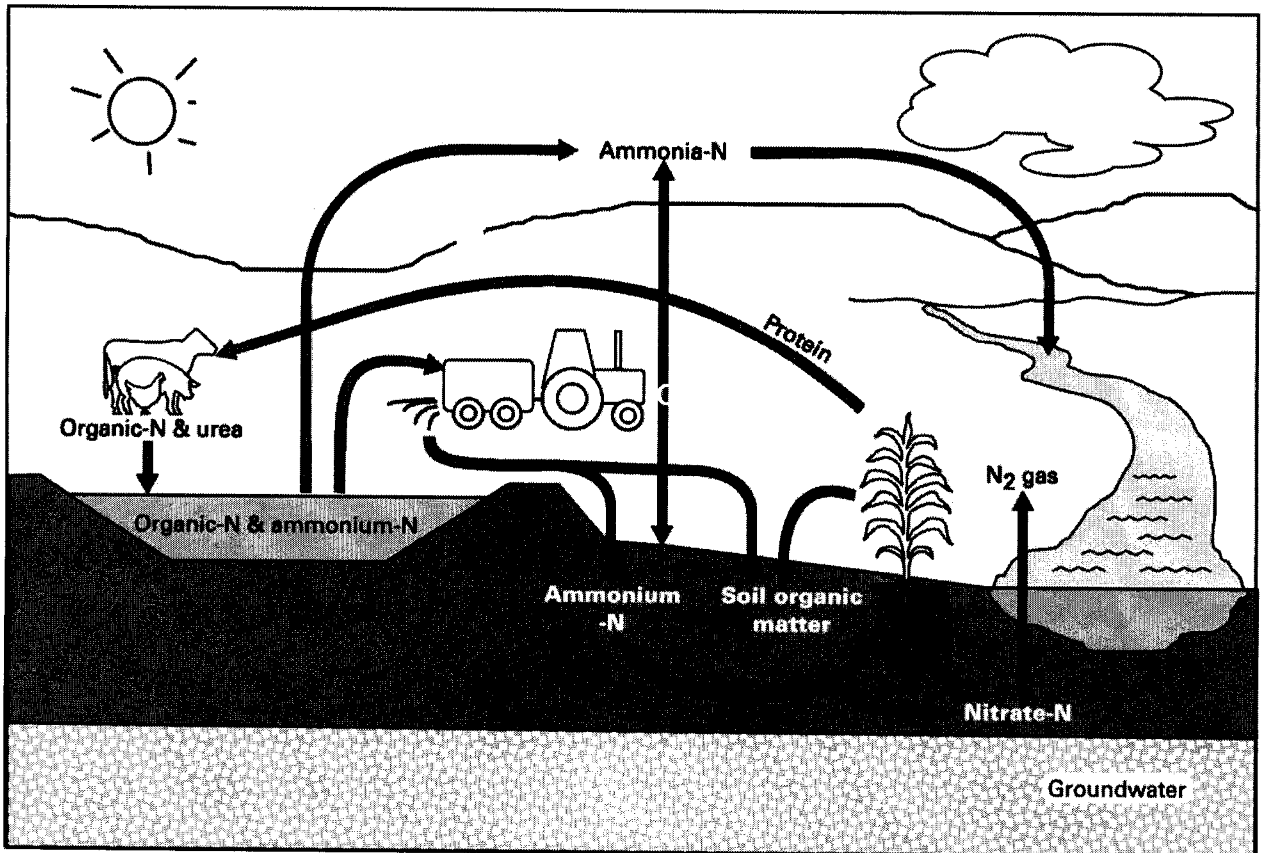

Figure 1-2. Common N flows on an animal and crop production system.

Excessive N loading to surface waters can cause algal blooms. Algae or phytoplankton are microscopic, single-celled plants. Most species of algae are not harmful and are actually food sources for many forms of life. Too much algae, however, causes water quality problems. Occasionally, conditions allow algae to grow very fast or "bloom." As these blooms die and decompose, oxygen is removed from the water. The low oxygen levels inhibit aquatic life, reduce fishery production, and cause fish kills. Nutrient loading, whether from fertilizers, manure, or other sources, is a leading contributor to poor water quality in ponds, rivers, lakes, and coastal waters.

**P**

Phosphorus transported from agricultural land to surface waters can also promote eutrophication (abnormally high growth of algae and aquatic weeds and associated low oxygen levels in surface waters). Other common problems associated with eutrophic water bodies include less desirable recreational use, unsuitable drinking water, and increased difficulty and cost of drinking water treatment. Eutrophic surface waters may also experience massive blooms of cyanobacteria (aka blue-green algae), some of which can kill animals and pose health hazards to humans.

Since P binds readily with soil or organic matter, soil erosion is a primary transport mechanism to surface water. Soil water also contains a small amount of dissolved P that is essential for plant uptake. Phosphorus leaching is rarely an issue unless the soils are sandy and have high water tables. However, as P levels in the soil increase, dissolved P in runoff water will also increase. Since dissolved P is readily available to algae, overloading soils with excessive amounts is a water resource concern.

### Pathogens

A pathogen is typically considered any virus, bacterium, or protozoa capable of causing infection or disease in animals or humans. Two pathogens shed in animal manure, *Cryptosporidium parvum* (*C. parvum*) and *Giardia lamblia (Giardia),* are of greatest concern to humans. *C. parvum*, commonly referred to as "crypto," and *Giardia* are parasites that cause severe diarrhea, nausea, fever, vomiting, and fatigue in humans. The risk of infection from these organisms is much greater for the very young, the elderly, and those with weak immune systems. These pathogens pose a particular risk since they are resistant to the disinfection processes used in most water treatment plants.

Livestock and poultry shed a number of viruses and bacteria in manure. While some of these can infect humans, it is relatively unlikely that they will unless the manure has direct access to a drinking water supply. Most bacteria can be controlled with common water disinfectants such as chlorine. Where untreated water such as that from wells (no chlorine treatment) is located near animal housing or manure storage, some cases of human illnesses and deaths due to bacteria such as *Escherichia coli* (*E. coli*) have been reported.

Most pathogens, including *C. parvum* and *Giardia*, do not multiply outside a host organism so they have a limited lifetime outside a host. The viability of these organisms can range from a few days to many months, depending on a number of environmental factors such as temperature, pH, sunlight, moisture, and the amount of oxygen available. Land application and composting are two processes that commonly speed up the decay of pathogens, because they are subjected to wider ranges of temperature and pH than they normally encounter.

Pathogens are most likely transported to water supplies through surface runoff and erosion or by direct animal access to surface water. Streams and lakes used for drinking water supply and recreational purposes provide the greatest opportunity for these pathogens to be transported to humans. Animal operations located upstream of drinking water supplies or recreational areas should recognize the potential risks associated with pathogens.

Soils provide a filtering mechanism, especially for larger organisms such as protozoa and bacteria. Although it is unlikely that pathogens will reach a groundwater supply, it can happen. Proper wellhead protection and separation distances are important. There is evidence that viruses and bacteria can travel some distance through sandy soils. Research and experience have shown that water can be contaminated from tile drainage shortly after the land application of manure because drainage tiles can short-circuit natural filtration processes that normally occur in the soil.

### Organic matter

Organic matter in manure, silage leachate, and milking center wastewater degrades rapidly and consumes considerable oxygen in the process. If this occurs in an aquatic environment, oxygen can be quickly depleted, resulting in fish kills and other aquatic impacts. Manure, silage leachate, and waste milk are extremely high in degradable organic matter. These products can be 50 to 250 times more concentrated than raw municipal sewage (primarily because animal production does not add the large volume of fresh water used for the dilution and transport of municipal waste).

Organic matter, like pathogens, P, and ammonia, is transported to water by surface water runoff. Rarely does it leach through soils. Organic matter is unlikely to be transported in sufficient quantities to nearby surface waters unless one of the following situations occurs:

1. A direct discharge from an animal barn, manure storage, open lot, or other facility is allowed to enter surface water.
2. A catastrophic failure such as an earthen storage break, broken pipeline, or continuous application by an irrigation system on the same location.
3. Significant rainfall occurs immediately after the surface application of manure.
4. Significant application is made on frozen, snow-covered, sloping, or saturated soils in close proximity to surface water.

## Contaminant Pathways

### Point vs. NPS pollution

Historically, "point sources" of pollution have been regulated at the state and federal level. Point source pollution is a single identifiable source of pollution such as a pipe discharging effluent from an industrial operation, a wastewater treatment plant, or a processing plant. A permit is usually required for this type of discharge because it is easy to find and regulate. "Nonpoint source" pollution is more difficult to trace to a single source because it takes place over a broad area and the release of pollutants can occur over a variety of areas and at different times. Usually, NPS pollution occurs following rainfall when runoff carries pollutants into surface water; however, contaminated groundwater that recharges rivers and streams can also be classified as NPS pollution. Today, greater emphasis is being placed on regulating NPS pollution as state and federal agencies realize that simply regulating point sources will not result in the clean water that society demands.

### Pollution pathways

The potential pollutants typically follow one or more of five possible pathways for reaching water (Figure 1-3). These pathways include runoff, leaching, macropore flow, wells, and ammonia volatilization and deposition.

***Runoff.*** Runoff from open lots, land application sites, and manure or feed storage units is a common pathway for contaminant transport. Contaminants in manure can travel with surface water runoff and soil erosion. Problems associated with P, pathogens, ammonia, and organic matter are most commonly associated with runoff or erosion.

***Leaching.*** Dissolved contaminants such as nitrate N can leach beyond a crop's root zone when the soil moisture exceeds its water-holding capacity and will eventually reach groundwater. Most contaminants in manure and other byproducts (e.g., organic matter, pathogens, and typically P) are filtered by soil and will NOT leach to groundwater. However, it is possible to overwhelm the soil's ability to restrict contaminant movement. For example, soil can allow ammonia movement of up to a few feet per year below manure storages.

***Macropore flow.*** Most contaminants in manure can travel through soil to shallow groundwater tables or tile drains by macropore flow. Macropore flow (root holes, wormholes, and cracks due to soil drying) provides pathways for contaminants to bypass the filtering capability of soil. Sinkholes and karst topography (fractured rock) also provide opportunities for contaminants to directly reach groundwater.

***Wells.*** Poorly constructed or maintained wells can provide a direct pathway for contaminants to reach groundwater. Abandoned wells, wells with poor well-casing designs, or wells located in close proximity to open lots or manure storage can provide a pathway for manure contaminants to move to groundwater.

***Ammonia volatilization and deposition.*** Ammonia-N can change from a liquid to a gas in a process called volatilization. Ammonia-N volatizes from manure storages, lagoons, and open lots. Once volatilized, most ammonia is re-deposited with rainfall. It can be transported over long distances. While some areas benefit from this deposition, other areas such as large water bodies are experiencing such high levels of deposition that it threatens the vitality of local ecosystems. In the United States, coastal areas are often adversely affected by ammonia deposition.

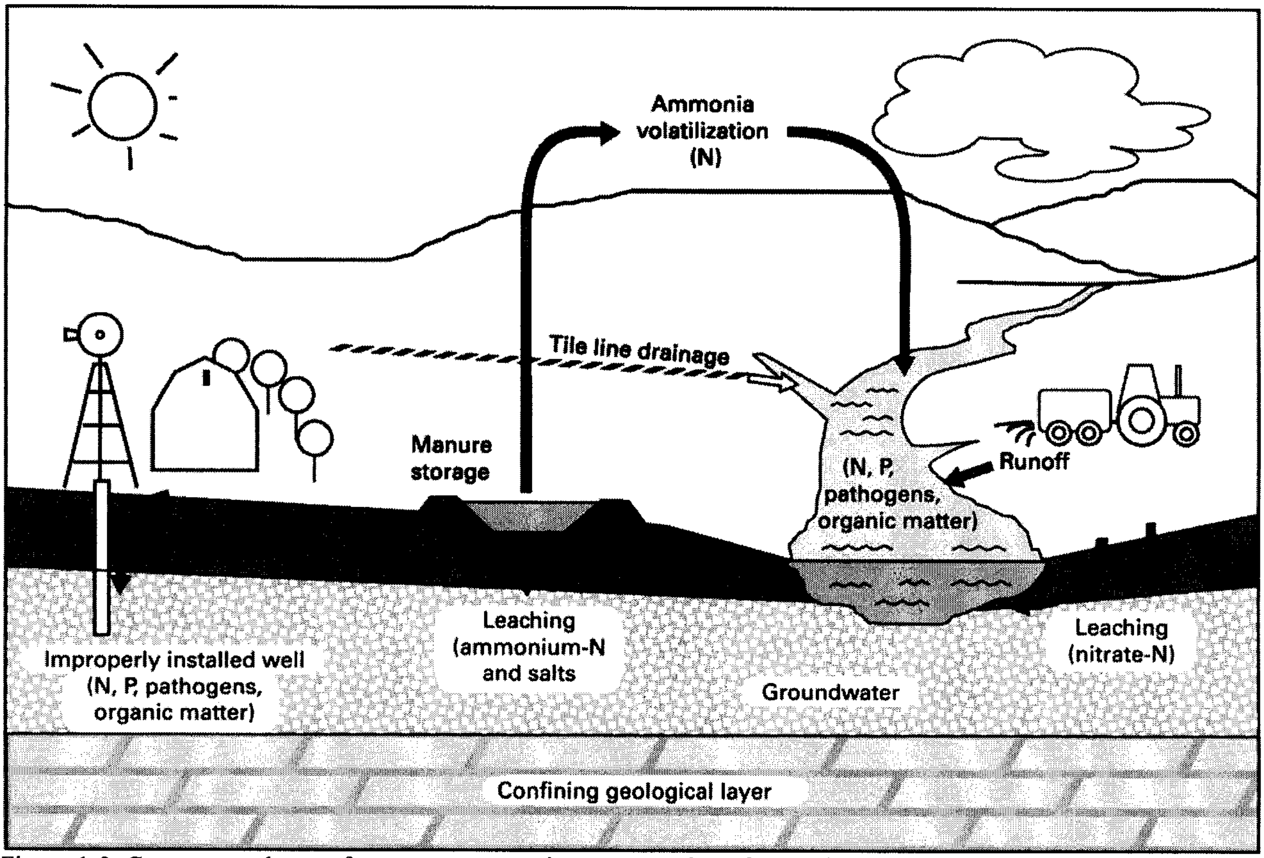


Figure 1-3. Common pathways for manure contaminants to reach surface and groundwater.

## Nutrient Concentration and Distribution

Of the five potential contaminants in manure, three of the five are also nutrients (see Table 1-2). Most of the management practices used to reduce environmental risks associated with pathogens and organic matter are the same as those used for nutrients. Therefore, if you properly manage nutrients, the operation should be environmentally sound. Over time, however, the concentration of nutrients on livestock or poultry operations can lead to a number of problems. Most nutrient-related issues associated with animal production result from poor nutrient "distribution." This distribution issue can be a local or a regional issue.

### Single-Field Nutrient Distribution Issues

An integrated crop and animal operation commonly experiences a single-field nutrient distribution issue within its own boundaries. Some fields, often those closest to the animal facility, receive excessive manure applications while commercial fertilizer is purchased to meet the needs of fields farther from the animals. Spreading manure based upon convenience and not the crop's nutrient requirements can lead to this inappropriate nutrient distribution.

### Individual Operation Nutrient Distribution Issues

Operations focused primarily on animal production often import significant quantities of nutrients as animal feeds. Animals utilize only 10% to 30% of the nutrients they consume and excrete the remainder in manure, causing a buildup of nutrients on the animal operation and a shortage of nutrients (typically replaced by purchased commercial fertilizers) on operations only growing crops. This lack of nutrient recycling on the operation may result in operations with nutrient imbalances.

## Regional Nutrient Distribution Issues

These issues have developed in the last 30 years as livestock and poultry production have concentrated in specific, but separate, regions of the country. Examples of these regional nutrient distribution issues include the concentration of pork production in the Carolinas, poultry in southern and mid-Atlantic states, beef cattle production in the High Plains, and dairy in western, north central, and northeastern states. The nutrients that these animals excrete can overwhelm the ability of locally grown crops to recycle the nutrients. Many of these regions import significant quantities of nutrients, primarily as feed grains, from the Corn Belt. Figures 1-4 and 1-5 illustrate regional imbalances throughout the United States.

# Whole Farm Nutrient Management

Nutrients are transported along multiple pathways and in a variety of forms on an animal operation, but an understanding of the overall farm nutrient balance is necessary in identifying the underlying causes of nutrient-related water quality problems as well as the solutions.

A picture of the nutrient flow on an operation is presented in Figure 1-6. On an animal operation, nutrients arrive as purchased products (fertilizer, animal feed, and purchased animals), nitrogen fixed by legume crops, and nitrates in rain and irrigation water. Some of these "Inputs" are converted to outputs such as meat, milk, or crops while some escape into the environment. Within the operation's boundaries, there is a "Recycling" of nutrients between the animal and crop components if crops are fertilized with manure and fed to animals.

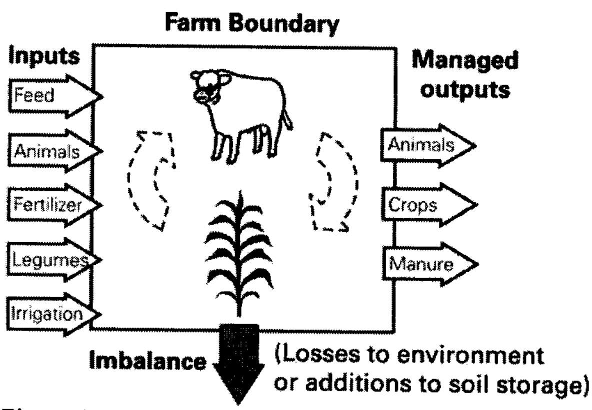


Figure 1-6. A whole operation nutrient balance considers all nutrient inputs, managed outputs, losses for a livestock or poultry operation.

Nutrients exit an animal operation preferably as "Managed Outputs," including animals and crops sold and possibly other products moved off the operation (e.g., manure sold or given to a neighboring crop producer). Some nutrients exit the operation as losses to the environment (nitrates in groundwater, ammonia volatilized into the atmosphere, and N and P into surface water). Nutrients (especially P) also accumulate in large quantities in the soil. Although not a direct loss to the environment, a growing accumulation of nutrients in the soil adds to the risk of future environmental losses, especially through erosion.

The "Imbalance" is the difference between the Inputs and the Managed Outputs. This Imbalance accounts for both the direct environmental loss and the accumulation of nutrients in the soil. Animal operations with an imbalance pose a greater risk to water quality. In contrast, animal operations that have achieved a balance represent a potentially sustainable production system.

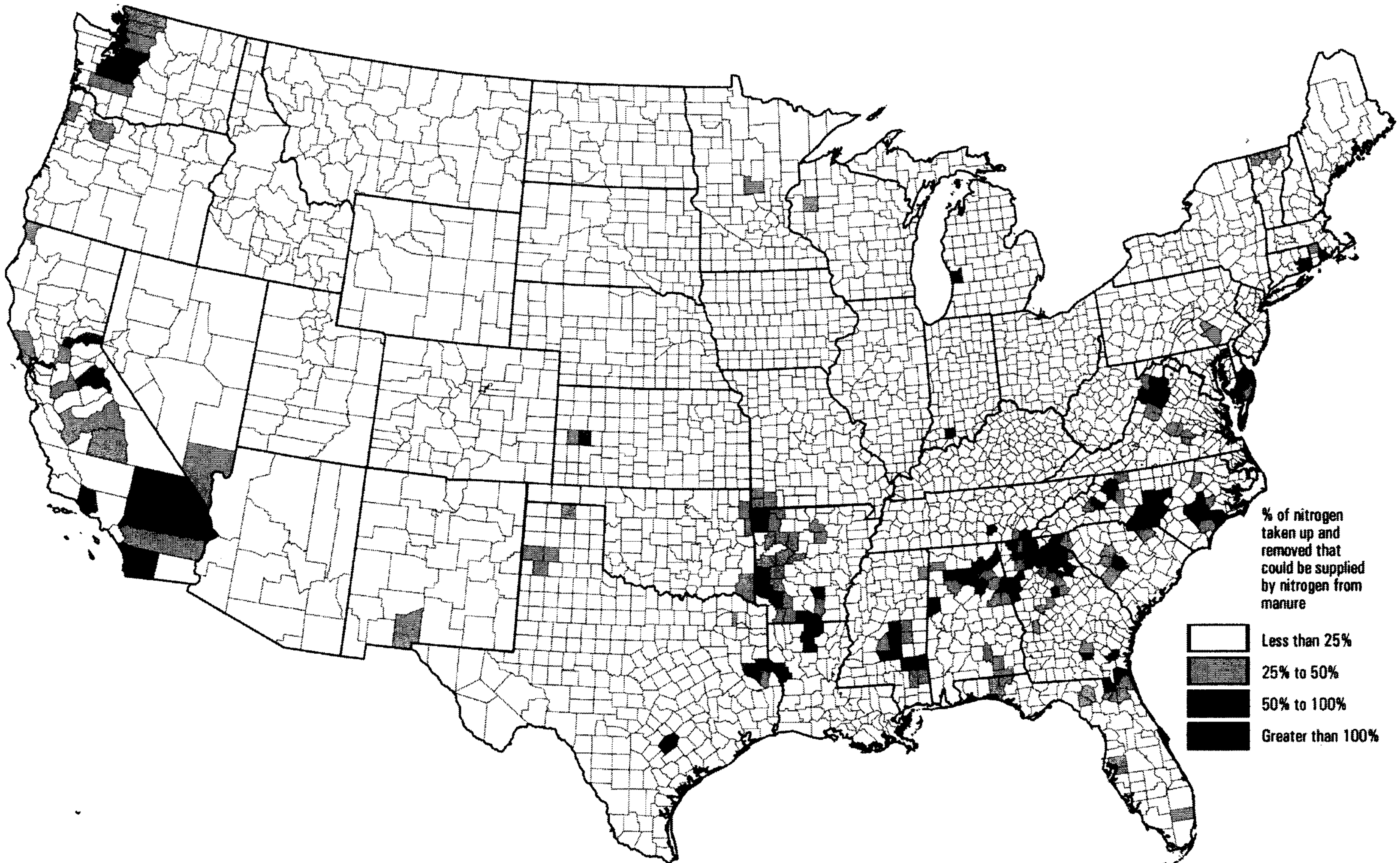


Figure 1-4. Potential for N available in animal manure to meet or exceed plant uptake and removal for harvested crop and hay land.
Source: Kellogg et al. 2000

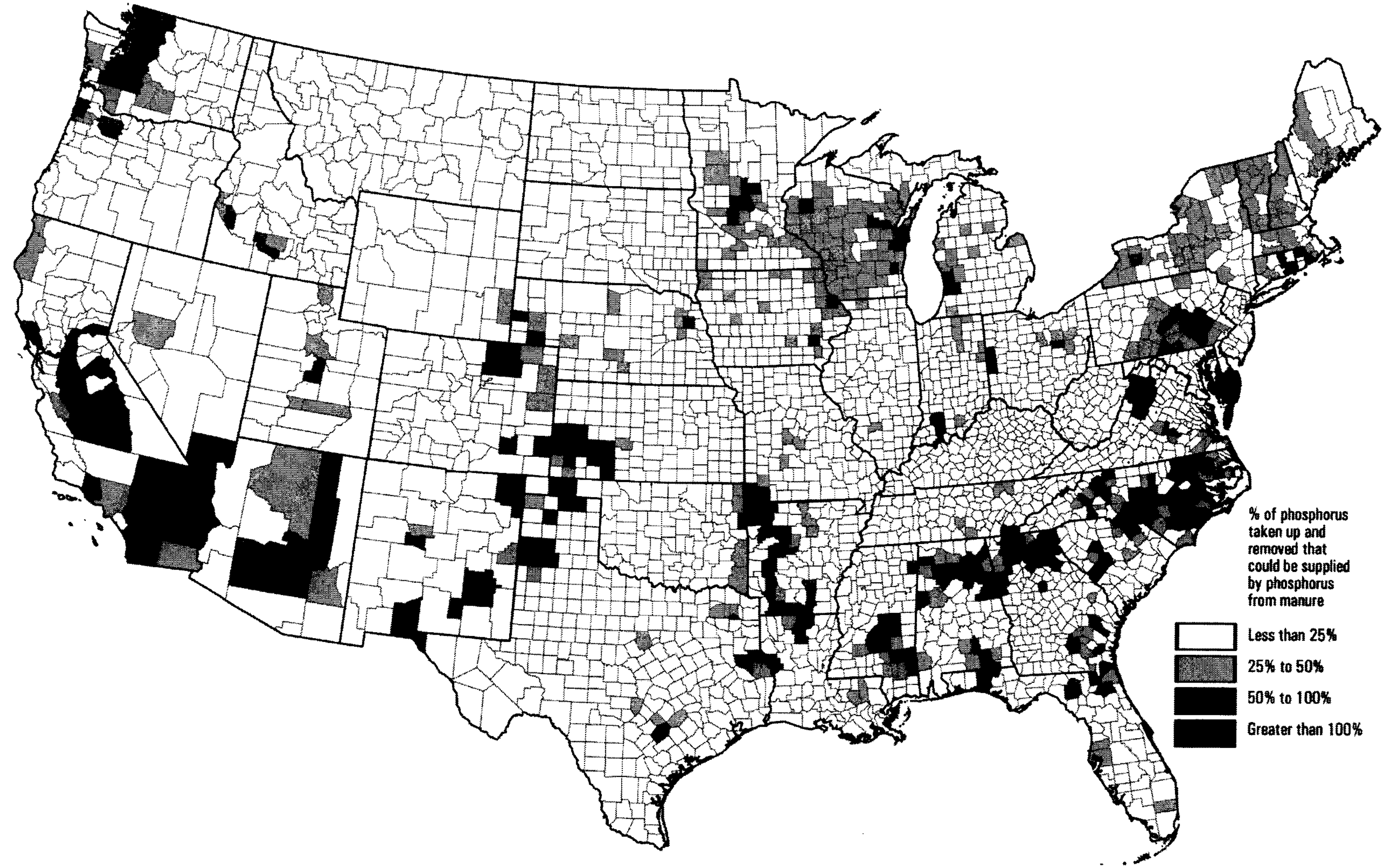


Figure 1-5. Potential for P available in animal manure to meet or exceed plant uptake and removal for harvested crop and hay land.
Source: Kellogg et al. 2000

The nutrient balance on an operation can often be expressed as the ratio of nutrient inputs to nutrient outputs. Ideally, your operation should be balanced for both N and P. An imbalance in N does not distinguish between the relatively harmless losses (e.g., denitrification of nitrate to $N_2$ gas) and the relatively harmful environmental losses (e.g., nitrate loss to water). In contrast, P losses affect water quality through increased soil P levels and greater concentration of P moving with surface runoff water. Ideally, an operation manager would want to manage his operation to maintain a P ratio near 1:1. Input-to-output P ratios on operations across the United States are commonly reported to range from less than 1:1 up to 8:1. Livestock and poultry operations with a large imbalance (1.5:1 and greater) should expect steadily increasing soil P levels that are not environmentally sustainable.

### Is My Livestock or Poultry Operation in Balance?

An understanding of nutrient balance and primary source of purchased nutrients is the key to operating an animal operation in an environmentally sustainable manner. A checklist of potential indicators of nutrient imbalance (Table 1-3) can be used as a first step in evaluating your operation. A second method, and the one that most regulatory agencies require, is a check of manure nutrient production vs. crop nutrient utilization. This method checks the ability of your land base to utilize the nutrients in manure. An excess of manure nutrients for crop production suggests a whole farm nutrient imbalance. This will be part of your NMP. A Whole Farm Nutrient Balance provides the "bottom line" answer to this issue. It also provides a measurement of progress made toward environmental sustainability following the implementation of changes. The producer must assemble information for animal purchases and sales, feed and grain purchases and sales, fertilizer purchases, manure sales, and possibly other contributors for a one-year period. A spreadsheet to aid the producer in conducting a whole farm nutrient balance is located at http://manure.unl.edu/Koelsch-nbalance.html.

Table 1-3. Environmental stewardship inspection. Indicators of a possible imbalance that may exist on my operation (check those that apply). "Yes" response indicates that potential for nutrient imbalance is high.

| Yes | No | Don't Know Indicator | |
|---|---|---|---|
| | | | Soil P levels for the majority of fields are increasing with time. |
| | | | Soil P levels for the majority of fields are identified as "High" or "Very High" on the soil test. |
| | | | The majority (more than 50%) of the protein and P in the ration originates from off-operation sources. |
| | | | Animal feed programs routinely contain higher levels of protein and/or P than National Research Council or land-grant university recommendations. |
| | | | A manure NMP is not currently in use for determining appropriate manure application rates to crops. |

## Strategies to Improve Nutrient Balance

Evaluating an animal system's nutrient balance from a whole farm perspective provides a more complete picture of the driving forces behind nutrient-related environmental issues. The original sources of these nutrient inputs are clearly identified, which in turn suggest management strategies for reducing excess nutrient accumulations. The following four management strategies are likely to reduce nutrient imbalances:

1. Efficient use of manure nutrients in crop production
2. Alternative feeding programs

3. Marketing of manure nutrients
4. Manure treatment

## Efficient Use of Manure Nutrients in Crop Production

By accurately crediting manure nutrients in a cropping program, the purchases of commercial fertilizer can be reduced or eliminated and the risk to the environment reduced. This practice is especially important to animal operations with significant crop production and substantial nutrient inputs in the form of commercial fertilizers. It may offer greater benefit for N-related issues due to common use of commercial N fertilizers as insurance on manure-applied fields.

## Alternative Feeding Programs

Opportunities are available for reducing both N and P inputs by alternative feeding programs. Specific management practices for reducing nutrient inputs as feeds are discussed in Module 2 titled *Nutritional Strategies to Minimize Nutrient Loss to Manure*. In addition to changes in feed rations, some additional options that may reduce purchased feed nutrient inputs include (1) alternative crops or crop rotations that allow a greater on-farm production of animal protein and P requirements and (2) harvesting and storage practices that improve the quality of animal feed and reduce losses.

## Marketing Manure Nutrients

Marketing manure creates an additional managed output, similar to the sale of crops or animal products. Manure may be marketed in raw forms; however, composting and other processes can create value-added products for sale.

## Manure Treatment

In some situations, it may be necessary for animal production systems to consider different manure treatment technologies. Many manure treatment systems focus on disposal of nutrients with modest environmental impact. For example, treatment systems commonly dispose of wastewater N as $N_2$ gas (no environmental impact) or ammonia (some environmental impact). This is a preferable alternative to N losses to surface water or groundwater. Other treatment systems enhance the value of manure (e.g., solids separation or odor stabilization) to allow alternative uses of the nutrients. Complementary manure treatment and manure marketing strategies can contribute to improved nutrient balance. For example, some producers are successfully combining composting (for odor control, pathogen reduction, and volume reduction) with marketing of manure to crop farms and urban clients.

A single strategy will not fit all situations. For systems with sufficient land base for utilization of manure nutrients, a strategy that utilizes manure nutrients effectively may be most appropriate. This strategy should focus on preventing manure nutrient losses and reducing commercial fertilizer inputs as a means of achieving a nutrient balance and gaining the greatest benefit from manure. Little incentive exists for animal producers with sufficient land to reduce nutrient excretion by changing diets or marketing manure to off-operation customers. When the land base becomes insufficient for utilizing the manure nutrients, animal dietary options for reducing manure nutrients may be an important strategy for attaining a nutrient balance. If neighboring crop farms or other nutrient users are in the vicinity of concentrated animal operations, manure treatment and marketing of manure nutrients to off-operation customers may also be an important alternative. If nutrient uses do not exist, manure treatment options that dispose of nutrients with little environmental impact may be an important option. These alternatives are discussed in greater detail in Module 5 titled *Animal Manure and Process-Generated Wastewater Treatment* and in the Livestock and Poultry Environmental Stewardship (LPES) module titled *Manure Storage and Treatment*.

# What is an NMP?

## Nutrient Management Planning

Nutrient management plans have been promoted for years as a method of determining application rates to single fields; however, recently, the concept of applying NMP to a whole operation was adopted by the U.S. EPA as the best way of improving nutrient management on an operation. The U.S. Department of Agriculture's (USDA's) Natural Resources Conservation Service (NRCS) also has been promoting the concept of comprehensive nutrient management plans (CNMP). Both of these plans have similar components and goals (CNMPs are more comprehensive and cover animal feeding while NMPs focus more on water quality). Nutrient management plans are expected to serve as the cornerstone of environmental plans assembled by animal feeding operations (AFOs) to address federal and state regulations.

An NMP performs several basic functions. It should serve as the environmental "operating plan" for a livestock or poultry operation. It should detail the management practices for minimizing the impact of nutrients and manure on soil, water, and air resources. The producer should be intimately familiar with this operating plan and use it to guide management decisions and convey desired outcomes to all participants in an animal operation (owner, manager, employees, and advisors). This same plan should also convey, to appropriate regulatory agencies, the management strategies employed. The EPA and NRCS have published information on nutrient management planning on the Internet at these sites:

EPA: http://www.epa.gov/owm/
NRCS: http://www.nrcs.usda.gov/programs/afo/cnmp_guide_index.html

## NMP Format and Content

Nutrient management plan specifications vary from state to state and among different agencies. At a minimum, an NMP should address all land units that the AFO owner/operator owns or has decision-making authority over and on which manure and organic byproducts will be generated, handled, stored, or applied. A general guide for contents of an NMP and suggested items under each major section are presented here. The precise content of an NMP will vary because it is tailored to meet the needs of the confined animal feeding operation (CAFO)/AFO owner and/or operator and particular regulations that a state or locale may enact.

## Contents of an NMP

### 1. Site and production information

Names, phone numbers, and addresses of the CAFO/AFO owner(s) and operator(s)
Location of production site: legal description, driving instructions from nearest post office, and the emergency 911 coordinates
Farmstead sketch
Animal types, phases of production, and length of confinement for each type at this site
Animal count and average weight for each phase of production on this site
Operation procedures specific to the production site and practices
Existing documentation of present facility components (i.e., as-built plans, year installed, number of animals component was originally designed for, etc.)
Federal, tribal, state, or local permits the site holds

### 2. Manure production information

Measured or calculated manure and wastewater volumes for this site
Manure storage type, volume, and approximate length of storage
Total amount of N, P, and K available in manure after storage and handling losses

3. **Manure utilization information**
Aerial maps of land application area with individual fields labeled and marked with setbacks, buffers, waterways, and environmentally sensitive areas such as sinkholes, wells, gullies, tile inlets, etc.
Soil map with appropriate interpretations
Risk assessments for potential P transport from fields (P index or equivalent state tool)
Land treatment practices or best management practices planned and applied
Crop types, realistic yield targets, and expected nutrient uptake amounts
Application equipment descriptions and methods of application
Expected application seasons and estimated days of application per season
Estimated application amounts per acre (volume in gallons or tons per acre and pounds of plant available N, P as $P_2 0_5$, and K as $K_2 0$ per acre)
Estimate of acres needed to apply manure generated on this site
Written manure application agreements (Where applicable)

4. **Offsite utilization**
Amount of manure transported offsite
Who the manure went to and intended use
Nutrient content of manure

5. ***Actual activity records*** **(Individual states or locales may have stricter requirements.)**
Soil tests-not more than 5 years old
Manure test annually for each individual manure storage containment
Planned and applied rates, methods of application, and timing (month and year) of nutrients applied (include all nutrient sources, i.e., manure, commercial fertilizers, etc.)
Current and planned crop rotation
Rainfall records
Actual crop and yield harvest from manure application sites
Record of internal inspections for manure system components
Record of any spill events

6. **Mortality disposal**
Approximate amount of annual mortality
Plan for mortality disposal
Methods and equipment used to implement the disposal plan

7. **Operation and maintenance**
Detailed operation and maintenance procedures for the conservation systems
Plans and procedures for calibration of land application equipment
Soil and manure sampling techniques
Emergency action plan covering fire, personal injury, manure storage and handling, and land application operations

## Understanding Air Quality Issues

Manure handling and storage associated with confinement livestock and poultry systems result in a wide range of air contaminants. More than 160 volatile compounds have been identified as contributing to the gaseous emissions from confinement facilities. Odors associated with many of these gaseous emissions are often the greatest environmental concern in a rural community, frequently triggering greater environmental and public scrutiny of an individual operation. Dust emission from animal housing is gaining greater attention, due to its health impact on neighbors and its ability to serve as a carrier of odor compounds. Animal production facilities release ammonia in large quantities. As described previously in the Water Quality Issues section, the problems associated with ammonia relate to its redeposition on land or water. Finally, the production of non-odorous gases including methane and carbon dioxide is gaining some attention as a potential contributor to global warming.

Many neighbors consider odorous volatile compounds as an unpleasant or nuisance experience. A neighbor's determination of odor nuisance is often related to a number of physical factors (sensitivity to an odor, frequency, duration, and intensity of odor experience) and social factors (neighbor's past experience with agriculture, neighbor's relationship with producer, and appearance of livestock or poultry operation). Odor nuisance issues must be taken seriously. These experiences are often the source of discontent within a community, opposition to new or expanding facilities, and increasing scrutiny of other potential environmental issues.

Animal production is a source of greenhouse gases (methane and carbon dioxide). These gases are primary end products of anaerobic and aerobic (carbon dioxide only) decomposition of manure and other byproducts. It has been estimated that carbon dioxide and methane account for 66% and 18%, respectively, of the greenhouse gas effect. The carbon released from manure, however, originated from plants that removed carbon dioxide as part of the photosynthetic process. Thus, agriculture recycles current greenhouse gases as opposed to contributing additional greenhouse gases, which occurs with the combustion of fossil fuels. In addition, regular land application of manure to cropland increases the organic matter (carbon content) of those soils, which may be an important tool for reducing greenhouse gases. Module 4 discusses air quality around production facilities and land application sites and highlights management practices that operators can use to minimize air quality impacts.

# Regulatory Compliance

## Federal Regulations

The past several years have brought many changes in the way AFOs are regulated. These changes are largely driven by an increasing focus on agriculture as a source of NPS pollution. Since the U.S. Clean Water Act was passed in 1972, a tremendous amount of resources have been put into cleaning up point source pollution from municipalities and industries through the National Pollutant Discharge Elimination System (NPDES) permit process. Large CAFOs are also regulated under the NPDES system. Because the program has been successful in reducing much of the nation's point source pollution, attention has now turned to reducing pollution from NPSs such as urban storm water runoff and agricultural runoff.

As part of the focus on agricultural sources of pollution, the U.S. EPA released new CAFO rules on December 15, 2002. A CAFO is defined as an operation that confines animals for feeding for 45 days or more during a year in an area that does not support vegetation. Pastures are not considered to be CAFOs unless they do not support vegetation. These rules revise the 30-year-old guidelines established under the Clean Water Act. The new rules require all CAFOs to have an NPDES permit, an NMP, conduct regular site and equipment inspections, maintain setbacks from streams, sample manure and soils, maintain spill records, and submit an annual report reviewing the past year's manure production and application.

The federal approach to regulating CAFOs is designed to target the largest operations on the assumption that larger operations pose a greater pollution "risk." The number of animals that a CAFO operator owns and their species determines whether the CAFO is considered to be small, medium, or large. Table 1-4 shows, by species, the number of animals in each category.

An important fact to remember is that two or more operations under common ownership are counted as a single operation if they adjoin each other (are contiguous) or if they use a common area system for manure treatment or utilization. Also, an operation with more than one species is classified as small, medium, or large based on a single species. Although small operations are not subject to the CAFO regulations, they are subject to the Clean Water Act. They cannot have discharge to surface waters and

Table 1-4. Summary of CAFO size thresholds for all species.

| Species | Large | Medium[1] | Small[2] |
|---|---|---|---|
| *Livestock* | | | |
| Beef cattle | 1,000 or more | 300-999 | Less than 300 |
| Dairy heifers | 1,000 or more | 300–999 | Less than 300 |
| Horses | 500 or more | 150–499 | Less than 150 |
| Mature dairy cattle | 700 | 200–699 | Less than 200 |
| Sheep or lambs | 10,000 or more | 3,000–9,999 | Less than 3,000 |
| Swine (weighing less than 55 lbs) | 10,000 or more | 3,000–9,999 | Less than 3,000 |
| Swine (weighing 55 lbs or more) | 2,500 or more | 750–2,499 | Less than 750 |
| Veal calves | 1,000 or more | 300–999 | Less than 300 |
| *Poultry* | | | |
| Chickens except laying hens (other than liquid manure handling system) | 125,000 or more | 37,500–124,999 | Less than 37,500 |
| Ducks (liquid manure handling system) | 5,000 or more | 1,500–4,999 | Less than 1,500 |
| Ducks (other than liquid manure handling system) | 30,000 or more | 10,000–29,999 | Less than 10,000 |
| Laying hens or broilers (liquid manure handling system) | 30,000 or more | 9,000–29,999 | Less than 9,000 |
| Laying hens (other than liquid manure handling system) | 82,000 or more | 25,000–81,999 | Less than 25,000 |
| Turkeys | 55,000 or more | 16,500–54,999 | Less than 16,500 |

[1] May be designated or must also meet one of the two following "method of discharge" criteria to be defined as a CAFO:

- Pollutants are discharged into waters of the United States through a man-made ditch, flushing system, or other similar man-made device or
- Pollutants are discharged directly into waters of the United States that originate outside of and pass over, across, or through the facility or otherwise come into direct contact with animals confined in the operation (i.e., confined animal has access to a stream).

[2] Never a CAFO by regulatory definition but may be designated as a CAFO on a case-by- case basis.

should use nutrient management planning. If there is evidence of pollution, even a small operation can be designated a CAFO and be required to go through the permitting process.

The new regulations require changes in the way AFOs do business. For the first time, runoff from land application sites is covered under the operation's NPDES permit if there are site-specific nutrient management practices to ensure proper agronomic utilization. Large CAFOs (and medium CAFOs that meet the discharge conditions) must apply for an NPDES permit. In most states, this is done through the NPDES-delegated authority (that is, state environmental organization). Nutrient management plans must be developed to ensure that stored manure and wastewater is properly utilized. Following the EPA's guidance, CAFO operators must determine the application rates, for the manure and process wastewater under their control, that will minimize P and N transport to surface water. The manure and process wastewater must be sampled annually for N and P; the soils receiving the manure or wastewater must be sampled at least every five years for P. During the application of manure and wastewater, CAFO operators must maintain a 100-foot setback from streams, ditches, or man-made conveyances or establish a 35-foot vegetated buffer. CAFO operators must also submit an annual report to the EPA or designated state agency, reviewing the past year's manure production, export, and utilization.

Likewise, the rule establishes additional requirements for production areas and manure storage facilities. These requirements relate to how manure and process wastewater will be collected, handled, stored, and treated (if applicable) on large operations. Specific requirements include weekly inspections of all storm water diversion structures and records of storage pond and lagoon liquid levels. Storage pond and lagoon liquid level markers must be installed and denote the 25-year, 24-hour storm storage and free-board levels. A mortality management plan needs to be developed, and mortalities cannot be handled in part of the manure-handling system. Records of all manure and wastewater exported off the operation must include the name, date, and address of recipients. CAFO operators must provide a copy of the recent manure analysis to all recipients. Spill records of the date, time, and estimated volume of any overflow or discharge must also be kept and maintained on site for 5 years.

The focus on nutrient management can improve profitability by encouraging better use of nutrients produced on the operations and reducing the need for fertilizer purchases. There may also be opportunities for composting and selling manure for off-operation uses. Although the new regulations require more record keeping, the records may help improve operation management and productivity. While they may appear complex, these regulations are designed to protect both the farmer and the environment. Compliance with the regulations will provide producers with documentation that they are making a reasonable effort to manage their operation in a safe and environmentally sound manner. For a complete copy of the new rule, please refer to <http://cfpub.epa.gov/npdes/afo/cafofinalrule.cfm>.

## Issues of State and Local Concern

While the federal regulations establish a minimum baseline that all states must meet, they also promote state flexibility and voluntary programs to help smaller AFOs avoid being regulated as CAFOs. Each state implements these rules differently and some go well beyond the federal rules. Local communities may also have additional requirements on issues such as zoning, setbacks, and building permits. It is essential that owners and operators of animal feeding facilities know what the regulations are and attempt to comply with them. Often your state permitting agencies, Cooperative Extension Service, and Soil and Water Conservation Districts have information available on local regulations. Table 1-5 (see following page), which lists regulatory issues, may be useful to operators who want to assess their compliance.

Table 1-5. Regulatory compliance issues applicable to your livestock or poultry operation.

| Regulatory Issue | Is this issue addressed by regulations? If "Yes," summarize those regulations. | Is my livestock/-poultry operation in compliance? |
|---|---|---|
| What agencies are involved in administrating regulations related to livestock/poultry manure? | ___ U.S. EPA ___ State ___ Local<br>List name, address, and phone no.: | |
| Is a permit required for construction of a manure management facility? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not applicable<br>___ Don't Know |
| Is a permit required for operation of an animal feeding facility? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not applicable<br>___ Don't Know |
| Must this permit be renewed at an established time interval? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not applicable<br>___ Don't Know |
| Must this permit be renewed for changes in livestock/poultry operation size? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not applicable<br>___ Don't Know |
| Do regulations vary based on size of livestock/ poultry operation? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not applicable<br>___ Don't Know |
| Do regulations apply to livestock/poultry pasture-based systems? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not applicable<br>___ Don't Know |
| Have regulations changed recently? Do you need to change practices to meet new requirements? How much time do you have to come into compliance? | ___ Yes ___ No<br><br>___ Yes ___ No<br><br>Date for compliance: ______________ | ___ Yes ___ No<br>___ Not applicable<br>___ Don't Know |
| Are there any local regulations that may apply to your operation? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not applicable<br>___ Don't Know |

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# Questions

1. The most important factor in determining if manure is beneficially used or results in environmental problems is the:
   a. Nutrient content of the manure.
   b. Form of the manure (liquid or solid).
   c. Producer's management commitment and decisions.
   d. Type of animal that excretes it.

Answer: c

2. According to the EPA, the leading source of water quality impairments to rivers in the United States is:
   a. Industrial point sources.
   b. Urban runoff and storm sewers.
   c. Municipal point sources.
   d. Agriculture.

Answer: d

3. Runoff and erosion from a land application area are an example of a/an:
   a. Nonpoint source discharge.
   b. Point source discharge.
   c. Violation of federal law.
   d. Easily prevented problem.

Answer: a

4. Which of the following is not a stewardship principle?
   a. Being a good neighbor
   b. Keeping your operation under 1,000 animal units
   c. Balancing your nutrient use on the operation
   d. Complying with all environmental regulations

Answer: b

5. Which of the following is not a contaminant associated with manure that impacts water quality?
   a. Nitrogen
   b. Phosphorus
   c. Pathogen
   d. Lead

Answer: d

6. Excess nutrients, such as nitrogen and phosphorus, in water can cause:
   a. Low dissolved oxygen or fish kills.
   b. Health problems from high nitrates.
   c. Algal blooms and appearance problems.
   d. All of the above

Answer: d

7. A pathogen is a/an:
   a. Organism that can cause a disease.
   b. Path that water or manure flows on.
   c. Insect that lives in manure.
   d. Organism that is difficult to kill.

Answer: a

8. Which of the following operations is subject to the Clean Water Act and cannot pollute waters of the United States?
   a. 3,000-head farrow-to-wean swine operation
   b. Swine facility with 50 sows and one boar
   c. 150-head dairy
   d. All of the above

Answer: d

9. What does CNMP stand for?
   a. Comprehensive Nutrient Management Plan
   b. Complete Nutrient Model Program
   c. Comprehensive National Manure Plan
   d. Crazy Nuts Make Profits

Answer: a

10. Which of the following would NOT be a component of a nutrient management plan?
   a. Maps showing the locations of fields
   b. Tax records and all INS documentation
   c. Manure and soil analysis
   d. Records indicating sales of manure to off-operation users

Answer: b

11. Which of the following is NOT a true statement?
   a. CNMPs must be updated regularly.
   b. CNMPs are required on operations with more than 1,000 animal units.
   c. CNMPs are not necessary if all fertilizer and manure nutrients are applied at agronomic rates.
   d. CNMPs would probably include information on the total amount of manure generated.

Answer: c

12. Which of the following is NOT an example of an operation nutrient input?
   a. Animal feeds
   b. Fertilizers supplied to crops
   c. Animals purchased for breeding
   d. Machinery and operation equipment

Answer: d

13. Which of the following long-term changes would be most likely if operation nutrient inputs are much higher than outputs over an extended period of time?
   a. Soil phosphorus levels will increase.
   b. Water quality will improve.
   c. Animal mortality will increase.
   d. Soil phosphorus levels will decrease.

Answer: a

14. Which of the following is a strategy for improving the nutrient balance on an operation?
    a. Applying all manure to fields closest to the lagoon or barn
    b. Feeding excess nutrients and washing waste feed to the lagoon
    c. Composting manure for sale off the operation
    d. Planting legumes instead of corn

Answer: c

15. How could operators improve the balance between nitrogen inputs and outputs on their operation?
    a. Buy more feed from off-operation sources
    b. Add nitrogen to their irrigation water
    c. Sell more hay that is grown on the operation
    d. Install buffers around streams on the operation

Answer: c

16. Mismanagement can result in fines, additional regulatory requirements, and production losses.
    True or False

Answer: True

Cooperative Extension
The University of Georgia College of Agricultural and Environmental Sciences

# Maps for Nutrient Management Planning

*Thomas M. Bass, Julia W. Gaskin, Biological & Agricultural Engineering Department, and Casey Ritz, Poultry Science Department*

**Introduction**
A nutrient management plan (NMP) is a tool for making wise use of manure nutrients while protecting water resources. Accurate farm maps are a central component to the NMP. The map will help you identify areas suitable for land application of manure and areas that need protection or special management due to environmental sensitivity. Maps will also help you evaluate your crop rotation and calculate acreage you have available for using animal manure. This document will explain the process of preparing maps for the management of nutrients from organic sources such as manures.

Maps for NMPs should include:

- farm property lines
- land use -- cropland, pasture, forest, etc.
- farm field boundaries with field identification
- surface water locations, including streams, rivers, ponds, ditches and wetlands
- arrows showing the direction of stream or river water flow
- well locations
- buffers around sensitive areas including surface water, wetlands, wellheads, springs, rock outcrops or sinkholes
- any residences or public gathering areas
- spreadable acres
- north arrow
- road names or numbers
- name of county
- legend with map symbols
- BAR SCALE on the map
- date prepared
- name of person who prepared map

**Dry Poultry NMP Exceptions**
In Georgia, a nutrient management plan for a dry litter poultry operation has less detailed mapping requirements. The map is still a valuable planning tool; however, it is only required to have the following:

- road names or numbers
- farm field boundaries with field acreage
- field identification (should match related documents in the NMP)
- farm property lines

**Making a Base Map**
There are several ways to create a farm map; one is with computer generated maps. Most of these options require the assistance of a professional.

**NRCS Toolkit**
The easiest way to acquire the map information needed for a NMP is to use the Natural Resources Conservation Service (NRCS) Toolkit. USDA Service Center Offices are equipped with computers and technology that can generate a map for you. A conservationist can provide an aerial photo of the farm with the Farm Service Agency (FSA) property lines and field lines. You can work with the conservationist to add streams, other water bodies, and locate buffers. This technology is in place in many district offices and is widely available

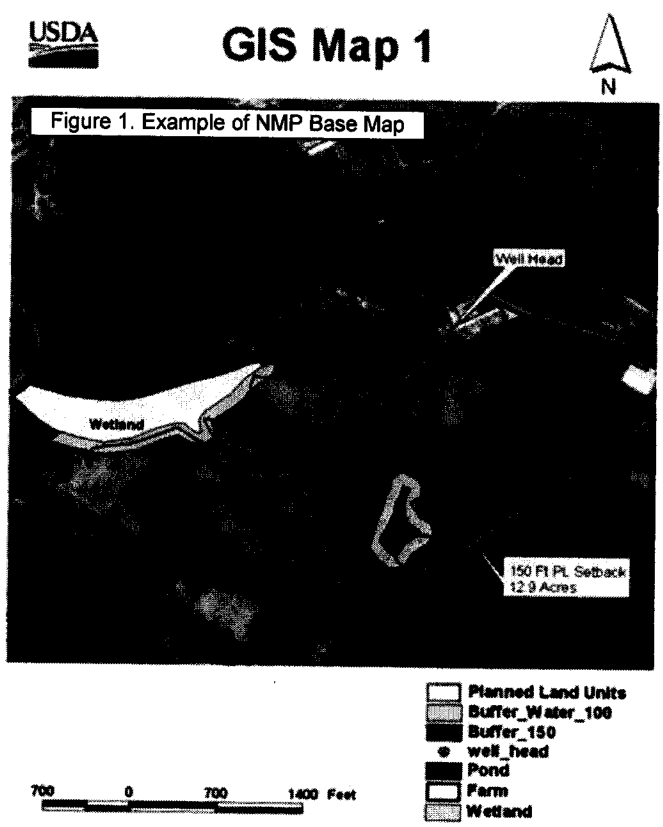



Figure 1. Example of NMP Base Map

throughout the state in local offices.

Figure 1 is an electronic aerial photo with the farm boundaries (black line), field boundaries (red line), 150 foot setback around the property line (green line), 100-foot buffer around surface water and wetlands (light violet), well (small circle), streams and pond (blue) overlain on the photo. This electronic map was developed with the NRCS Toolkit. The Toolkit can calculate the area of the fields, buffers and any other area that is desired. USGS topographic maps and some soil maps are available for overlaying on the base aerial photo.

The map labeled "Nutrient Mgt. Plan Map" (Figure 2) is an example of an actual map from a nutrient management plan prepared using the NRCS Toolkit. Revising or updating electronic maps can be accomplished with minimal time and effort. The map shows the basics for nutrient management plans, including: property boundaries, field numbers, size and boundaries, the lagoon or holding pond, sensitive areas and buffering, setbacks required by the Environmental Protection Division rules, and a scale. Note that on Figure 2, the 150-foot setback from the property line is continuous around the farm. This 150-foot setback could be placed only on fields that are going to be used for manure application similar to Figure 1.

**Online Maps**

There are several sources for maps online, three of which are listed below. These maps can serve as your base from which to build a more detailed depiction of the farm and its surroundings. The aerial photographs available at some of these sites can also be used to make the base map for your NMP. After you have obtained the topographic map or aerial photograph of your farm, you can hand draw the property boundaries, streams, fields, etc., or use

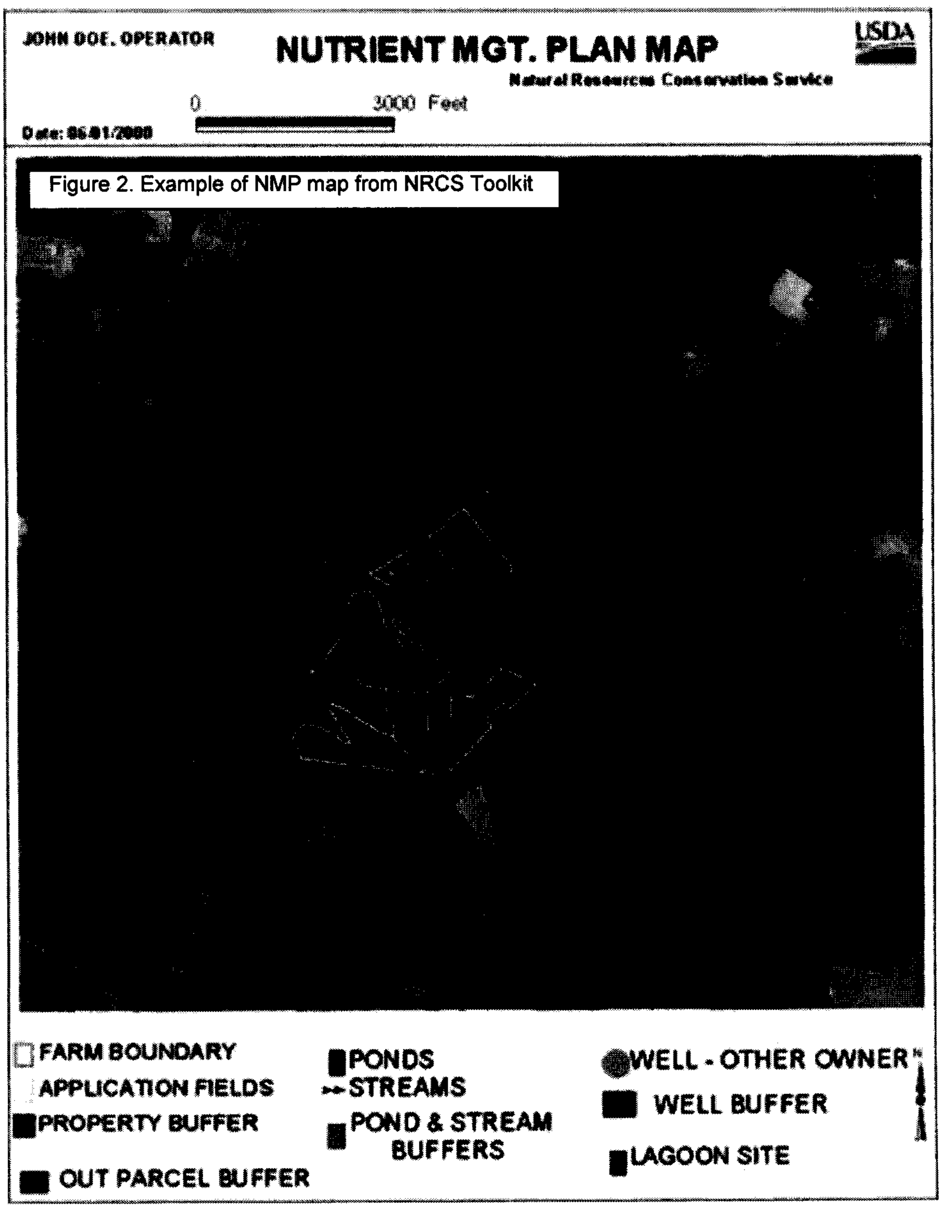


Figure 2. Example of NMP map from NRCS Toolkit

computer software to add the needed features. You will have to determine the scale of the photograph by measuring a known distance on the map. More details on how to add features and determine scales follows in the photocopied maps section.

FREE:

- TerraServer USA: **http://terraserver.microsoft.com**. From the homepage, use the "advanced find" function to search for the property in question by address. If available, both a USGS topographic map and aerial photo will be offered.

FEE BASED:

- Topozone, by Maps a la carte, Inc.: **http://www.topozone.com/**.

ADVANCED TOOLS:

- Georgia GIS Clearinghouse web site: **http://gis.state.ga.us/**.

**Photocopied Maps**
You can also construct a base map from photocopies. You will need:

- copies of the FSA maps of your farm, an aerial photograph or topographic map
- a ruler
- a transparent dot grid, planimeter or other method to determine acreage

Anytime a document is photocopied, the image size may change. You should use a bar scale to make sure your scale is accurate. Draw a 1-inch line on a piece of paper and place it on the map *before* it is copied. Then measure the 1-inch line on the map copy to make sure it still measures one inch. If it does not, you will have to set up a ratio to determine the true scale of the map. An example of how to set up a ratio for a map follows. The original scale is 1 inch = 660 feet, and on the copy the 1-inch line measures 1.2 inches. On the new map, 1.2 inches = 660 feet as well. If you wish to adjust the new map back to a one inch scale the ratio looks like this:

$$1 \text{ in}/1.2 \text{ in} = x \text{ ft}/660 \text{ ft}$$

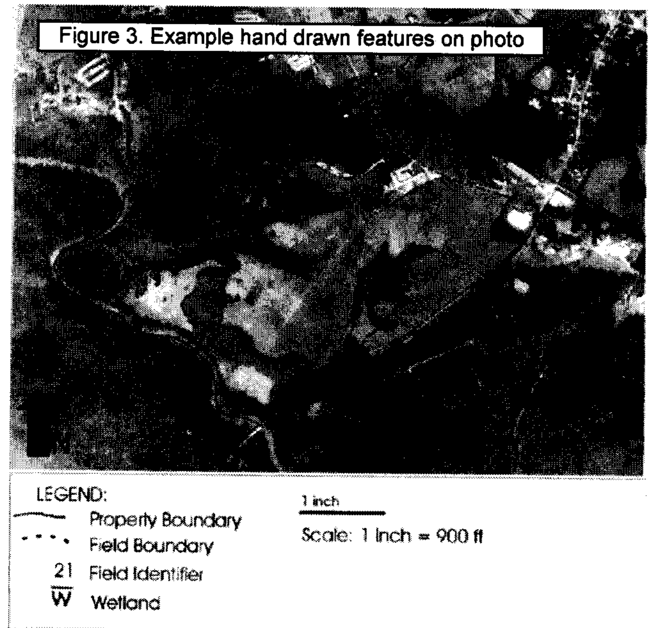
$$(660 \text{ ft})(1 \text{ in}/1.2 \text{ in}) = x \qquad (660 \text{ ft})(.83) = x$$

$$x = 550 \text{ feet}$$

The new scale is 1 inch = 550 feet.

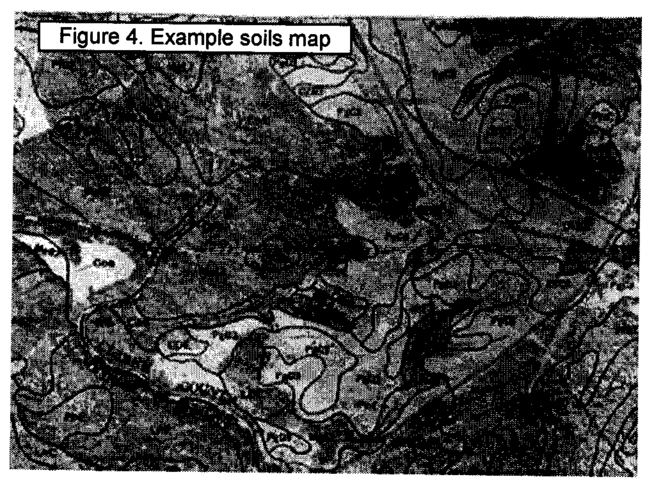
Because the FSA maps are aerial photographs, they will show land use and many surface water features, as well as roads with road names or numbers. Identify your property lines and field boundary lines if not shown on base map. Fields must be identified with a unique name or number, the total acreage and spreadable acreage of each field shown (see section "Calculating Acreage" for explanation). These features can be added by hand with pens or colored pencil. Leaving a blank or white area below the map will leave you room for the legend, scale and any necessary comments.

Figure 3. Example hand drawn features on photo




**Additional or Supporting Maps**
A soil survey map may also be a valuable tool in planning for nutrient applications. It is especially valuable when considering phosphorus application and utilizing the GA Phosphorus Risk Analysis Index (P Index).

Figure 4. Example soils map



**Land Suitability**

Site suitability for manure application is largely determined by the soils, topography and location of surface water. You may also want to consider how close a field is to public roads, public gathering areas or residences. The best sites for manure application are on level to gently sloping, deep, well-drained soils with some clay content. You should avoid:

- Soils less than 24 inches to bedrock
- Soils with water tables less than 36 inches below the soil surface
- Slopes greater than 12 to 15 percent.

You should also be careful about irrigation with manure wastewater on deep sandy soils. Water moves very rapidly through these soils and they have a limited ability to hold nutrients.

You probably have a good idea where these types of soils occur on your farm, but you can obtain this soils information from the county soil survey. Your soils map will have symbols on it that indicates the type of soils you have. Look up the symbol in the Soil Legend to get the name of the soil and the range of slopes associated with that map unit. Then go to the Soil and Water Feature Table, where you can look up the water table depth and depth to bedrock for that map unit. Remember the county soil survey is on a large scale and maps the dominant soils on the site. This means that soils other than the one mapped can and most likely will exist in a given field. If you have questions about whether the soils on your farm have the above characteristics, contact the NRCS.

If you have fields or parts of fields that have the characteristics listed above, you may need to exclude them from manure or wastewater application. Mark these areas on your base map. You should discuss these areas with NRCS or County Extension personnel to determine if the need to be permanently excluded from your land application program, or if they can be used seasonally or with special management. You should keep the soils information you have developed with your NMP. The information may prove useful if the NMP needs to be modified.

**Setbacks and Buffers around Sensitive Areas**

Sensitive areas such as wellheads, streams, or wetlands may be impacted by nutrient inputs. Setbacks are areas in which manures and nutrients are not applied. Buffers are setbacks that are managed with certain types of vegetation to help prevent nutrients and sediments from reaching surface waters.

Setbacks around wellheads will reduce the potential for groundwater contamination due to nutrients from manures, fertilizers or pesticides. Table 1 gives the distances required by law that you need to have separating wellheads from various potential contaminants. Table 2 gives recommendations for separation distances from potential contaminant sources.

**Table 1. Minimum distances between wells and potential contaminants based on the Georgia Well Standards Act of 1985.**

| Potential Contamination Source | Distance from Well (feet) |
|---|---|
| Sewer line | 10 |
| Septic tank | 50 |
| Septic tank absorption field | 100 |
| Cesspool or seepage pit | 150 |
| Animal or fowl enclosure | 100 |

**Table 2. Recommended separation distances from various potential contaminant sources.***

| Potential Contamination Source | Distance from Well (feet) |
|---|---|
| Waste lagoon | 150 |
| Dead animal burial pits | 150 |
| Pesticide storage, mixing & loading facilities | 100 |
| Fertilizer storage | 100 |
| Petroleum tanks | 500 |
| Manure or chemical application | 150 |

* Tyson, A. 1996. Improving Drinking Water Well Condition. Georgia Farm*A*Syst, Cooperative Extension Service Bulletin 1152-3.

Setbacks and buffers around streams, rivers, ponds and wetlands reduce the chance these surface waters will become overloaded with nutrients. Phosphorus in runoff or in water moving through the soil into the surface water can cause excessive algae growth that creates problems for recreation and other uses. Table 3 gives some general guidelines for buffer widths. Effective buffers are highly site specific and depend on land use, slope, and vegetation. You should review any proposed buffers with NRCS or county Extension personnel. Governmental rules and regulations may require specific setback and buffer widths. Some permitted animal feeding operations are required to observe a 100 ft setback from surface waters for manure application. This setback may be substituted with a managed 35 foot vegetated buffer adjacent to the water feature. Such regulations take precedence over any recommended widths.

**Table 3. Guidelines for surface water buffers. Do not apply animal manures within these buffers. Use fertilizers carefully. ***

| Distance from Surface Water | Feature |
|---|---|
| At least 50 feet | Ponds, sinkholes, wetlands |
| At least 90 feet if buffer slope is less than15% | Streams, rivers |
| At least 120 feet if buffer slope is greater than 15% | Streams, rivers |
| At least 35 feet | Ditches |

*Gaskin, J., and G. Harris. 1999. Nutrient Management Farm*A*Syst. University of Georgia, Cooperative Extension Service Bulletin 1152-16.

**Calculating Acreage**
Now that you have determined the setbacks and buffers needed around these sensitive areas, you need to mark them on your map, determine the acreage, and subtract the acreage from the total acreage of the field. Make sure you know the correct scale for your map. First measure the correct setback and buffers distance with your ruler and outline the buffer area in a distinct color. You may want to shade or otherwise mark the setback and buffer areas.

Now calculate the acreage in each field that is not useable for manure application due to the setbacks and buffers, sensitive areas or unsuitable areas. Setback and buffer areas can be calculated by measuring the area with a ruler or using a dot grid. A dot grid is a transparent piece of paper or plastic with a known number of dots per square inch. Place the dot grid over the buffer area and count the number of dots within the buffer. If a dot falls on the buffer line, include every other dot in your count for the buffer area. Divide the total number of dots by the number of dots per square inch to get the square inches of land in the buffer. Now find the scale of your map. Multiply the number of feet per inch by itself to get square feet per square inch. Then multiply the number of square inches from your dot grid by the square feet for your base map, convert to acres, and you're done.

**Limitations of Land Application Equipment**
The acreage remaining for application after all appropriate buffers and setbacks have been considered may still not be the actual acreage available. This is most true when considering liquid waste applied through an irrigation system. For example, a center pivot system will not reach all of the corners of a field. The map should show the wetted areas for irrigation systems; this final area is what should be used for budgeting applications in a field. NRCS Toolkit is recommended for illustrating coverage area and calculating actual acreage.

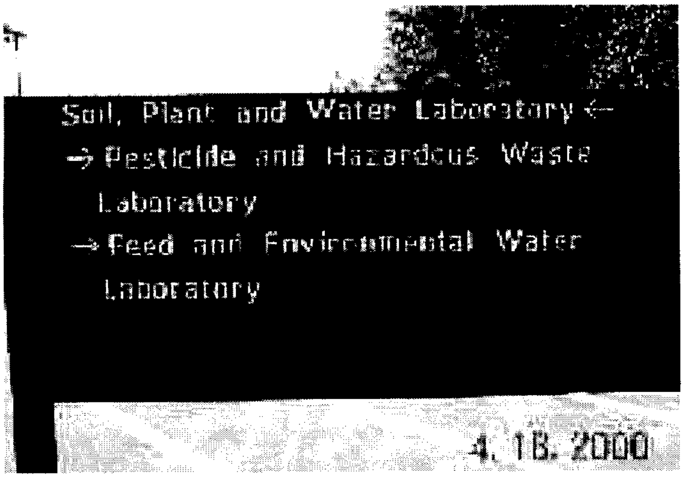
**Summary**
You have now developed the basis for your NMP. These maps are critical for conservation, planning land application of manures, and crop rotations. You should keep them as accurate as possible.

**Publication/Date**
The University of Georgia and Ft. Valley State University, the U.S. Department of Agriculture and counties of the state cooperating. The Cooperative Extension Service, the University of Georgia College of Agricultural and Environmental Sciences offers educational programs, assistance and materials to all people without regard to race, color, national origin, age, sex or disability. October 2005.

# Soil, Manure, and Monitoring Well Testing in Georgia

by:

Dr. Paul F. Vendrell, Dr. Parshall B. Bush, Dr. David E. Kissel, and Dr. Leticia S. Sonon




# SOIL, MANURE, AND MONITORING WELL TESTING

**Acknowledgements:** This training lesson was modified and adapted in part from the materials prepared for Lesson 34 from the Livestock and Poultry Environmental Stewardship Curriculum Project by Karl Shaffer[1] and Ron Sheffield[1] and other material prepared by Owen Plank[2] and Wayne Jordan[3].

## Outline

I. Introduction

II. Manure Testing

- A. Manure Sample Collection
  - 1. Liquid manure
    - a. Lagoon effluent
    - b. Liquid slurry
    - c. Lagoon sludge
  - 2. Solid manure
    - a. Stockpiled manure or litter
    - b. Surface-scraped manure
    - c. Composted manure
- B. Test to Request
  - 1. Basic UGA manure test package
  - 2. Additional test on liquid manure for CNMP
  - 3. Georgia regulations for testing lagoon effluent
- C. Manure Report

II. Soil Testing

- A. Soil Sample Collection
  - 1. When
  - 2. Where
  - 3. How
- B. Soil Test Parameters
- C. Soil Test Report

III. Monitoring Well Testing

- A. Monitoring Well Location
- B. Monitoring Well Construction
- C. Groundwater Monitoring Requirement

D. Sampling and Analysis
E. Guidance Documents

IV. Review Questions

[1] Shafer, K. and R. Sheffield, 2000, Lesson 34, Land application records and sampling, USDA/EPA National Curriculum Project, http://www.mwpshq.org/curriculum_project/currproj.htm .

[2] Plank, C. O., 2000, Soil testing, Leaflet 99,Cooperative Extension Service Publication, University of Georgia, College of Agriculture and Environmental Sciences, http://www.ces.uga.edu/pubcd/L99.htm .

[3] Jordan, C. W., 2000, Soil and manure sampling and analysis, Unpublished information, Agricultural and Environmental Services Laboratories, University of Georgia, Cooperative Extension Service, College of Agriculture and Environmental Sciences.

## Introduction

The collection and analysis of soil, manure, and monitoring well water are addressed in this training. Soil and manure testing are needed to perform comprehensive nutrient management planning (CNMP). Utilization of manure or lagoon effluent within a CNMP requires soil and manure testing for measurement of plant available nutrients. Soil test reports give the level of available plant nutrients and provide recommendations for any additional lime and fertilizer nutrients needed to achieve optimum crop yields. Animal manure is a valuable resource and can be used to provide the additional soil nutrients prescribed in the soil test recommendations. Growers should not base application rates on laboratory test results from previous years because nutrient concentrations can change significantly, particularly when the manure has been exposed to the environment. For example, nutrient levels in a lagoon or storage pond can be greatly influenced by rainfall.

For regulatory purposes the lagoon effluent and water from the monitoring wells need to be sampled semiannually and tested. Total Kjeldahl nitrogen (TKN) and nitrate-nitrogen ($NO_3$-N) are required for the lagoon effluent. However, in order to use the lagoon effluent as a fertilizer source in nutrient management, additional testing for phosphorus, potassium, and micronutrients will be necessary. Monitoring wells require TKN and $NO_3$-N and possibly other primary drinking water parameters may be advisable.

Utilization of swine manure or lagoon effluent within a CNMP requires soil and manure testing. Soil test reports give the level of available plant nutrients and provide recommendations for any additional lime and fertilizer nutrients needed to achieve optimum crops yield. Animal manure is a valuable resource and can be used to provide the additional soil nutrients prescribed in the soil test recommendations. Growers should not base application rates on laboratory test results from previous years because nutrient concentrations can change significantly, particularly when the manure has been exposed to the environment. For example, nutrient levels in a lagoon or storage pond can be greatly influenced by rainfall.

Producers who fail to test each manure source before or just after land application are faced with a number of questions they simply may not be able to answer: Are they supplying plants with adequate nutrients? Are they building up excess nutrients that may ultimately move into surface water or groundwater? Are they applying heavy metals at levels that may be toxic to plants and permanently alter soil productivity?

## Manure Testing

Manures can be quite variable in nutrient content. This variability may be due to different animal species, feed composition, bedding material, storage and handling as well as other factors. Testing at or near the time of application tells you the fertilizer value to make decisions about rates to apply. Some livestock producers are faced with nutrient management regulations that require manure testing. Also, if buying or selling litter/manure for fertilizer use, testing will help both buyer and seller establish the fertilizer value.

**Manure Sample Collection**

According to the Georgia Environmental Protection Division (EPD) "Animal Non-Swine Feeding Operation Permit Requirements", lagoon effluent is to be sampled semiannually. Preferably, the sample should be taken as near the application time as possible prior to the manure application. However, if it is urgent to pump down a full lagoon or storage pond, you should not wait until you can sample and obtain the results. You should sample the day of irrigation. The results can later be used to determine the nutrients applied to the fields and identify the need for additional nutrients to complete crop production.

Manures should be sampled and tested near the time of application because the nutrient content can change considerably over time, particularly if stockpiled and unprotected from the weather. Nitrogen (N) is the nutrient that is the most likely to be affected. The frequency for testing your manure will depend upon several factors, but, as noted above, lagoon effluent needs to be tested at least semiannually. The type of manure and overall management system will also be factors. Animal producers using lagoon manure storage systems should sample every time that the liquid or slurry will be pumped and applied to the land. Proper sampling is the key to reliable manure analysis. Although laboratory procedures are accurate, they have little value if the sample fails to represent the manure product. Manure samples submitted to a laboratory should represent the average composition of the material that will be applied to the field. Reliable samples typically consist of material collected from a number of locations. Precise sampling methods vary according to the type of manure. The laboratory, County Extension Agent, or crop consultant should have specific instructions on sampling.

**Liquid Manure**

Liquid manure samples submitted for analysis should meet the following requirements:

- Place sample in a sealed, clean plastic container with about a 1-pint volume. Glass is not suitable because it is breakable and may contain contaminants.
- Leave at least 1 inch of air space in the plastic container to allow for expansion caused by the release of gas from the manure material.
- Refrigerate or freeze samples that cannot be shipped on the day they are collected. This will minimize chemical reactions and pressure buildup from gases.

Ideally, liquid manure should be sampled after it is thoroughly mixed. Because this is sometimes impractical, samples can also be taken in accordance with the suggestions that follow.

***Lagoon effluent:*** Premixing the surface liquid in the lagoon is not needed, provided it is the only component that is being pumped. Growers with multistage systems should draw samples from the lagoon they intend to pump for crop irrigation.

Samples should be collected using a clean, plastic container similar to the one shown in Figure 1. One pint of material should be taken from at least eight sites around the lagoon and then mixed in the larger clean, plastic container. Effluent should be collected at least 6 feet from the edge of the lagoon at a depth of about a foot. Shallower samples from anaerobic lagoons may be less representative than deep samples because oxygen transfer near the surface sometimes alters the chemistry of the solution. Floating debris and scum should be avoided. One pint of the mixed material should be sent to the laboratory. Galvanized containers should never be used for collection, mixing, or storage due to the risk of contamination from metals like zinc in the container.

***Liquid slurry:*** Manure slurries that are applied from a pit or storage pond should be mixed prior to sampling. If you agitate your pit or basin prior to sampling, a sampling device pictured in Figure 1 can be used. If you wish to sample a storage structure without agitation, you must use a composite sampling device as shown in Figure 2. Manure should be collected from approximately eight areas around the pit or pond and mixed thoroughly in a clean, plastic container. An 8- to 10-foot section of 0.5- to 0.75-inch plastic pipe can also be used: extend the pipe into the pit with ball plug open, pull up the ball plug (or press your thumb over the end to form an air lock), and remove the pipe from the manure, releasing the air lock to deposit the manure into the plastic container.

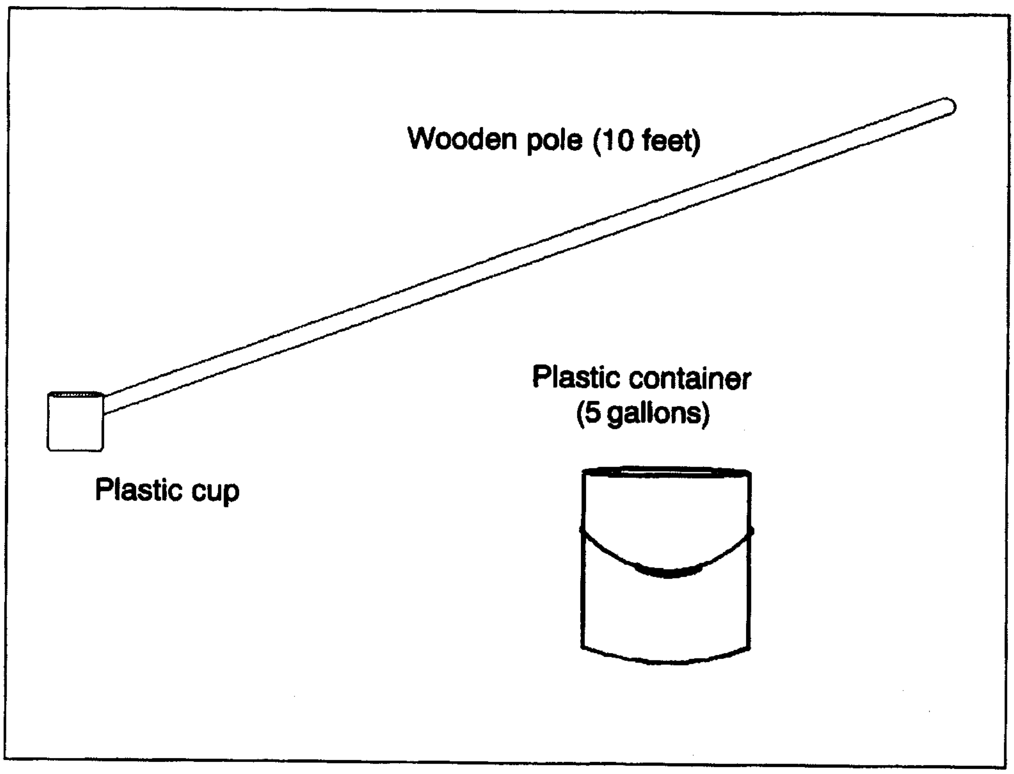



***Figure 1. Liquid manure sampling device***

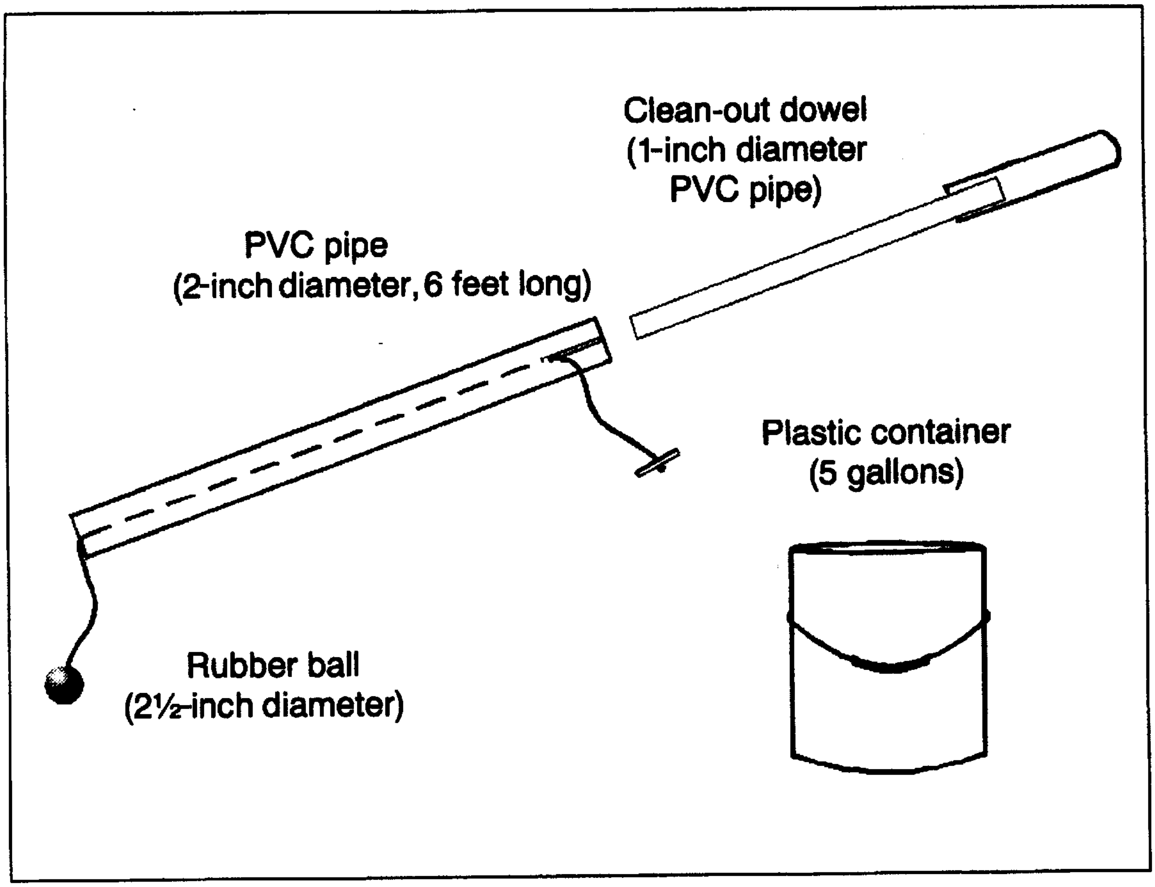



***Figure 2. Composite sampling device***

***Lagoon sludge:*** Representative samples of lagoon sludge are more difficult to obtain than samples with lower solid contents. Two common methods are used. One method requires lagoon pump-down to the sludge layers. Then, during sludge agitation, a liquid or slurry type of sample described above may be collected. The other method requires insertion of a probe into the lagoon to the bottom to obtain a column of material. A "sludge-judge" is a device commonly used for this type of sampling. The sludge component of this column is then released into a clean plastic bucket, and several (12-20) other sampling points around the lagoon are likewise collected to obtain a composite, representative sample. This procedure must be performed with a boat or mobile floating dock.

For analysis, most laboratories require at least 1 pint of material in a plastic container. The sample should not be rinsed into the container because doing so dilutes the mixture and distorts nutrient evaluations. However, if water is typically added to the manure prior to land application, a proportionate quantity of water should be added to the sample.

**Solid Manure**

Solid manure samples should represent the average moisture content of the manure. A one-quart sample is adequate for analysis. Samples should be taken from approximately eight different areas in the manure pile, placed in a clean, plastic container, and thoroughly mixed. Approximately one quart of the mixed sample should be placed in a plastic bag, sealed, and shipped directly to the laboratory. Samples stored for more than two days should be refrigerated. Figure 3 shows a device for sampling solid manure.

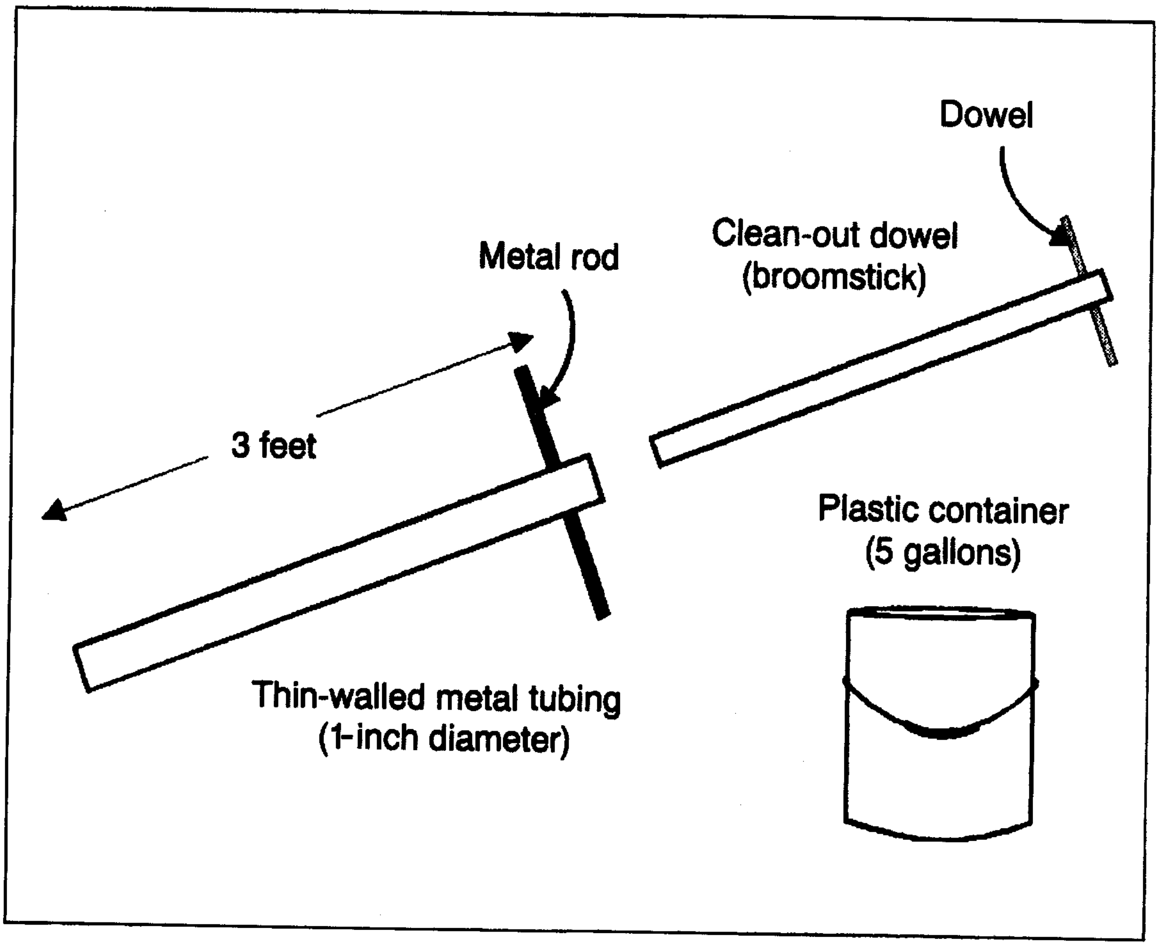



*Figure 3. Solid manure sampling device*

## SAMPLING TECHNIQUES FOR DETERMINING BROILER LITTER NUTRIENT CONTENT

***In-house Litter:*** The nutrient content of litter in a poultry house can vary considerably depending on location within the house. For example, in a recent study, we found the nitrogen content of 30 uniformly spaced broiler litter samples from within a house to vary as shown in the following table:

| | Center of the house | Around feeder | Around drinkers |
|---|---|---|---|
| | (%) | | |
| Average | 3.31 | 4.44 | 3.49 |
| Minimum | 2.83 | 4.15 | 2.35 |
| Maximum | 3.68 | 4.75 | 4.50 |

The average % N of samples taken around feeders was 25% higher than samples taken from the center of the house and 21% higher than the average around drinkers. Samples taken around drinkers varied as much as 48% (range 2.35 to 4.50 %N). Therefore, **it is not recommended** to sample litter while still being used as a bedding layer in the poultry house. Wait until clean out to sample after mixing the litter by scraping it into a pile. Then, follow the procedure given below for sampling litter from piles, stockpiles, or spreader trucks. If sampling of litter is necessary in the house prior to clean out, use the sampling procedures as originally provided.

***Piled manure, litter, or from a spreader truck:*** This procedure is for manure or litter temporarily collected into piles during clean out. To obtain a representative sample, collect at least 10 shovelfuls of manure or litter from the piles or from the spreaders, so that it represent all of the manure or litter, which is hauled or spread. Combine the collected portions in a clean 5-gallon plastic bucket or wheelbarrow, and mix thoroughly. Place a one-quart portion from this mixture in a plastic bag, seal it securely, and ship it to the laboratory as soon as possible. For wet manure, refrigerate the sample if it will not be shipped within one day of sampling. Unless hauling or spreading immediately, protect surface-scraped manure or litter from the weather. Sample stockpiled litter or manure according to the guidelines given below.

***Stockpiled manure or litter:*** A stockpile consists of manure or litter stored in a pile for later use. Store stockpiled manure or litter under cover on an impervious surface. The weathered exterior of uncovered waste may not accurately represent the majority of the material, since rainfall generally moves water-soluble nutrients down into the pile. Sample stockpiles using the same method for piles described above except collect at a depth of 18 inches from the surface of the pile, and as close as possible to its application date.

**Manure Tests to Request**

The County Extension Office has sample submission forms and information on tests that are most often needed and can assist with shipping samples to the University of Georgia (UGA) Ag and Environmental Services Laboratories. The UGA manure sample submission forms are displayed in Figures 4 and 5. Poultry producers should use the form illustrated in Figure 5, Poultry Litter/Manure Submission Form for Nutrient Management Plans. All others should use the form illustrated in Figure 4, Animal Waste Submission Form for Land Application. If using an independent or company laboratory, contact them directly about services and prices.

***Basic UGA manure test package:*** Your individual permits will dictate the frequency and kinds of testing. The basic manure test package at the UGA Ag and Environmental Services Laboratories includes: (all are as total elemental nutrient)

- nitrogen (N)
- phosphorus (P)
- potassium (K)
- calcium (Ca)
- magnesium (Mg)
- sodium (Na)
- sulfur (S)
- aluminum (Al)
- iron (Fe)

- boron (B)
- copper (Cu)
- manganese (Mn)
- zinc (Zn)

***Additional test on liquid manure for CNMP:*** Lagoon effluent samples submitted for basic manure testing at the UGA Ag Services Labs will have additional analyses that include:

- total Kjeldahl nitrogen (TKN), (for permit)
- nitrate nitrogen, (for permit).
- Ammonium nitrogen (not required for permit but used for nutrient management)

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College of Agricultural and Environmental Sciences
Cooperative Extension Service

SOIL, PLANT, AND WATER LABORATORY
2400 College Station Road

# ANIMAL WASTE
## SUBMISSION FORM FOR LAND APPLICATION

Please Note - Retain a copy of this form for your files. Submit one copy per sample.

Name: ______________________ Sample #: ______________
Mailing address: ______________ County: ______________
City,State,Zip: ______________
Phone #: ______________ Date Received: ______________

**Check kind and Condition**

| | Kind | Condition |
|---|---|---|
| LITTER | A. Broiler ____ | E. Fresh/Stackhouse ____ |
| | B. Layer ____ | F. Deep Stacked ____ |
| | C. Breeder ____ | G. Composted ____ |
| | D. Pullet ____ | H. Other ____ |
| MANURE | I. Dairy | |
| | J. Swine | N. Slurry |
| | K. Beef | O. Solid |
| | L. Horse | P. Composted |
| | M. Other | |
| LAGOON | Q. Swine ____ | S. Layer ____ |
| | R. Dairy ____ | T. Other ____ |

**Application Method**
(Check One)

Broadcast Surface ____
Broadcast Incorporated ____
Soil Injected ____
Irrigation applied ____
Other

**TEST REQUESTED** (Check all that apply and consult schedule for fees)

Total Minerals: (Includes total Kjeldahl nitrogen (excluding nitrate nitrogen) phosphorus, potassium, calcium, magnesium, sulfur, manganese, iron, aluminum, boron, copper, zinc, sodium)

Total Kjeldahl Nitrogen only ____ (excluding nitrate nitrogen)
Nitrate Nitrogen ____ (important for lagoons)

Ammonium Nitrogen ____ Moisture or Solids ____ Other ____

**FOR LAB USE ONLY**

Date Received: ______________ Date Returned: ______________
Payment Received: ______________ Invoiced #: ______________

$NH_4$-N ____ Moisture ____ $NO_3$-N ____ Total Nitrogen ____ Other ____

*Figure 4. Example of the UGA "Animal Waste Submission Form for Land Application"*

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SOIL, PLANT, AND WATER LABORATORY
2400 College Station Road

LAB # ________________ (lab use only)

**POULTRY LITTER/MANURE SUBMISSION FORM**

**FOR NUTRIENT MANAGEMENT PLANS**

**Please Note - Retain a copy of this form for your files. Submit one copy per sample.**

**Name:** ________________________ **Sample #:** __________ (One form per sample)

**Mailing address:** ________________________ **County:** ________________

**City,State,Zip:** ________________________ **Date:** ________________

**Phone #:** ________________________

**For First Time Users please answer the following:**

1. Have you attended Nutrient Management Training?; Yes___ No___
   *If you have not received training check with your County Extension Agent.
2. Will these results be used for Nutrient Management Planning?; Yes ___ No ___
3. How many flocks were produced on this litter? ____
4. Was the litter caked ___ or Full clean-out ___ (Check One)

**Please check all that apply:**

| **Kind** | **Condition** |
|---|---|
| Broiler ______ | Fresh ______ |
| Layer ______ | Stockpiled ______ |
| Breeder ______ | Composted ______ |
| Pullet ______ | Lagoon ______ |

**Application Method:**
(Check One)
Surface ______
Incorporated
(within 2 days)
Soil Injected
Irrigation applied ______

**TESTS REQUESTED:**

______ Total Minerals (free basic test)
(Includes: total nitrogen,phosphorus,potassium,calcium,magnesium,sulfur,manganese, iron,aluminum,boron,copper,zinc,sodium)

Extra Tests (price per fee schedule)
Nitrate Nitrogen ______ Ammonium Nitrogen ______
Moisture Solids Other

*************************************************************************

**FOR LAB USE ONLY**

**Date Received:** **Date Returned:**
**Payment Received:** __________ **Invoice #:** __________

**$NH_4$-N** _____ **Moisture/Solids** _____ **$NO_3$-N** _____ **Total Nitrogen** _____ **Other** _____

**Manure Report**

The UGA Ag and Environmental Services Laboratories reports results for solid manures in both percentages and pounds of nutrients per ton on an "as received" basis since this is how you will be applying the material. In the Animal Waste Report (Figure 6), liquid sample results are reported as parts per million (ppm) and converted into both pounds per 1,000 gallons and pounds per acre inch of application for your convenience in determining rates per acre. The phosphorus and potassium are reported in the fertilizer basis as $P_2O_5$ and $K_2O$ respectively. Other laboratories may report their results differently. If a lab reports phosphorus and potassium as elemental P or K, you must convert them into the fertilizer basis of $P_2O_5$ or $K_2O$. This can be done with the following conversions:

P multiplied by 2.29 = $P_2O_5$

K multiplied by1.20 = $K_2O$

The amount of the total nutrients in manure that will be available to plants varies depending on the type of manure and whether it will be applied to the surface of the soil, incorporated or injected. County Extension Agents and other qualified professionals can assist with the calculation of manure nutrient availability based on when and how you will make application. This information, combined with the soil test report and other information, is necessary to develop a CNMP.

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## Animal Waste Report

**Soil, Plant and Water Laboratory**

**Sample ID**

**Grower Information**
Client: John Doe
[illegible] Street
Athens, GA [illegible]
Sample: 1
Type: Lagoon Swine [illegible] Applied

**Lab Information**
Lab: [illegible]
Completed: [illegible]
Printed: [illegible]

**County Information**
Clarke County
[illegible]
Athens, GA [illegible]

**Results**
(Reported on an as-received wet basis.)

| Lab Results | ppm | lbs/1000 gal | lbs/acre-inch |
|---|---|---|---|
| Total Kjeldahl Nitrogen | [illegible] | [illegible] | 22.5 |
| Ammonium Nitrogen | [illegible] | [illegible] | [illegible] |
| Nitrate Nitrogen | [illegible] | [illegible] | [illegible] |
| Phosphorus ($P_2O_5$) | [illegible] | [illegible] | [illegible] |
| Potassium ($K_2O$) | [illegible] | [illegible] | [illegible] |
| Calcium | [illegible] | [illegible] | [illegible] |
| Magnesium | [illegible] | [illegible] | [illegible] |
| Sulfur | [illegible] | [illegible] | [illegible] |

| Lab Results | ppm | lbs/1000 gal | lbs/acre-inch |
|---|---|---|---|
| Manganese | [illegible] | negligible | negligible |
| Iron | [illegible] | [illegible] | [illegible] |
| Aluminum | [illegible] | [illegible] | [illegible] |
| Boron | [illegible] | [illegible] | [illegible] |
| Copper | [illegible] | [illegible] | [illegible] |
| Zinc | [illegible] | [illegible] | [illegible] |
| Sodium | [illegible] | [illegible] | [illegible] |

[illegible]

Total Kjeldahl Nitrogen includes ammonium and organic nitrogen combined, and does not include nitrate.

**Application Information:** The amount of reported nitrogen expected to be available for crop production will vary depending on several factors. Your County Agent can assist in calculating the amount of nitrogen that will be available under your specific set of conditions.

Rates of the animal waste product to apply for crop production should be based on soil test recommendations and take into consideration the nutrient content of the product as well as the method of application, the amount of nutrients applied from commercial fertilizer, and previous crop residue. Where large amounts of animal waste are used annually, it is important that regular soil testing be used to monitor the impact on soil fertility levels.

[illegible]

***Figure 6. Example of a liquid manure report form the UGA Ag and Environmental Services Laboratories***

## Soil Testing

Presently, manure application rates are based on the nitrogen requirement of a crop or forage and according to a CNMP, sufficient animal waste can be applied to satisfy that need. In the southern United States, soil test nitrogen does not accurately predict the response of crops and forages to residual soil nitrogen; consequently, soil nitrogen is not measured. In Georgia, nitrogen fertilizer recommendations are based on long-term experiments conducted to determine the rates of N fertilizers needed for specific crops. In a CNMP, the rate of animal waste applied is based on nitrogen requirements. Therefore, why do soil testing if nitrogen is the regulating nutrient? Crop yield and nitrogen uptake will increase when other nutrient deficiencies are corrected, such as low pH, other macronutrients, or micronutrients. Nitrogen fertilizer recommendations are made on the assumption that all other nutrients are at optimum levels and soil testing is the way to detect nutrient deficiencies other that nitrogen. Another reason for soil testing is that repeated manure applications can lead to over applications of nutrients, especially phosphorus (P). Soil testing can track the build-up of P and assist with management decisions to utilize this high phosphorus animal waste on soils with lower soil test P. Soil testing can also monitor any build-up of zinc, which could possibly increase to toxic levels (for sensitive crops like peanuts) from long-term and heavy applications of poultry litter.

### Soil Sample Collection

***When:*** Soils should be tested annually. Fall is a good time to take samples, but samples can be taken at any time of the year. To make good comparisons from year to year it is important to sample at approximately the same time each year.

***Where:*** There can be considerable variation in nutrient and pH levels within a field. For most accurate results the sample must be representative of the field or area from which it is collected. Areas within a field that have obviously different soil type, drainage, crop growth, or slope characteristics should be sampled separately. Figure 7 illustrates the recommended zigzag pattern for soil core collection and the logic behind collecting separate samples due to changing field conditions. Figure 8 illustrates an example of taking separate soil samples based on topography and differing management practices.

Avoid areas where fertilizer or lime has been spilled or stockpiled as well as areas around old house or barn locations.

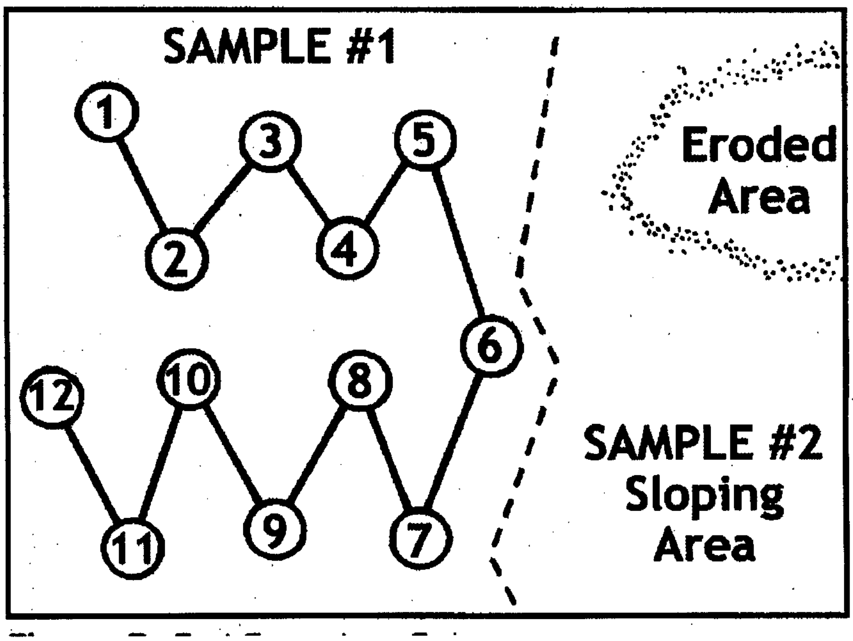


*Figure 7. Zigzag pattern for collecting soil samples*

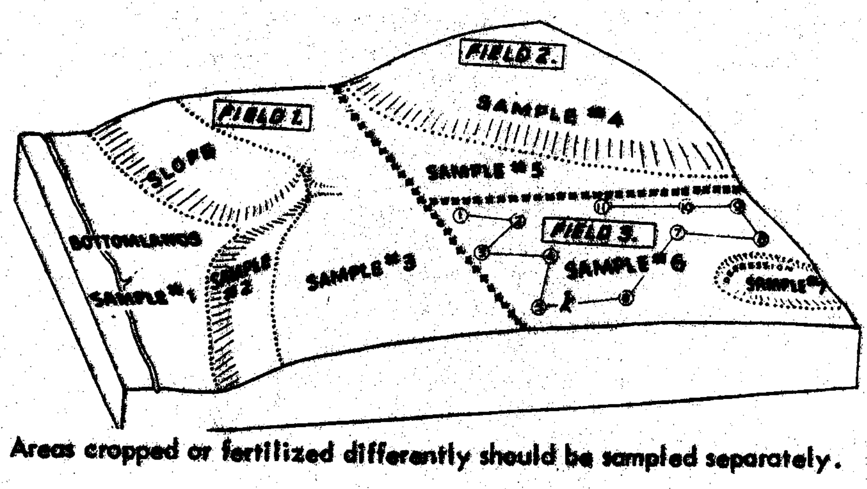


*Figure 8. Collection of separate samples based on topography and differing management practices*

***How:*** The depth of sampling depends on management practices. From plowed fields take the sample to 6 inches or to plow depth. No-till fields or pastures should be sampled to 4-inches depth (Figure 9). From each area to be sampled take 10 to 20 cores at random, place in clean, plastic container and thoroughly mix. Remove about a pint of the composite soil for submission to the laboratory. Be sure to clearly mark each sample so that you know which field and area of field it represents.

For submission to the UGA Agricultural and Environmental Services Laboratories, contact the local County Extension Agent for more information on soil sampling, submission forms, and sample bags. Private laboratories can also provide information on these topics and the services offered.

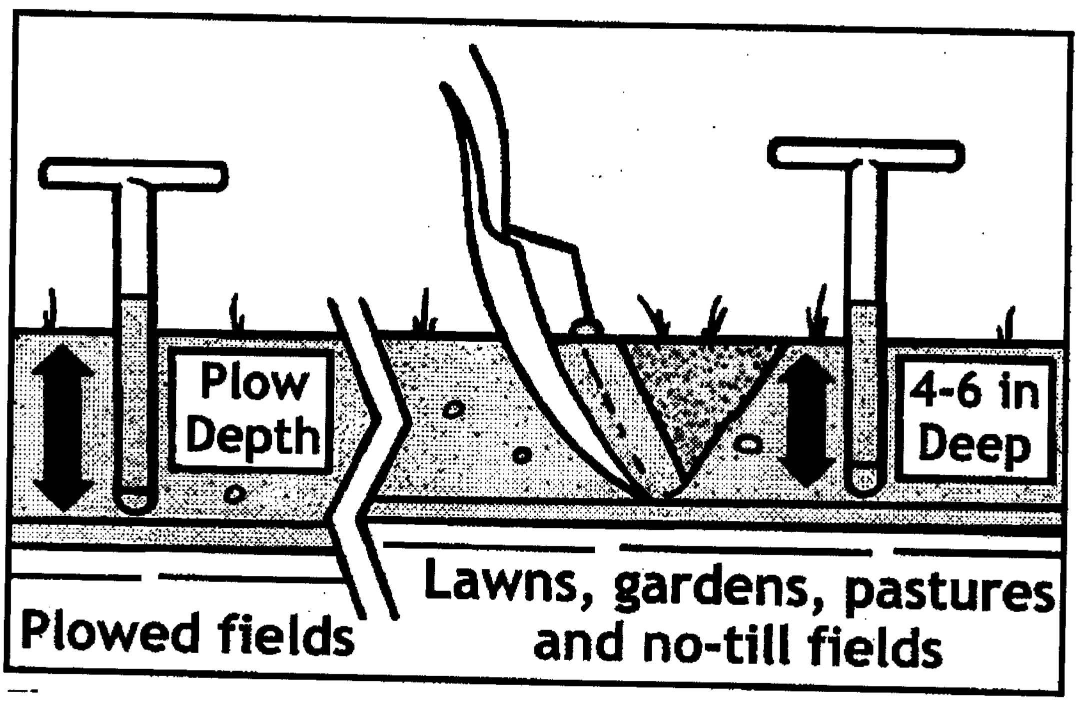


***Figure 9. Soil sampling depths for plowed fields (6 inches or plow depth) and no-till or pastures (4 inches)***

**Soil Test Parameters**

The routine soil test conducted by the UGA Ag and Environmental Services Laboratories include:

- phosphorus (P)
- potassium (K)
- calcium (Ca)
- magnesium (Mg)
- manganese (Mn)
- zinc (Zn)
- pH
- lime requirement

Soil tests for nitrogen (N) are generally not reliable for predicting crop response due primarily to the high rainfall of the southeastern U.S.; therefore, recommendations given in soil test reports are based on long-term experiments conducted to determine the rates of N fertilizers needed for specific crops. Other tests like cation exchange capacity (CEC), organic matter, copper (Cu), and boron (B) are available on request. The UGA Ag and Environmental Services Laboratories methods are well correlated with Georgia soils. Various independent laboratories also provide soil-testing services. It is important that the laboratory of your choice uses methods and makes recommendations based on Georgia conditions.

**Soil Test Report**

The laboratory report will show the test results and give a recommendation for fertilizer nutrients and lime if needed. The recommended rates of nutrients may be supplied from commercial fertilizers, animal manures, lagoon effluents or a combination of sources.

Soil test results are usually reported in pounds of nutrients per acre but some laboratories may give the results as parts per million (ppm). These numbers are merely an index of the nutrients in the soil and are not the actual amounts available for plant uptake. To simplify the interpretation, soil test results are classified into low, medium, high and very high categories. These categories refer to the relative nutrient-supplying power of the soil. Little or no fertilizer nutrients are recommended when soil test levels are rated as high and very high. Examples of UGA soil test reports and recommendations are given in Figures 10 and 11. Nutrient application to soils with very high soil tests could lead to a nutrient imbalance as well as contribute to surface water quality problems.

In summary, a soil test report tells you the fertility status of the soil and how much, if any, additional nutrients are needed for the particular crop. When animal manure will be used as the fertilizer source it is essential to also know the nutrient content of the manure so appropriate rates can be applied.

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# Soil Test Report

**Soil, Plant and Water Laboratory**

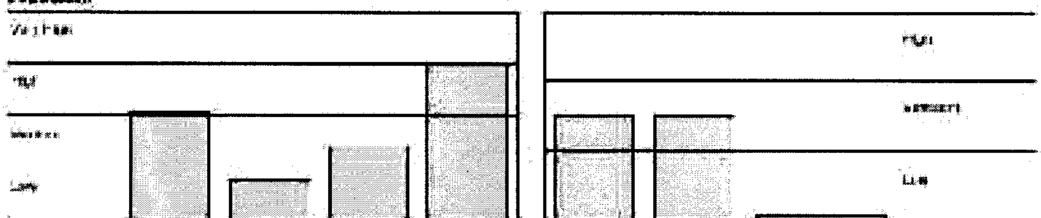
## Sample ID

**Grower Information**
Client: [illegible]
123 [illegible] Street
Athens, GA [illegible]
Sample: 1
Crop: [illegible] Bermuda Pasture

**Lab Information**
Lab #: [illegible]
Completed: [illegible]
Printed: [illegible]

**County Information**
Clarke County
[illegible] W. [illegible]
Athens, GA 30[illegible]

## Results



| | Phosphorus (P) | Potassium (K) | Calcium (Ca) | Magnesium (Mg) | Zinc (Zn) | Manganese (Mn) | Soil pH |
|---|---|---|---|---|---|---|---|
| Soil Test Index | [illegible] lbs/Acre | [illegible] lbs/Acre | [illegible] lbs/Acre | [illegible] lbs/Acre | [illegible] lbs/Acre | [illegible] lbs/Acre | [illegible] (7.[illegible] Lime Index) |

## Recommendations

| Limestone | Nitrogen (N) | Phosphate ($P_2O_5$) | Potash ($K_2O$) | Sulfur (S) | Boron (B) | Manganese (Mn) | Zinc (Zn) |
|---|---|---|---|---|---|---|---|
| 2.5 tons/Acre | * | [illegible] lbs/Acre | 70 lbs/Acre | -- | -- | -- | -- |

*If [illegible] is not intensively grazed apply 75 to [illegible] pounds nitrogen per acre. If intensively grazed [illegible] apply 125 to 175 pounds nitrogen per acre.

If excess forage is common under grazing conditions, split the pasture in half and apply nitrogen to only one section in March, and to the remaining apply nitrogen in July or August, dependent upon the amount of forage that will be utilized.

NOTE: The amounts of nitrogen (N), phosphate ($P_2O_5$), and potash ($K_2O$) actually applied may deviate 10 pounds per acre from that recommended without appreciably affecting yields.

**PUTTING KNOWLEDGE TO WORK**

**Figure 10. Example of a UGA soil test report and fertilizer recommendations for common Bermuda pasture**

Figure 11. Example of UGA soil test report and fertilizer recommendations for small grain silage,

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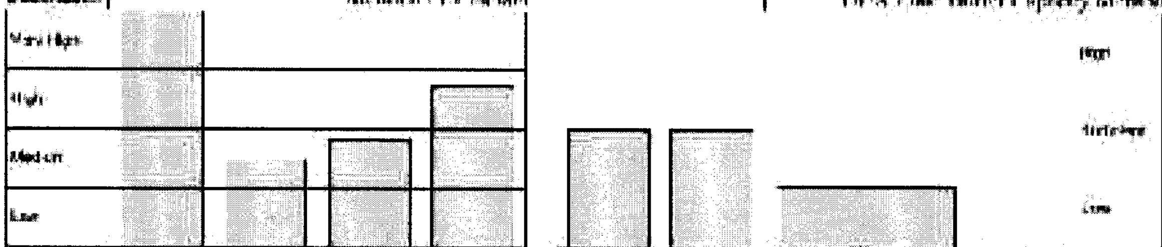
# Soil Test Report

**Soil, Plant, and Water Laboratory**

**Sample ID**

| Grower Information | Lab Information | County Information |
|---|---|---|
| Client: Jane Doe<br>2540 Sanford Street<br>[illegible], GA 30621<br>Sample: 3<br>Crop: Small Grain Silage | Lab #: [illegible]<br>Completed: [illegible]<br>Printed: [illegible] | [illegible] County<br>2000 [illegible]<br>[illegible], GA [illegible]<br>305-123-4567 |

**Results** — Mehlich I Extractant | UGA Lime Buffer Capacity Method




| | Phosphorus (P) | Potassium (K) | Calcium (Ca) | Magnesium (Mg) | Zinc (Zn) | Manganese (Mn) | $pH_{CaCl_2}$ | Equivalent Water pH | Lime Buffer Capacity (LBC) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Soil Test Index | 206 lbs/Acre | 165 lbs/Acre | 872 lbs/Acre | 188 lbs/Acre | 18 lbs/Acre | 16 lbs/Acre | 5.3 | 5.9 | 199 | Soil Test Index |

## Recommendations

| Limestone Target pH 6.5 (recommended) | Limestone Target pH 6.0 | Nitrogen (N) | Phosphate ($P_2O_5$) | Potash ($K_2O$) | Sulfur (S) | Boron (B) | Manganese (Mn) | Zinc (Zn) |
|---|---|---|---|---|---|---|---|---|
| 0.5 tons/Acre | 0.75 tons/Acre | 120-160 lbs/Acre | 0 lbs/Acre | 130 lbs/Acre | -- | -- | -- | -- |

A target pH of 6.0 ($pH_{CaCl_2}$ of 5.4) is recommended for most Agronomic crops. However, a lime recommendation for pH 6.5 ($pH_{CaCl_2}$ of 5.9) is also provided on this soil test report. Liming to pH 6.5 helps reduce low pH areas in highly variable fields.

*For small grain following a legume apply 120 pounds nitrogen (N) per acre; for small grain following cotton, corn, etc. apply 140 pounds nitrogen per acre; for small grain following grain sorghum apply 160 pounds nitrogen per acre. Apply 20 to 40 pounds of the recommended nitrogen per acre in the fall and the remainder in February.

On deep sandy soils, apply 10 pounds of sulfur (S) per acre. The sulfur should be applied when the topdress nitrogen application is made.

If no phosphate ($P_2O_5$) or potash ($K_2O$) is recommended (no more is applied), sample soil again next year.

NOTE: The amount of nitrogen (N), phosphate ($P_2O_5$), and potash ($K_2O$) actually applied may deviate 10 pounds per acre from that recommended without appreciably affecting yields.

Water quality monitoring is required by the Georgia Environmental Protection Division (EPD) to detect and quantify contamination, as well as to measure the effectiveness of waste holding systems for animal feeding operations over 1000 animal units. Monitoring should be thought of as a tool used to measure the efficiency of site design and location factors affecting ground water quality. It is beyond the scope of this training to give detailed instructions on well installation and monitoring and we recommend that you contract a professional that has the skills and experience with this type of monitoring.

**Monitoring Well Location**

Monitoring points should be located so that they detect contamination as early as possible, while observing standards of good practice and common sense. The monitoring wells should be as close as possible to the outer down-gradient edge of the lagoon. At existing lagoons with less certainty on design features and past waste disposal practices, the monitoring well should be located no closer than 25 feet from the toe of the lagoon dike in undisturbed soil. The well should not be located in fill material.

In most cases, the focus of monitoring will be the shallowest saturated zone, which is likely to be the first area impacted. Monitoring wells should be no deeper than is absolutely necessary to monitor the first year-round water-bearing unit encountered. Existing wells can be used if approved by GA-EPD. However, pre-existing wells are usually not located down-gradient of lagoons.

In order to reduce the chances of an accidental spill in the vicinity of a monitoring well, or contamination of soil around a well, certain minimum horizontal distances should be maintained between the well and sources of unrelated contamination. The following are recommended minimum distances:

a. Septic tank - 50 feet

b. Septic tank absorption field - 100 feet

c. Dead animal burial pits - 150 feet

d. Animal or fowl enclosure - 100 feet

e. Pesticide storage, mixing and loading facilities - 100 feet

f. Fertilizer storage - 100 feet

g. Petroleum storage -100 feet

**Monitoring Well Construction**

The actual placement and construction details of the monitoring wells are based on the hydrogeology of the site. Down-gradient wells must be located, and screened to insure that releases from the waste management unit will be detected. Down-gradient wells must be located at the edge of the waste management unit. Minimums of three wells are needed to calculate a hydrologic gradient and designate a down-gradient well. Determining the down-gradient location without additional wells to measure water elevations will be the "best-guess" of the well driller, geologist, or professional engineer based on surface topography. It is advisable to install two other temporary wells to monitor water elevations and confirm that the permanent well is actually down-gradient during the semiannual monitoring.

Details for well construction are given in EPD's "Manual for Groundwater Monitoring". In accordance with the Water Well Standards Act, a licensed well driller under the supervision of a licensed geologist or professional engineer must install monitoring wells. At the completion of the fieldwork and well installation, a land surface contour map and potentiometer surface maps should be prepared.

**Groundwater Monitoring Requirements**

**Table 1. Groundwater monitoring parameters under non-swine swine feeding operation permit requirements.**

| Parameter | Measurement Frequency | Tolerances | Sample Holding Time |
|---|---|---|---|
| Nitrate-Nitrogen (mg/l as N) | Semiannually | 10 ppm nitrate-N | 14 days |
| Total Kjeldahl-N (mg/l TKN) | Semiannually | - | 28 Days |
| Depth to Groundwater | Semiannually | - | On-site |

| | |
|---|---|
| Note 1: | Sampling container: plastic or glass. |
| Note 2: | Semiannual monitoring results are either submitted with the June and December reports to the EPD, or retained on site. Check your permit. |
| Note 3: | Most permits will contain the statement, "Groundwater leaving the land application system boundaries must not exceed primary maximum contaminate levels for drinking water" (Table 2). At the initiation of well water monitoring program, it is a good idea to have samples analyzed for primary drinking water parameters plus chloride and sulfates. These parameters need not be measured again unless a problem develops. |

**Table 2. Primary drinking water standards**

| Contaminant | Maximum Contaminant Level |
|---|---|
| **Primary** | **(ppm)** |
| Arsenic | 0.05* |
| Barium | 2.0 |
| Cadmium | 0.005 |
| Chromium | 0.10 |
| Fluoride | 4.0 |
| Lead | 0.015 |
| Mercury | 0.002 |
| Nitrate | 10.0 |
| Nitrite | 1.0 |
| Total Nitrate and Nitrite | 10.0 |
| Selenium | 0.05 |

*Note: EPA is currently proposing to lower value to 0.005 ppm.

| Contaminant | Maximum Contaminant Level |
|---|---|
| **Secondary** | **(ppm)** |
| Chloride | 250 |
| Copper | 1.0 |
| Sulfate | 250 |
| Zinc | 5.0 |

**Sampling and Analysis**

An effective groundwater sampling and analysis program requires a written plan to include: procedures for sample collection, sample preparation and collection, analytical procedures and chain-of-custody control.

To meet the current parameter requirements (Table 1), the depth to groundwater must be determined semiannually (Figure 12). Following determination of the depth to water table, the well should be purged. For shallow low yielding wells, the well is usually purged (bailed dry) with a dedicated bailer. Disposable Teflon bailers are recommended (Figure 13). If the well cannot be bailed dry, then 3 well volumes should be removed prior to sampling. The well is allowed to recharge and the well is sampled for TKN and nitrate-N. Table 3 contains a list of equipment available from several sources and estimated prices.

*Figure 12. Measuring the depth to groundwater*

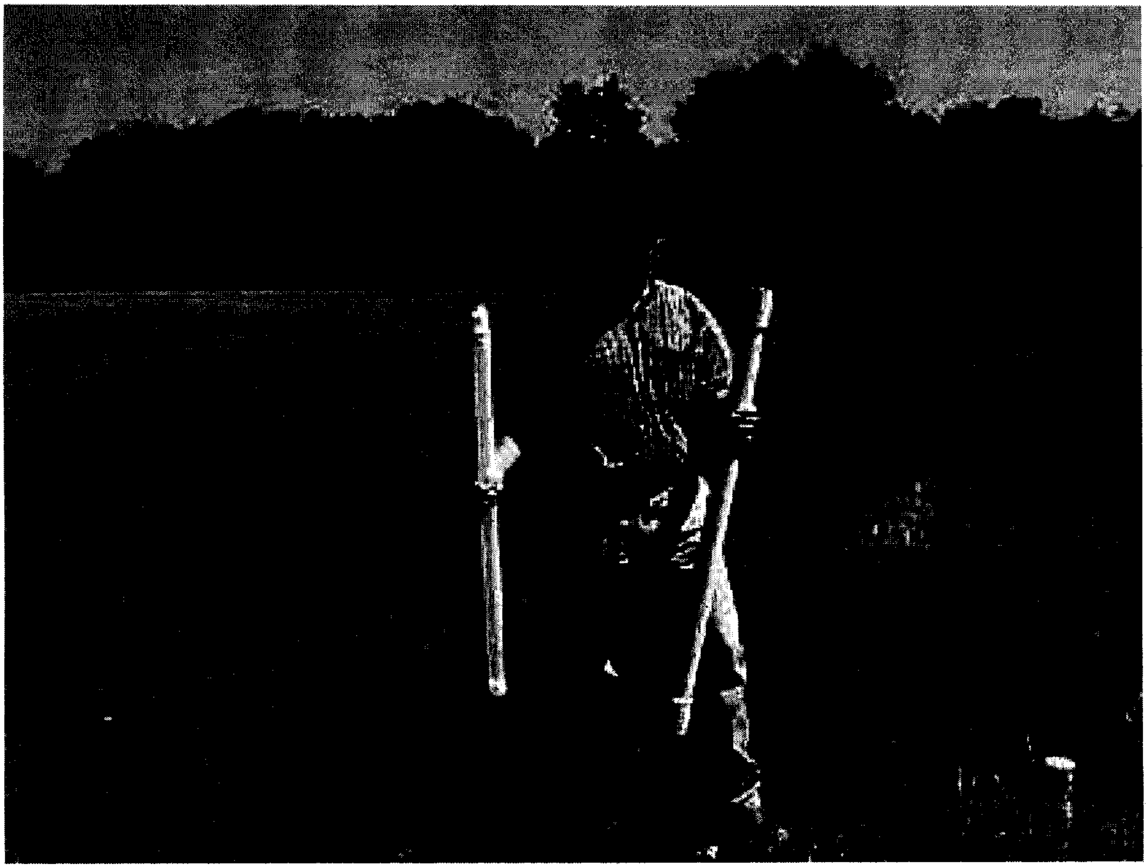


***Figure 13. Teflon well bailer***

Sampling personnel should wear clean plastic gloves and an effort should be made to minimize contact of the bailing equipment with the ground. Cleanliness and attention to detail minimize cross contamination. A distilled water blank should be carried to the field and put through the entire sampling procedure.

Samples for nitrate-N and TKN determination should be stabilized and collected in a glass or plastic container, stabilized to pH <2 with sulfuric acid and shipped to the laboratory as soon as possible. Samples can be held on ice (4 C) until stabilization. A chain-of-custody form that documents the sample handling from sampling to analysis should be maintained (Figure 14).

**Table 3. Equipment and supplies available from Ben Meadows, Forestry Suppliers, Fisher Scientific, VWR Scientific and other scientific supply houses**

| Parameter | Instrument | Estimated Price |
|---|---|---|
| Well purging | Bailer (disposable, Teflon) | $250/case of 12 |
| Depth to water table | Conductivity tape | $250 |
| Nitrate | Laboratory analysis | $8-20/sample |

**Action Plan When Nitrate-N Exceeds 10 ppm**

When a water sample from a monitoring well exceeds the 10 ppm nitrate-N tolerance or when the sum of nitrate-N ($NO_3$-N) plus TKN exceeds 10 ppm, the actions listed in Table 4. should be followed before taking more serious action.

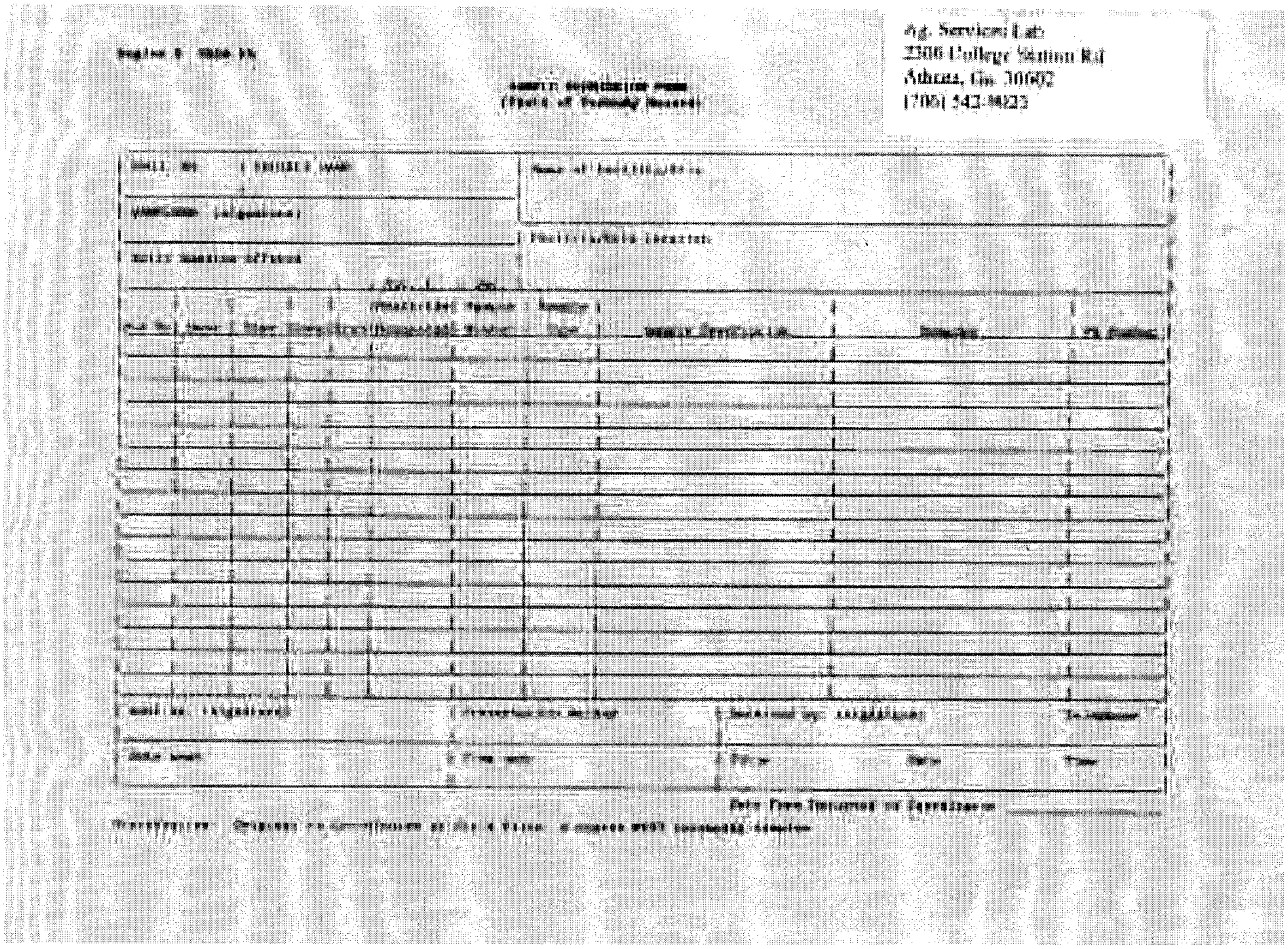
**Table 4. Recommended actions when nitrate-N or nitrate-N plus TKN exceed the 10 ppm tolerance**

| Case | Sample | $NO_3$-N | $NO_3$-N + TKN | Action |
|---|---|---|---|---|
| 1.1 | Sample taken during routine compliance monitoring schedule | <10 ppm | <10 ppm | Continue collecting samples semiannually |
| 1.2 | Sample taken during routine compliance monitoring schedule | >10 ppm | <10 ppm | Take another (second) sample making sure to follow the instructions for "Sampling and Analysis". It is critical to purging the well dry or a minimum of three well volumes, allowing the water level to recover, before collecting the sample. Have this sample analyzed as soon as possible for TKN, nitrate-N, and specific conductance. |
| 1.3 | Same as 2.1 | >10 ppm | <10 ppm | Same as 1.2 |
| 1.4 | Same as 2.1 | >10 ppm | >10 ppm | Same as 1.2 |
| 2.1 | Confirming (second) sample collected in cases 1.2, 1.3, or 1.4 | <10 ppm | <10 ppm | Return to collecting samples semiannually. Review historical data and watch for increasing trends |
| 2.2 | Same as 2.1 | >10 ppm | <10 ppm | Collect another confirming (third) sample by repeating action 1.2 |
| 2.3 | Same as 2.1 | <10 ppm | >10 ppm | Same as 2.2 |

| | | | | |
|---|---|---|---|---|
| 2.4 | Same as 2.1 | >10 ppm | >10 ppm | Same as 2.2 |
| 3.1 | Confirming (third) sample collected in cases 2.2, 2.3, or 2.4 | <10 ppm | <10 ppm | Return to collecting samples semiannually. Review historical data and watch for increasing trends. Consider installing more monitoring wells up-gradient and down-gradient, halfway between the lagoon and the property line. |
| 3.2 | Same as 3.1 | >10 ppm | <10 ppm | Contact a trained professional and discuss initiating a more detailed investigation |
| 3.3 | Same as 3.1 | <10 ppm | >10 ppm | Same as 3.2 |
| 3.4 | Same as 3.1 | >10 ppm | >10 ppm | Same as 3.2 |

In cases where there is already a history of repeated nitrate-N levels above 10 ppm, it is important to prevent those high levels from reaching a neighbors property, especially when a shallow drinking water well is down-gradient.

**Figure 14. Chain-of-custody form**



**Guidance Documents**


1. Georgia DNR. 1991. Manual for Groundwater Monitoring. Environmental Protection Division. Atlanta Georgia.

2. McLemore, W. H. 1981. Monitoring Well Construction for Hazardous-Waste Sites in Georgia. (Georgia Geologic Survey Circular No. 5) Georgia Department of Natural Resources, Environmental Protection Division. Atlanta Georgia.

3. Georgia DNR. 2000. Rules and Regulations for Water Quality Control Chapter 391-3-6. Revised April 2000. Environmental Protection Division. Atlanta Georgia.

4. Georgia DNR. 1991. The Water Well Standards Act of 1991 Official Code of Georgia 12-5-120 through 12-5-138. Environmental Protection Division. Atlanta Georgia.


These documents can be found at the Georgia Department of Natural Resources.
Contact: Tom Hopkins, 4220 International Parkway, Atlanta, GA 30354.
Phone: (404) 362-4916 or (404) 362-2680
Email: Tom_Hopkins@dnr.mail.state.ga.us


5. Wellhead Protection for Farm Wells, UGA Cooperative Extension Service Circular 819-13/Revised January 1993 (http://www.ces.uga.edu/pubcd/c819w.html).

## Review Questions*

1. Why is manure tested for developing a CNMP?
2. When should manures be sampled for laboratory analysis?
3. How should manure be sampled?
4. How do you convert elemental P and K to fertilizer basis ($P_2O_5$ and $K_2O$)?
5. Why should soil be tested when developing a CNMP?
6. How should soil samples be taken in the field? Sampling zones, sampling depths, number of samples, walking patterns.
7. Which nutrients are measured in the routine soil test?
8. Which nutrients are of primary environmental concern and why?
9. What monitoring parameters are required by the Animal (Non-Swine) Feeding Operations Permit on lagoon effluent and groundwater? How frequently must wells be sampled?
10. What well monitoring parameter is determined on-site?
11. Where is the proper location for the monitoring well?
12. Who should be responsible for constructing the monitoring wells?

*** For Planners only (Review questions 1-12).**
**For Operators (Review questions 1-8 only).**

# Assessment of the Nutrient Supply on Livestock and Poultry Farms

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## Introduction

A manure utilization plan is a plan that addresses manure production and how manure nutrients are utilized on the farm . Typically, the manure is used as a nutrient and organic matter source in a cropping system. However, there are other possible end uses of manure. The plan must describe all manure nutrients and the ultimate end use of all manure (crops, local landowners, composted and bagged, re-feeding blends, incineration, etc.). Manure nutrients must be tracked because livestock and poultry use only a small portion of the nutrients fed to them to produce meat, milk, and eggs. The remaining nutrients are excreted in the urine and feces. Depending on the species of livestock, about 70% to 80% of the nitrogen (N), 60% to 85% of the phosphorus (P), and 80% to 90% of the potassium (K) is returned in the manure.

Manure utilization planning is a two-part process. The first component can be termed *strategic planning*, because it focuses on average manure generation volumes, manure storage times, and average manure nutrient contents to develop a general cropping plan and to estimate the number of acres needed to properly land apply the manure. The second component can be referred to as the *annual plan*. The annual plan refers to the actual implementation of the strategic plan. It covers such things as how many acres of which crops will be grown during the year, the planned times for manure applications, results from periodic soil tests and manure analyses, and records of manure applications and crop yields. Once manure begins to be produced on the farm, the manure utilization plan must be implemented. A manure utilization plan requires careful attention to make it work properly. The farm owner or manager will need to understand how to use the information in the plan, along with monitoring information and equipment calibration to make the plan work. Accurate crediting of manure nutrients within a total crop nutrient program is fundamental to utilizing manure as a resource.

### *Components of a Manure Utilization Plan*

Manure utilization plans can vary a great deal in the components and the way in which they are organized. However written, all plans should address the following basic components:

1) Manure generation and other sources of nutrients (can be referred to as Sources)
2) Manure nutrient availability (can also include Placement and Timing)
3) Crop selection and crop nutrient requirements (can be referred to as Amounts or Needs)
4) Best management practices (BMPs)
5) Summary of laws, rules, and regulations that must be followed.

While the first three components must be considered together to ensure that the manure nutrients generated on the farm are applied in harmony with crop needs and soil characteristics, this lesson will concentrate on the first component, nutrient sources and quantities.

Manure utilization plans may be written for one primary nutrient (often nitrogen) or several plant nutrients. Generally, two major plant nutrients (nitrogen and phosphorus) are the ones targeted in manure utilization plans because they are required in relatively large quantities for plant growth, and if mismanaged are likely to have the most adverse affect on the environment. Other nutrients, including potassium and micronutrients, may also have some effect on a manure utilization plan.

## Nutrient Sources

Animal manures contain significant levels of plant nutrients and crop residues and/or legumes can provide nutrients for the subsequent crop. Accounting for and utilizing these nutrients can improve both the environmental and economic response of the fields. Planning starts with an inventory of the nutrients produced in the manure of animals grown on the farm, the quantities of manure collected and stored, either dry or as liquid, and analyses of the nutrient content of the stored manure. An inventory of any other by-products available, such as mortality compost or lagoon sludge (if lagoon cleaning is planned), and of any crop residue nutrients or legume nitrogen expected in each field should also be performed. This information will allow manure nutrients to be balanced with purchased fertilizer nutrients to support the expected yields of the crops grown. If the crop acreage is small relative to the number of animals, it will also allow evaluation of the extent that it may be necessary to move nutrients off the farm, and thus avoid over application of manure with the increased potential for movement of nutrients to ground and surface water.

***Animal manure***

The first part of developing a manure utilization plan is assessing the amounts of manure nutrients that are being generated, or for new operations, the amounts that are expected to be generated. There are four basic methods for estimating the quantities of manure nutrients produced and available for use as fertilizer. The first method involves multiplying the weight of the animals by average excretion estimates for each species and class of animal. After this value is adjusted for the amount of time that the animals are present on the farm, expected losses due to handling, treatment, and storage are calculated to estimate the amounts of nutrients that will be available for utilization. A second method, which will give a more accurate estimate of nutrient excretion in most cases, involves the development of a nutrient balance for the animals. The nutrient content of the feeds used on the farm during the year is calculated, thus the total pounds of nitrogen (N, calculated from protein content), phosphorus (P), and potassium (K) that were fed are known. Next the total amount of animals or animal product sold or moved off the farm during the year is calculated. This is multiplied by the N, P, and K content of the animals or animal products (usually based on average compositions, but may be adjusted for lean percentage, milk protein content, etc.) to get the amounts of nutrients moved off the farm. The difference between the feed nutrients and the animal nutrients is an accurate estimate of the quantities of manure nutrients. This estimate is then corrected for the expected handling, treatment, and storage losses to estimate the amount of nutrients available for use as fertilizer. The third method for estimating manure nutrients involves the use of standard concentration values multiplied by the quantity of manure in storage. While this method has some application for litter based situations, the variation in nutrient content (especially N) of manures held as liquids or slurries generally precludes its use in those situations. The fourth method involves measuring the amounts of manure removed from treatment or storage, sampling the manure for analysis of nutrient content, and calculating the total nutrients available for use as fertilizer. This method is most accurate from the standpoint of developing a cropping plan (because it also accounts for treatment and storage losses), and should be a goal of the nutrient management plan.

However, one of the methods of estimating the quantity of nutrients excreted should also be used, especially if there is a need to reduce the amounts of nutrients produced on the farm, there is a need for additional N fertilizer on the farm and loss estimates are helpful, or a lagoon treatment and storage system is used. When lagoons are used, much of the P may accumulate in sludge on the bottom, where it is usually not available for the annual cropping plan. In those cases, the difference between the estimated P excretion and the amount of P calculated from manure volumes and concentrations pumped from a lagoon is likely to be present in the sludge, and it will have to be managed when the lagoon is emptied.

***Other nutrient sources***

When developing manure utilization plans, all sources of nutrients on the farm need to be considered. Sources of nutrients include nutrients already in the soil, commercial fertilizers, crop residues, and other manure or by-product applications. To account for these nutrients, manure and soil analysis should be used. Examples of other sources would include legumes and crop residues which can leave plant-available nitrogen (PAN, discussed in another lesson) for the following crop. Manure and soil sampling and analysis will be covered in other lessons. When planning manure applications, the producer should account for all nutrient sources when determining manure application rates to fields.

## What Are the Amounts of Manure Nutrients Produced on a Farm.

The nutrient value of manure can vary from farm to farm and from time to time on the same farm. Factors that affect the nutrient levels include:

- The lean growth potential or other production characteristics of the animals.
- The animal diets fed (ration composition).
- The amounts of feed wastage.
- Time of year (season, temperatures).
- The handling and treatment of the manure between animal excretion and land application.
- Length of time manure is in a storage structure and/or the level of sludge buildup.
- The timing of land application and the method used.

On a per unit of body weight basis, animals with greater lean gain, or other product production potential will require greater protein intakes and will excrete larger amounts of N than less productive animals. However, on a per pound of lean growth (or unit of other product), their excretion of N may be no more, and usually less, than that of animals with lower potential. Manure nutrient excretion can be minimized by feeding animals according to their needs at any given time. In addition to balancing diets with needs, the availability or digestibility of the feed nutrients will affect excretion. These concepts will be covered in more detail in another lesson.

Feed wastage can be a significant contribution to waste nutrients in some cases. For example, if properly adjusted, most modern swine feeders are capable of limiting feed wastage to 5% or less (and others, especially some wet/dry feeders, to 1%), while some older feeders allowed feed wastage as high as 20%, which can be especially important in slotted floor housing. A 20% feed wastage can result in an increase of 30% or more in the manure N and P. Pelleting or crumbling feed also generally reduces feed wastage and reduces separation of nutrients during handling, contributing to improved animal feed efficiency. Season differences in manure nutrient excretion are related to the increased feed intake, decreased water intake associated with cold conditions and the decreased feed intake, increased water intake associated with hot environments. These fluctuations can be minimized by formulating diets to counteract part of these effects. Manure nutrient losses related to handling and treatment will be discussed in another lesson but will also be covered to some extent later in this lesson. Nitrogen is the nutrient that is most influenced by handling and treatment since it occurs in several forms, some of which are gases that can and will be lost to the atmosphere. Storage losses can also affect the supply of manure nutrients available for use as fertilizer. In addition to N, P management is often influenced by storage, especially for lagoons where much of it may end up in the sludge, rather than being available for the yearly soil fertility program. Manure application methods and timing will be covered and discussed in another lesson. All these possible variations are reasons to have manure analyzed frequently.

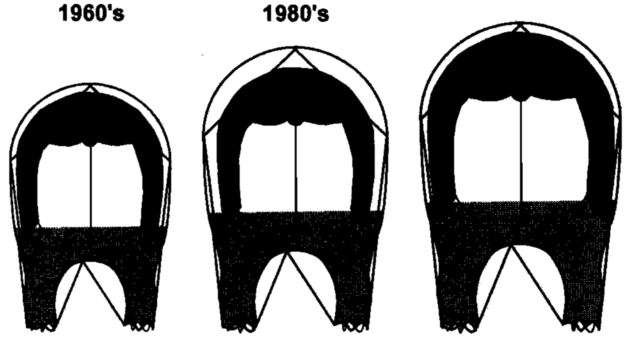
***Calculating Manure Nutrient Excretion using Standard Excretion Estimates.***

Table 1 (all Tables are attached at the end of the lesson) illustrates the use of standard excretion estimates to calculate the yearly nutrient excretion of the animals. In all the tables, nitrogen is calculate as N, phosphorus is calculated as phosphate ($P_2O_5$), and potassium is calculated as potash ($K_2O$). In order to use Table 1, locate the proper animal class in column 1, fill in the yearly average number of animals of that class in column 2, fill in the average weight of the animals in column 3 (mean of starting and ending weight, ending weight - starting weight / 2, for growing animals), and do the indicated multiplications for the remaining columns. (Multiply animal numbers by animal weight to get total weight of animals, then multiply that total by the excretion factors given for N, $P_2O_5$, and $K_2O$ - an example line for finishing swine is given in the table.) When that is done, add up the N, $P_2O_5$, and $K_2O$ (across the bottom of the table) for all the animal classes to get the total excretions for the farm. The average capacity should be the yearly average. For example, if the farm has a 3,000 head capacity swine feeding floor that is open 4 weeks per year, the yearly average number of animals might be 2,770 (3,000 pigs X 337days/365days, or 3,000 X 0.923 = 2,770).

The excretion factors given in Table 1 were developed from data collected during the mid to late 1980's. As a consequence, the resulting excretion estimates will likely be somewhat inaccurate, especially for pigs. The differences in finished pigs over time is illustrated in Figure 1, below, which also lists the previous excretion factors (for N and $P_2O_5$), which were developed from mid to late 1960's data. Similar changes may have occurred for other animal species, so excretion factors for most classes of animals are currently being re-evaluated, and revised factors may be available in the near future.

For the swine example, there were significant numbers of very lean, “stress susceptible”, “double muscled” pigs during the late 1960's. Because of production problems associated with these pigs, they were selected against, and, on average, pigs reaching slaughter houses became slightly fatter. During the 1990's, with productivity back in the swine herd, increased leanness was achieved and slaughter weights were further increased. In addition, a 1995 survey of states producing 75% of the US slaughter hogs estimated that 67% of pigs were fed more than two grower/finisher diets (29% were fed two diets), and that 25% of the hogs marketed in the Southeast were split-sex fed (38% in the Midwest). The management and feeding of nursery

Figure 1. Some Changes in Pigs Over the Past 30 Years



| | Mid to Late 1960's | Mid to Late 1980's | Late 1990's |
|---|---|---|---|
| Market Wt (lb) | 210 | 225 | 255 |
| lb/lb body wt/yr | | | |
| N Excretion | 0.164 | 0.153 | ? |
| P Excretion | 0.125 | 0.134 | ? |

pigs has also changed, with more early weaning and phase nursery diets, including increased use of animal products and amino acids. As an indirect result, many nursery diets contain a higher proportion of highly available P sources than in the past (lower levels of phytate P, covered in another lesson), which should result in lower P excretion. Using nutrient balance estimates for current practices and pigs, it appears that on a body weight basis, N excretion has returned to 1960's levels, or greater, and that P excretion has returned to 1960's levels, or lower. Since it is difficult and cumbersome to have tables which list estimated excretion factors for a large number of animal and feeding alternatives and provide space for calculations, a computer aided excretion estimator has been developed which should provide improved nutrient excretion estimates compared to those derived from Table 1. This program will be available at training sessions, and after testing and further review, at County Extension Offices and on the Web. In addition, a number of other manure nutrient calculating programs and models are available. A good place to start looking for other manure software is the UGA AWARE web page (www.agp2.org/aware/). Other animal and farm management models are also available which calculate estimated nutrient excretion, and some ration balancing programs are also useful when using the nutrient balance method of estimating nutrient excretion.

### *Calculating Manure Nutrient Excretion using Nutrient Balance Estimates.*

Tables 2a, b, and c illustrate the procedures for calculating manure nutrient excretion estimates using nutrient balance procedures. It has been shown that calculating manure nutrients by subtracting the nutrient content of the animals or animal products moved off the farm from the feed nutrients fed to the animals generally provides a more accurate estimate of nutrient excretion than does the use of standard excretion estimates. Table 2a list the factors which are used to convert feed protein, phosphorus, and potassium to amounts of N, $P_2O_5$, and $K_2O$ and the average composition values of whole animals and products necessary to convert animal live weights and products to amounts of N, $P_2O_5$, and $K_2O$.

Table 2b contains an example calculation for a swine finishing farm marketing 6,000 pigs per year. In that example it was assumed that the feeds were purchased and that only two diets were fed, in order to make the example shorter and simpler. Any number of diets could be included, or if diets are mixed on-farm, it is usually simpler to calculate from ingredients. In that case, the total quantity of corn, soybean meal, other protein supplements (milk by-products in nursery diets, amino acids, etc.), and phosphorus supplements would be entered on a separate line for each. Purchased animals moving onto the farm would complete the nutrient inputs. Nutrient outputs from the swine operation would include all animals sold or otherwise moved off the farm. The difference in nutrient inputs and nutrient outputs will be a close estimate of manure nutrients produced on that farm. Table 2c is a blank table for use in calculating manure nutrients for a farm, should this method be selected.

Calculating manure nutrient output using the estimated balance method will usually result in larger values than would be obtained by using the standard excretion method. Part of this difference is due to the fact that normal feed "shrinkage" is included as input, and especially since any spilled and wasted feed is included in the manure nutrient estimate. Even more accurate estimates can be obtained by adjusting the animal and product composition factors to account for differences in lean percentage and product nutrient content between different herds or flocks, some software allows this to be done.

### *Calculating Manure Nutrients Using Standard Concentration Values.*

As noted above, when manure is in a relatively dry state and nutrient concentrations are not affected by widely varying amounts of dilution water, such as with poultry litter, manure nutrients can be calculated by estimating manure production of the animals and multiplying this amount by standard nutrient concentration values for the particular type of manure and storage system. This procedure thus also estimates the storage losses which occur prior to removal of the manure for land application. The procedures for calculating manure nutrients using this method are illustrated in Tables 3a, b, and c. Table 3a lists manure production and nutrient concentration values for some classes of poultry. The per bird manure production estimates are used in Table 3b to estimate the total quantity of manure produced on the farm during the year, example calculations are shown for broilers and layers, with additional lines for other calculations. The quantity of manure calculated in Table 3b is then entered into Table 3c, along with the appropriate concentration (pounds/ton) values for nitrogen, phosphate, and potash from Table 3a. The calculations in Table 3c are then completed to estimate the total quantities of nutrients produced on the farm during the year. Example calculations are again provided, along with additional blank lines for other calculations.

### *Treatment and storage losses.*

Before discussing the fourth method of estimating manure nutrient production on farms, it is necessary to briefly discuss nutrient losses during handling, treatment, and storage. Table 4 lists some manure treatment and storage options along with factors used to estimate the quantities of nutrients remaining after treatment and/or storage. The example given in the table is for a top loaded manure storage tank or structure. To use the table to estimate the nutrients remaining after storage, find the appropriate system in column 1, place the N excretion estimate (from either Table1 or 2, or a software derived estimate) in column 2, the $P_2O_5$ excretion estimate in column 5, the $K_2O$ excretion estimate in column 8, and perform the indicated multiplications. Notice that for lagoons, much of the $P_2O_5$ is calculated as lost during storage. This is not really the case, as most of this P actually remains in the lagoon sludge and will have to be managed at some point when sludge is removed from the lagoon.

The amount of $P_2O_5$ in the lagoon sludge can be estimated by filling in Table 5. If the lagoon is emptied essentially completely at some point during the year, P reductions will be minimal. If all lagoons are agitated during pumping such that some sludge is re-suspended, P reductions will be much less than 65%, but will depend upon the degree of agitation. The computer aided nutrient calculator mentioned above includes calculations for nutrient losses during treatment and storage, but does not include separating lagoon P between sludge and effluent, since it will likely vary from farm to farm, depending upon effluent removal practices. If lagoons are not agitated and only effluent is removed, $P_2O_5$ calculations from the computer calculation should be factored as in Table 5. In addition, the computer estimate will provide a ranges for N losses. If the treatment and storage time are relatively short (90 days or less) the N values will likely be near the larger amount, whereas if manure is applied only once per year, the N value will likely be nearer the lower value.

***Calculating Manure Nutrients from Measured Quantities and Sample Analyses.***

If amounts of manure handled on the farm each year are known, plus there are manure nutrient analyses, calculation of manure nutrients available for use as fertilizer can be calculated in a straight forward manner. For farms that handle slurry and dry manures, the manure quantity may be estimated from the number of loads handled during a typical clean-out operation along with the number of clean-outs per year. For operations that use a liquid manure management option such as flush floors and lagoons, the volume of manure generated is more difficult to determine. Liquid system manure generation can be estimated if good records on irrigation applications (from a meter, pump capacity X run times, or rain gauges in the field) are maintained. These quantities will need to be multiplied by concentration values obtained from samples submitted to a laboratory, in order to obtain total yearly nutrient estimates. Manure sampling procedures are covered in another lesson. In some cases there may be a need or desire to estimate micronutrient (such as copper or zinc) production and land application. Manure sampling and analysis is a logical way of obtaining those values. Table 6a and b are provided for making manure nutrient calculations from measured quantities and nutrient concentrations. If the concentration of nutrients in manure from the animals varies with the time of year, an average composition should be used or calculate an amount for each clean out by season of the year and add them for a yearly total, or develop seasonal land application plans. Table 6a contains an example to illustrate how the calculations are made and Table 6b is a blank table for additional calculations.

If there is a good handle on manure generation and manure composition, this is likely the most accurate estimate of manure nutrients available for use as crop fertilizer. This estimate will include animal effects, diet effects, feed wastage effects, and, most importantly, treatment and storage losses. It should be a goal of the plan to arrive at this point, in order to more accurately manage nutrients on the farm. However, if the farm uses lagoons, one of the first two methods should also be used in order to estimate the quantity of $P_2O_5$ accumulating in lagoon sludge, that will have to be managed at some point in time.

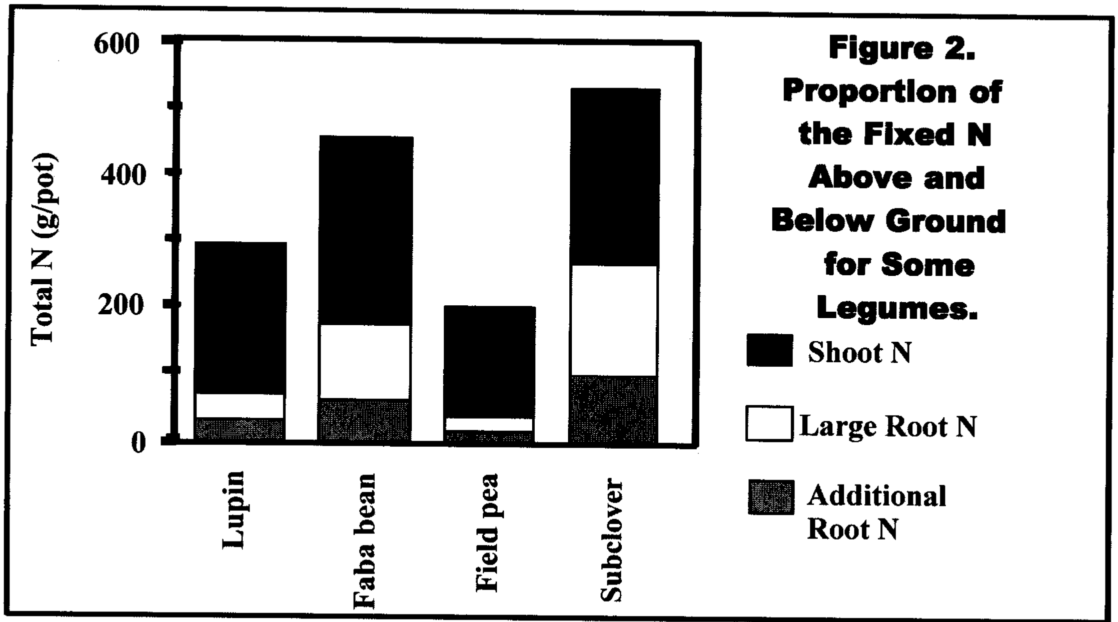



**Figure 2. Proportion of the Fixed N Above and Below Ground for Some Legumes.**

(From: http://www.agric.wa.gov.au/cropupdates/1998/pulses/nitro.html-ssi)

Results from either method of manure nutrient estimation may be used for planning purposes (strategic plan). As records of manure quantities are developed and manure samples are submitted to a laboratory to determine the actual nutrient content, the plan will be updated and modified to reflect these more accurate estimates. *Where manure analyses and quantities are available, they should be used to develop the initial manure utilization plans and application rates.*

## Other Nutrient Sources

Note that Table 6 includes a line (6) used to enter other on-farm nutrient sources. This could be mortality compost (an amount and nutrient analysis will be needed) or possibly nitrogen fixed by legumes. Table 7 lists estimates for available N amounts following some legumes. The actual amount of N will vary with management of the legume, especially if none of the plant was harvested (as with a winter legume which was not grazed cut for hay), part of the plant was harvested (as with soybeans), or most of the plant was harvested (as with peanuts plus peanut hay). Soybeans, peanuts, and lupin for example, may accumulate more than 250 lbs of N per acre, but much of this N is removed with seed harvest. Figure 2 shows above and below ground N accumulations for some legumes as an illustration of how harvest can affect N remaining after a legume crop. (It should be noted that subclover seed develop below the soil surface.)

Parts of this lesson were taken from National Curriculum Lesson 31: Manure Utilization Plans, written by Karl Shaffer, 6/1/2000 draft.

**Summary**

The manure nutrient supply on an animal farm originally came from the feed which was fed to the animals. Therefore the quantity of manure nutrients is affected by the productivity of the animals (the proportion of the feed nutrients converted into growth or other products). This conversion efficiency is affected by the nutritional balance of the diets fed relative to the nutritional needs of the animals at their current productivity stage. In addition, feed wastage often contributes nutrients directly to manure management systems, without the reduction in amounts associated with animal digestion. Two of the easiest and least costly (often profitable) methods of reducing manure nutrient production are to more closely balance the diets to the needs of the animals and to take steps to minimize feed wastage (such as frequent feeder adjustment, use of pelleted feeds, or installing feeders of newer design).

There are four basic methods for estimating the production of manure nutrients on farms. The first involves multiplying animal weight by excretion factors for nitrogen (N), phosphorus (P), and potassium (K). For pigs, and likely other animals, as their feeding and management have changed, the published standard excretion factors currently in use most likely underestimate N excretion and overestimate P excretion, as leaner pigs tend to excrete more N and less P than fatter pigs. The second method involves subtracting the estimated nutrient content of animals and animal products leaving the farm from the nutrient content of the feeds used on the farm. Manure N is derived from the protein and amino acids in the feed and manure P and K are derived from minerals in the feedstuffs and mineral supplements. Since all of the nutrients in the feed must go somewhere, if the amounts fed are known, this procedure will generally produce a more accurate estimate than the use of standard excretion estimates.

For both of these nutrient excretion estimation methods, nutrient losses which occur during treatment and storage of manure must be taken into account in order to estimate the quantities of nutrients available for use as fertilizer. Nitrogen voided in the urine (about half of the N excretion in most animals) is quickly converted to ammonia. Loss of this ammonia to the air can occur quickly under some conditions. During treatment and storage of manure, additional N is often converted to ammonia (and in some cases to nitrate, which is subject to denitrification and loss to the atmosphere as well). Nitrogen losses will often have larger effects on the amount of manure N available for use as plant fertilizer than the amount actually excreted.

The third method for estimating manure nutrient quantities is to calculate the expected manure production and multiply it by standard nutrient concentration values. These concentration values are usually for manures as they are removed from storage, thus this method does account for an average nutrient loss. The fourth method is to measure the quantity of manure removed from storage each year, sample and analyze it to determine the nutrient concentration of the manure, and multiply the concentrations by the quantity to estimate the total manure nutrients. This method automatically accounts for everything from wasted feed to treatment and storage losses, but it does not account for some nutrient separations, such as P in lagoon sludge, which will eventually have to be managed. It should be a goal of the nutrient management plan to develop a measurement and sampling procedure for calculating nutrient quantities, since it will be less likely that manure nutrients will be under or over applied to fields, since either could be uneconomic and over application could also be environmentally unsound. With either calculation method, other on-farm nutrient sources may also need to be accounted, such as mortality compost, or, on a field by field basis, legume N fixation.

**Table 1. Total manure nutrients produced by livestock.** Nitrogen, $P_2O_5$, and $K_2O$ production can be calculated by entering a livestock operation's information into Columns 2 and 3 for the appropriate animal species and class and multiplying by the relevant factors.

| 1. Livestock or Poultry Species | 2. Number of animals (average capacity) | 3. Average Weight, lbs. | 4. Total Animal Weight (Col 2 X Col 3) | 5. Lbs. of N/ lb. of animal weight per year | 6. Lbs. N/ yr. (Col 4XCol 5) | 7. Lbs. of $P_2O_5$ /lbs. of animal weight per year | 8. Lbs. $P_2O_5$ /yr. (Col 4X Col7) | 9. Lbs. of $K_2O$/lbs. of animal weight per year | 10. Lbs. $K_2O$/ yr. (Col 4XCol 9) |
|---|---|---|---|---|---|---|---|---|---|
| *Example: Swine... Finish* | *2,000* | *150* | *300, 000* | *0.15* | *45,000* | *0.13* | *39,000* | *0.10* | *30,000* |
| Swine: Nursery | | | | 0.22 | | 0.21 | | 0.15 | |
| Grow | | | | 0.15 | | 0.13 | | 0.10 | |
| Finish | | | | 0.15 | | 0.13 | | 0.10 | |
| Sows & Litter | | | | 0.17 | | 0.12 | | 0.13 | |
| Sows (Gestation) | | | | 0.07 | | 0.05 | | 0.05 | |
| Gilts | | | | 0.088 | | 0. 066 | | 0.058 | |
| Boars | | | | 0.055 | | 0. 042 | | 0.044 | |
| Beef (450- 750 lbs) | | | | 0.11 | | 0.083 | | 0. 088 | |
| Beef feeder (high- energy diet) | | | | 0.11 | | 0.078 | | 0. 092 | |
| Beef feeder (high- forage diet) | | | | 0.11 | | 0.091 | | 0. 11 | |
| Beef Cow | | | | 0.12 | | 0.10 | | 0.11 | |
| Dairy Cow... 50 lbs/ d milk | | | | 0.18 | | 0.087 | | 0. 100 | |
| Dairy Cow... 70 lbs/ d milk | | | | 0.22 | | 0.096 | | 0. 110 | |
| Dairy Cow... 100 lbs/ d milk | | | | 0.27 | | 0.110 | | 0. 130 | |
| Dairy Dry Cow | | | | 0.11 | | 0.074 | | 0. 079 | |
| Dairy Heifers/ Calves | | | | 0.11 | | 0.033 | | 0. 11 | |
| Layer | | | | 0.30 | | 0.26 | | 0.15 | |
| Pullet | | | | 0.23 | | 0.20 | | 0.11 | |
| Broiler | | | | 0.40 | | 0.28 | | 0.20 | |
| Turkey | | | | 0.27 | | 0.23 | | 0.12 | |
| Total: If more than one manure storage or treatment system is used for different groups of animals, it is best to separate the groupings of animals and their nutrient excretion totals for each manure system. | | | System 1: | | | | | | |
| | | | System 2: | | | | | | |

Source: NRCS Agricultural Waste Management Handbook, 4/ 92 with exception of lactating and dry dairy cows. Dairy estimates are from H. H. Van Horn 1991, Achieving environmental balance of nutrient flow through animal production systems. *The Professional Animal Scientist* . 7( 3): 22- 33.

**Table 2a. Calculating Nutrient Excretion Using Input-Output Balance: Nutrient factors.**

Feed and Animal Factors for determining N, $P_2O_5$, $K_2O$ Content of Inputs and Outputs of an Animal Enterprise.

| Material | Multiplication Factor for: | | |
|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ |
| Feeds, Grains, Protein Supplements, Minerals | Multiply % Protein by 0.0016 | Multiply % Phosphorus by 0.0229 | Multiply % Potassium by 0.012 |
| Pigs less than 100 lbs. | Use 0.025 | Use 0.0128 | Use 0.003 |
| Swine from 100 to 300 lbs. | Use 0.024 | Use 0.0108 | Use 0.0029 |
| Swine over 300 lbs. | Use 0.023 | Use 0.0108 | Use 0.0028 |
| Dairy Cattle | Use 0.012 | Use 0.016 | Use 0.0024 |
| Milk | Multiply % Protein by 0.0015 | Use 0.0023 | Use 0.0018 |
| Beef Cattle, 400 lbs. | Use 0.029 | Use 0.0071 | Use 0.0023 |
| Beef Cattle, 600 lbs. | Use 0.024 | Use 0.0058 | Use 0.0023 |
| Beef Cattle, 800 lbs. | Use 0.02 | Use 0.0051 | Use 0.0023 |
| Beef Cattle, 1000 lbs. | Use 0.015 | Use 0.0038 | Use 0.0023 |
| Broiler Chickens | Use 0.029 | Use 0.0046 | ? |
| Layer Hens | Use 0.026 | Use 0 .0141 | ? |
| Chicken Eggs | Use 0.019 | Use 0.0048 | Use 0.0021 |
| Turkey | Use 0.028 | ? | ? |

**Table 2b. Calculating Nutrient Excretion Using Input-Output.** Example Calculations for a 2000 Head Swine Finisher Farm Using Purchased Feed.

| Inputs - Outputs | 1. Quantity | 2. Percent Protein | 3. X 0.0016 (Feed N factor) | 4. N Quantity (Col 1 X Col 3) | 5. Percent Phosphorus | 6. X 0.0229 (Feed $P_2O_5$ factor) | 7. $P_2O_5$ Quantity (Col 1 X Col 6) | 8. Percent Potassium | 9. X 0.012 (Feed $K_2O$ factor) | 10. $K_2O$ Quantity (Col 1 X Col 9) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Inputs** | | | | | | | | | | |
| *Example: Grower Feed* | *537 tons* | *16.78* | *0.02685* | *14.417 tons* | *0.66* | *0.01511* | *8.116 tons* | *0.72* | *0.00864* | *4.639 tons* |
| *Example: Finisher Feed* | *1,035 tons* | *14.20* | *0.02272* | *23.515 tons* | *0.55* | *0.0126* | *13.036 tons* | *0.60* | *0.0072* | *7.452 tons* |
| *Example: Total Feed Inputs* | *1,572 tons* | | | *37.932 tons* | | | *21.152 tons* | | | *12.091 tons* |
| *Example: 6,060 pigs @ 50 lbs* | *151.5 tons* | | 0.025 | *3.787 tons* | | .0128 | *1.939 tons* | | 0.003 | *0.455 tons* |
| *Example: Total Inputs* | | | | *41.719 tons* | | | *23.091 tons* | | | *12.546 tons* |
| **Outputs** | | | | | | | | | | |
| *Example: 6.000 pigs @ 255 lb* | *765 tons* | | 0.024 | *18.360 tons* | | 0.0108 | *8.262 tons* | | 0.0029 | *2.219 tons* |
| **Balance** | | | | | | | | | | |
| *Example: Nutrient Excretion* | | | | *23.359 tons* | | | *14.829 tons* | | | *10.327 tons* |

**Table 2c. Calculating Nutrient Excretion Using Input-Output.** Table for doing Your Calculations, Following Example Above.

| Inputs - Outputs<br>**Inputs** | 1. Quantity | 2. Percent Protein | 3. X 0.0016 (Feed N factor) | 4. N Quantity (Col 1 X Col 3) | 5. Percent Phosphorus | 6. X 0.0229 (Feed $P_2O_5$ factor) | 7. $P_2O_5$ Quantity (Col 1 X Col 6) | 8. Percent Potassium | 9. X 0.012 (Feed $K_2O$ factor) | 10. $K_2O$ Quantity (Col 1 X Col 9) |
|---|---|---|---|---|---|---|---|---|---|---|
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| **Outputs** | | | | | | | | | | |
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| **Balance** | | | | | | | | | | |
| | | | | | | | | | | |

**Table 3a. Typical Amount And Nutrient Composition For Poultry Manures Handled As Solids[a].**

| Manure Type | Pounds of Manure per Bird Produced or Maintained per Year | Nutrient | | |
|---|---|---|---|---|
| | | Nitrogen (N) | Phosphate ($P_2O_5$) | Potash ($K_2O$) |
| | | Pounds / Ton of Litter or Manure | | |
| Broilers (litter) | 2.5 | 66 | 50 | 40 |
| Breeders (litter) | 44.0 | 31 | 40 | 35 |
| Pullets (litter) | 8.0 | (68) | (53) | (41) |
| Layers (highrise) | 40.0 | 38 | 56 | 30 |
| Stockpiled Litter | | 36 | 55 | 35 |

[a]Adapted from L. Vest, B. Merka, and W.L. Segars, 1998.

**Table 3b. Calculating Manure Quantities For Poultry Farms Using Dry Manure Handling.**

| Type of Bird | 1. Number of birds housed | 2. Turns per year | 3.[a] Total birds per year | 4. Manure per bird, lbs | 5. Total manure per year, lbs. | 6. Tons of manure / year |
|---|---|---|---|---|---|---|
| *Examples* | | | *(Col 1 X Col 2)* | *(from Table 3a)* | *(Col 3 X Col 4)* | *(Col 5 / 2,000)* |
| *Broilers* | *40,000* | *6* | *240,000* | *2.5* | *600,000* | *300* |
| *Layers* | *70,000* | *1* | *70,000* | *40* | *2,800,000* | *1,400* |
| Additional Lines For Your Use: | | | | | | |
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[a]You may also start in this column.

**Table 3c. Calculating Nutrient Quantities For Dry Poultry Manure Systems.**

| Bird or Manure Type | 1. Tons of manure / year | 2. Pounds N / ton | 3. Total pounds N | 4. Pounds $P_2O_5$ / ton | 5. Total pounds $P_2O_5$ | 6. Pounds $K_2O$ / ton | 7. Total pounds $K_2O$ |
|---|---|---|---|---|---|---|---|
| *Example:* | *(Table 3b)* | *(Table 3a)* | *(Col 1 X Col 2)* | *(Table 3a)* | *(Col 1 X Col 4)* | *(Table 3a)* | *(Col 1 X Col 6)* |
| *Broilers* | *300* | *66* | *19,800* | *50* | *15,000* | *40* | *12,000* |
| *Layers* | *1,400* | *38* | *53,200* | *56* | *78,400* | *30* | *42,000* |
| Additional Lines For Your Use: | | | | | | | |
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**Table 4. Nutrients available (annually) after losses from open lot, storage, or lagoon [1].** Locate your storage/treatment system in column 1, then enter the total manure nutrients produced (from Table 1 or 2) in Columns 2, 5, and 8 and multiply by the relevant factors listed for your manure management system..

| 1. | Nitrogen | | | $P_2O_5$ | | | $K_2O$ | | |
|---|---|---|---|---|---|---|---|---|---|
| Manure Storage/ Treatment System | 2. N Produced, Table 1 or 2 | 3. Multiplication Factor | 4. Available N After Losses | 5. $P_2O_5$ Produced, Table 1 or 2 | 6. Multiplication Factor | 7. Available $P_2O_5$ After Losses | 8. $K_2O$ Produced, Table 1 or 2 | 9. Multiplication Factor | 10. Available $K_2O$ After Losses |
| *Example: Storage (liquid swine manure, top loaded storage)* | *45,000* | *X 0.70 =* | *31,500* | *39,000* | *X 1.0 =* | *= 39,000* | *30,000* | *X 1.0 =* | *= 30,000* |
| Open lot or feedlot | | X 0.6 = | | | X 0.95 = | | | X 0.7 = | |
| Manure pack under roof | | X 0.70 = | | | X 1.0 = | | | X 1.0 = | |
| Bedded pack for swine (e. g., hoop building) | | X 0.50 = | | | X 1.0 = | | | X 1.0 = | |
| Bedded pack & compost for swine (e. g., hoop building) | | X 0.35 = | | | X 1.0 = | | | X 1.0 = | |
| Solid/ semi- solid manure & bedding held in roofed storage | | X 0.75 = | | | X 1.0 = | | | X 1.0 = | |
| Solid/ semi- solid manure & bedding held in unroofed storage | | X 0.65 = | | | X 0.95 = | | | X 0.9 = | |
| Liquid/ slurry storage in covered storage | | X 0.90 = | | | X 1.0 = | | | X 1.0 = | |
| Liquid/ slurry storage in uncovered storage | | X 0.75 = | | | X 1.0 = | | | X 1.0 = | |
| Storage (pit beneath slatted floor) | | X 0.85 = | | | X 1.0 = | | | X 1.0 = | |
| Poultry manure stored in pit beneath slatted floor | | X 0.85 = | | | X 1.0 = | | | X 1.0 = | |
| Poultry manure on shavings or sawdust held in housing | | X 0.70 = | | | X 1.0 = | | | X 1.0 = | |
| Compost | | X 0.70 = | | | X 0.95 = | | | X 0.9 = | |
| One - cell anaerobic treatment lagoon | | X 0.20 = | | | X 0.35 = | | | X 0.65 = | |
| Multi- cell anaerobic treatment lagoon | | X 0.10 = | | | X 0.35 = | | | X 0.65 = | |

1 Multiplication factor is portion of nutrients retained in the manure. Remaining N volatilizes into air as ammonia and remaining phosphate settles to lagoon bottom as solids or is lost as runoff in open lot. Actual losses for individual situations may vary substantially from listed values .

**Table 5. Phosphorus retained as settled solids by an anaerobic treatment lagoon [1].**

Enter quantity of total manure phosphorus estimated from Tables 1 or 2, interval (years) between when settled solids are removed, and complete the calculation.

| Total Pounds $P_2O_5$ Produced Annually, from Tables 1 or 2 | Single or Multiple Cell Treatment Lagoon | | |
|---|---|---|---|
| | Years Between Solids Removal | Portion Retained in Lagoon | Total $P_2O_5$ in Settled Solids |
| *Example: 39,000 lbs* | *X 5* | *X 0.65 =* | *126,750 lbs.* |
| | X | X 0.65 = | |
| | X | X 0.65 = | |

[1] This applies to an anaerobic treatment lagoon with a permanent liquid pool and no agitation at the time of effluent removal.

**Table 6a. Example of Calculating Manure Nutrient Generation Using Measured Quantities and Analyses.**

*Example:* You operate a swine-finishing operation with a 4,000-head capacity. Your manure-handling system is a slurry system, and the manure analysis shows 25.2 pounds of N, 23.7 pounds of $P_2O_5$, and 16.8 pounds of $K_2O$ per 1,000 gallons of manure. Your application system is a honeywagon with incorporation. Manure generation is ( 4,000 head X 751 gal/animal =) 3,004,000 gal/year.

| Use this worksheet when you know the volume of manure that is handled based on cleanout or pumping records. | | | | |
|---|---|---|---|---|
| 1 | Manure generation, tons or thousands of gallons/year | *3,004 thousand gal.* | | |
| | | N | $P_2O_5$ | $K_2O$ |
| 2 | Manure analysis, lb/ton or lb/1,000 gallons | *25.2* | *23.7* | *16.8* |
| 3 | Manure nutrient availability coefficients* | *0.7* | *0.8* | *0.8* |
| 4 | Corrected manure analysis* (multiply above two rows, 2 X 3, for each column) | *17.64* | *18.96* | *13.44* |
| 5 | Total manure nutrients to handle (manure generation X corrected manure analysis) | *52,990 lbs.* | *56,956 lbs.* | *40,374 lbs.* |
| 6 | Total other nutrients on the farm (includes starter fertilizer, residual N credits, other waste sources, N from recent soil test. Note: These are on a field-by-field basis.) | *625 lbs.* [a] | *0* | *0* |
| 7 | Total nutrients to handle in cropping system | *53,615* | *56,956* | *40,374* |

*These are needed if lab results are not in plant-available nutrients (discussed in another lesson). If lab results are plant-available nutrients, skip this part.

[a] Based on 25 acres of soybeans at 25 pounds of residual N per acre.

**Table 6b. Calculating Manure Nutrient Generation Using Measured Quantities and Analyses.**

Table for Your Use.

| Use this worksheet when you know the volume of manure that is handled based on cleanout or pumping records. | | | | |
|---|---|---|---|---|
| 1 | Manure generation, tons or thousands of gallons/year | | | |
| | | N | $P_2O_5$ | $K_2O$ |
| 2 | Manure analysis, lb/ton or lb/1,000 gallons | | | |
| 3 | Manure nutrient availability coefficients* | | | |
| 4 | Corrected manure analysis* (multiply above two rows, 2 X 3, for each column) | | | |
| 5 | Total manure nutrients to handle (manure generation X corrected manure analysis) | | | |
| 6 | Total other nutrients on the farm (includes starter fertilizer, residual N credits, other waste sources, N from recent soil test. Note: These are on a field-by-field basis.) | | | |
| 7 | Total nutrients to handle in cropping system | | | |

*These are needed if lab results are not in plant-available nutrients (discussed in another lesson). If lab results are plant-available nutrients, skip this part.

**Table 7. Nitrogen residual following some legume crops.**

| Legume Crop Type | N Available for Next Crop, Pounds Per Acre |
|---|---|
| Peanuts | 20 - 40 |
| Soybeans | 30 - 45 |
| Clovers[1] | 40 - 100 |
| Alfalfa[1] | 50 - 125 |
| Lupin[1] | 50 - 150 |
| Hairy vetch | 80 - 110 |

[1] For forage crops, N remaining for next crop depends upon amount of top growth harvested and the stage of growth at termination; for lupin it is assumed that termination is before significant seed development.

# Manure Storage and Treatment Systems

**John W. Worley**

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## Goals/Objectives of Manure Storage and Treatment Systems

Animal waste storage and treatment systems have historically been selected and designed to efficiently utilize valuable fertilizer nutrients for crop production while protecting soil, air, and water quality. The primary reason to store manure is to allow the producer to land spread the manure at a time that is compatible with the climatic and cropping characteristics of the land receiving the manure. Manure nutrients can be best utilized when spread near or during the growing season of the crop. Therefore, the type of crop and method of manure application are important considerations in planning manure storage and treatment facilities. The selection of the system also depends on the owner/operator's goals for utilization of waste. If the nutrients in the waste are needed for crop production, a system is designed to conserve and utilize in a timely manner as much of each nutrient as possible. If the nutrients are not needed for crop production, the manure tends to be seen as something that must be disposed of as economically as possible. The goal then is to reduce the waste stream as much as possible. In either case, the waste storage/treatment system is designed to provide storage and/or treatment without allowing surface or ground water to become contaminated with excess nutrients, pathogens, or organic matter which can cause oxygen levels in water to drop below the level needed to sustain aquatic life.

## Alternative Storage and Treatment Systems

Most swine and dairy operations and some poultry operations use liquid or slurry manure storage and handling systems. In fact, in Georgia, most of the systems are liquid. The discussion here will therefore focus on liquid systems. However, slurry systems will also be discussed in order to enhance understanding of the difference between the goals and management strategies of the two systems. "Dry" systems (systems where manure is handled as a solid) will also be discussed. Some systems use solids separation devices to remove some of the solids from the liquid stream. These systems are really a combination of liquid and dry systems and must be handled as such.

### Liquid Storage Systems (Lagoons)

Lagoons are probably the most common form of liquid manure handling system. A lagoon is a waste treatment system as well as a storage facility for manure, and it represents the most economical means currently available of reducing the waste stream in liquid systems. A properly operating lagoon will reduce odors and convert much of the organic matter into gases which are given off into the air. Odor reduction comes as a result of purple sulfur bacteria which grow near the surface of the lagoon and convert odorous compounds (primarily hydrogen sulfide) into less offensive gases.

Nutrient reduction is primarily in the form of nitrogen which is converted to nitrogen gas and ammonia. Some of the phosphorus and potassium tend to settle to the bottom of the lagoon and are stored in the sludge. Thus the land needed to apply nutrients from a lagoon is reduced since the nutrients in the lagoon are reduced. It must be noted, however that phosphorus and potassium are still in the lagoon and must be accounted for in nutrient management budgets when the sludge is removed. If properly designed, constructed, and managed, a lagoon will minimize seepage of nutrients into the ground below, and will present a minimum risk of overflow into surface waters.

Advantages of lagoon storage of manure may include cost per animal unit, ability to store large amounts of manure and/or runoff, treatment of manure to reduce odors, and potential to handle manure with conventional pumping and irrigating equipment. Disadvantages of lagoons may include lack of appropriate soil materials for construction, the need for solids separation or sludge removal equipment if bedding or other non-biodegradable materials are present, aesthetic appearance and/or public perception. In addition, the effluent from a lagoon is less well balanced with crop needs, since nitrogen is released, and phosphorus and potassium remain in the lagoon.

**Manure Slurry Storage Systems**

Manure slurry storage systems tend to be used when the need for nutrients for crop growth in the area is high since these systems tend to maintain higher levels of nutrients (particularly nitrogen) than do lagoons. Many types of facilities are used to store manure in the slurry form. One type is the under-floor pit in which manure is deposited directly into the pit (usually 6 ft deep or more) through slatted floors. Other slurry manure storage facilities include fabricated or earthen structures. Fabricated manure storage tanks are usually either concrete or coated metal (glass-lined steel). Such tanks may be above ground, or partially or fully below ground. Manure is usually scraped or flushed from the production buildings and may flow into these tanks by gravity or be pumped into the tank from a collection sump or reception pit. Adequate agitation is necessary to suspend solids and facilitate complete removal of the contents of these manure tanks. Fabricated tanks are usually the least costly to cover, which is sometimes desirable for odor control.

Slurry manure may also be stored in earthen structures or basins. Because storage volume can usually be obtained at less cost in an earthen basin than in a fabricated facility, these facilities are often used when manure and wastewater volumes are relatively large due to wash-water use or lot runoff. Earthen structures require a relatively high degree of planning and preliminary investigation to ensure that proper soil materials are available to create a seal and that the seal is constructed properly. These facilities are basically similar to lagoons, but smaller since less water is added to the manure. Space requirements are greater with earthen structures than fabricated manure storage tanks due to the required berms and front/back slopes that have structural integrity and can be properly maintained. Maintenance requirements may be greater with earthen structures due to the need for maintaining and mowing a vegetative cover on the berm area and keeping it free of weeds, trees, and shrubs. Agitation is equally important in earthen structures, and access points for agitation and pumping should be part of the design plan. Some earthen storage units are partially or completely lined with concrete and built with an access ramp so that loading and hauling equipment can enter the basin. Earthen storage structures are more difficult to cover than tanks if odor control is needed. Odor is generally a greater problem in slurry storage structures than in a properly operating lagoon, but if coverage is necessary, it is less costly in a slurry storage facility because of the smaller size.

Advantages of storing manure in the slurry form may include less volume (higher solids content compared to a lagoon), adaptability to tank storage either under floor or above ground, possibility of covering the manure storage facility to reduce odors, higher nutrient retention, and the potential to collect and transport hydraulically. Disadvantages may include higher odor potential (unless storage unit is covered), increased danger of toxic or combustible gas buildup in enclosed areas, number of loads or trips that must be made when the storage is emptied, and odor and runoff potential if the slurry is spread without injection or incorporation.

**Dry Systems and Solids Separators**

Dry manure storage can be as simple as using the confinement building itself as storage, as is often done in poultry houses where three or more flocks of chickens are raised before cleaning out the building. In cases where crop needs do not coincide with the need to clean out a broiler house, a dry swine house, or a dairy lot; manure is often stacked either in a building or outside until it can be utilized by a crop. These stacks should always be covered to protect them against runoff in case of rain **or** the runoff should be contained and treated as a liquid waste.

When swine are raised on litter, they tend to dung in limited areas of the building, so that the litter is very non-homogeneous when removed from the building. Some loads contain almost no nutrients, and some are very concentrated. To achieve a homogeneous product, it is necessary to compost, or at least stack and mix the material from these houses. Some producers have experimented with only removing the wet areas which contain most of the nutrients and reusing the dry litter, but it is not clear if this system is sustainable because of concerns about worms and parasites transferring from one batch of pigs to the next.

Another type of "dry" storage is a settling basin used to separate solids from a liquid stream. Typically, these basins are designed to store 3 to 4 weeks of manure, with two or more basins being utilized in order to allow one basin to drain while the other one is being filled. This design allows more flexibility in timing the application of solids onto crops and pastures. These basins are lined with concrete and the runoff from them flows into a lagoon to prevent contamination of surface waters.

Mechanical solid separators are also used. These devices usually produce a dryer product than a settling basin which is better for composting or hauling to remote sites or off the farm. Their main disadvantage is that, being mechanical systems, they do break down and require periodic maintenance. They also have a cost of operation involved since they require energy to operate. The solids fractions from these systems are typically stored on a concrete pad with the runoff going into a lagoon or protected by vegetated buffers.

## Basic Design Principles

**Lagoons**

A lagoon must be sized to provide adequate storage for manure, dilution water so that proper microbial digestion will occur, storage of sludge (indigestible materials that settle to the bottom), storage of rain water and wash water, and a safety margin in case of severe storms. (See Figure 1) If all of these capacities are not accounted for, the lagoon will not function properly, will begin to act like a manure storage facility, and will have to be pumped out much more frequently. Adequate sizing of a lagoon depends upon location, the number and size of animals using the lagoon, whether or not solids separation will be used, and how long sludge will be allowed to build up before removing. In addition, good management practices, such as loading the lagoon on a uniform basis, maintaining proper vegetation on berms, regular inspections and maintaining safe levels in the lagoon are necessary to provide safe, efficient operation.

Lagoons must be designed by a properly trained engineer (NRCS or consulting engineer). The berms (walls) must be designed to be stable under load and the lagoon must be properly lined with either a compacted clay or synthetic liner to prevent leakage into ground water. The owner/operator should understand the limitations of the system, and how the expansion of animal numbers will prevent the lagoon from operating properly. He/she should know the capacity of the lagoon, how many animals it is supposed to handle, how often it should be pumped down, and to what level it should be pumped down. Any major expansion or change in the operation of a facility would require a reassessment by the design engineer.

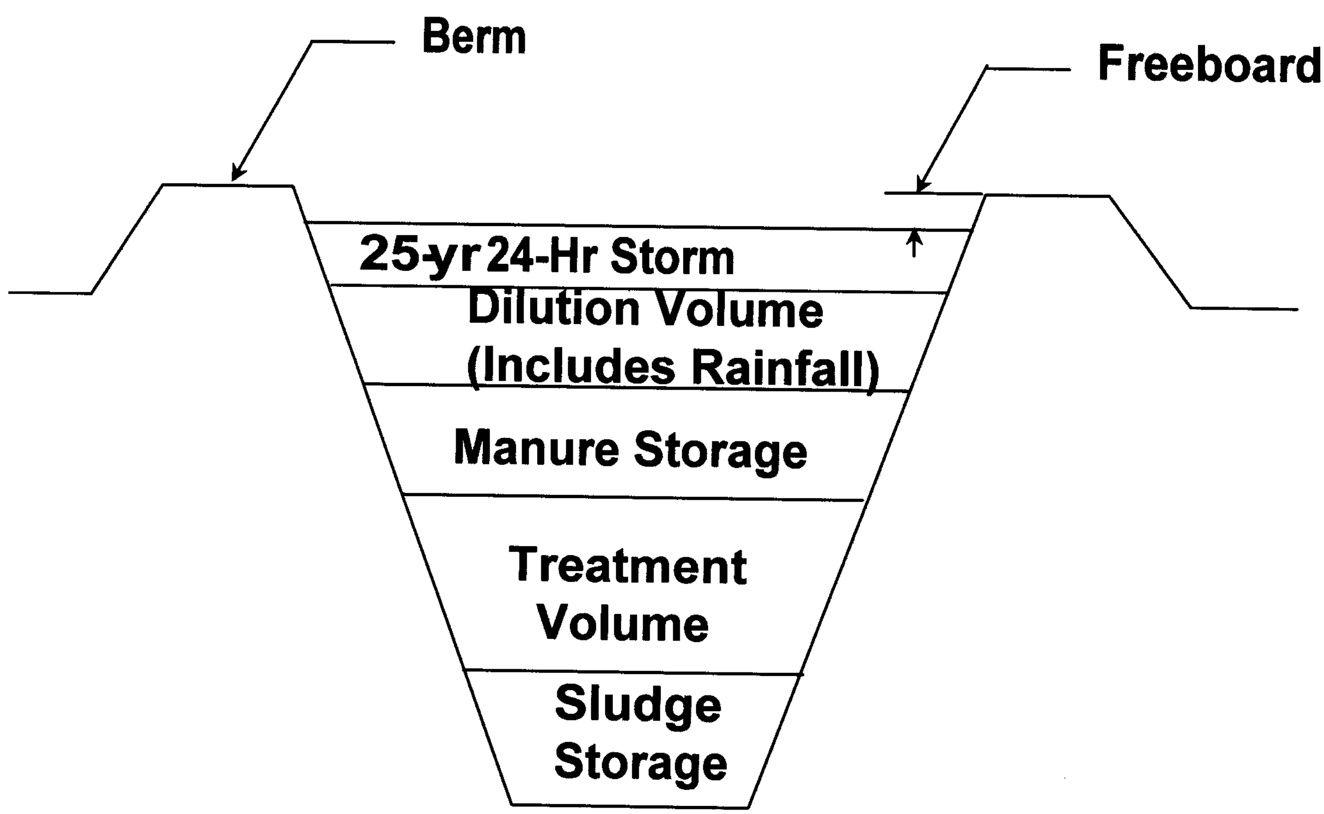



**Figure 1. Capacities that must be included in a proper lagoon design.**

**Manure Slurry Storage**

The actual size of a manure slurry storage structure needed depends upon the same factors used in sizing a lagoon with the notable exception that no treatment volume of water must be added since microbial breakdown of manure is not desired. Manure is left in a more solid state, which hinders bacterial growth. Also, sludge accumulation is not accounted for since this facility should be completely emptied one or more times per year. The design storage period plays a significant role in sizing these structures. Storage period needed depends primarily upon cropping system, climatic conditions, and labor/equipment availability. Most operations utilizing a single, full-season annual row crop or small grain crop will need at least six months manure storage to schedule land spreading around cropping operations. Experience has shown that even a full year's storage is beneficial when wet conditions may make fall application difficult and manure needs to be stored until spring.

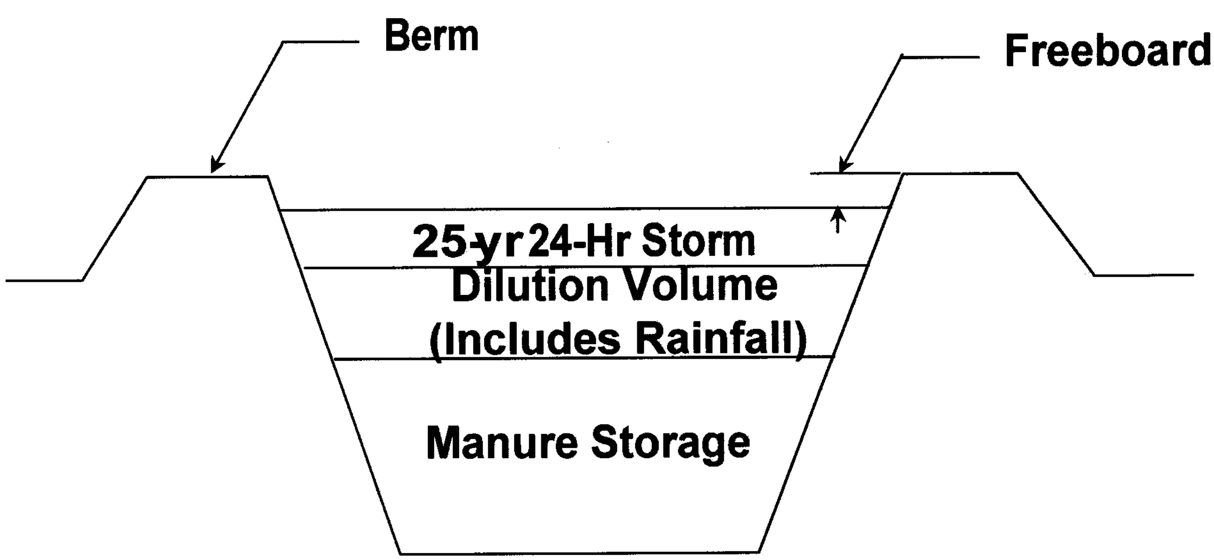



**Figure 2. A manure storage facility is smaller than a lagoon, but must still be sized to handle volumes according to the planned management.**

A manure storage facility for a given number of animals is much smaller than a lagoon for the same farm (See Figure 2), since no storage space is needed for dilution water. However, adequate size must still be supplied for manure storage, rainwater, and a safety factor for severe storms.

As in the case of lagoons, a manure slurry storage system should be designed by an NRCS or properly trained consulting engineer, whether it is an earthen basin (Figure 2) or a concrete or steel structure. The engineer should also be consulted before any expansion or major change in the operation takes place.

**Dry Systems and Solid Separators**

If manure is to be stored in a building (commonly called "dry-stack houses" in the poultry industry, the building should be designed to safely handle the loads it will experience, and should be designed to withstand the corrosive atmosphere in which it will exist while manure is stored in it. Assistance on building design is available from the NRCS or the Cooperative Extension Service Plan Service. Concrete floors are recommended, but clay floors are acceptable if mortality composting is not to be done in the facility.

Storage of manure in stacks outside a building should be avoided. Stacks can be covered with plastic which will protect them from leaching while in place, but when the stack is removed and spread on a field, it is almost impossible to remove all of the material, and the remaining manure can leach into the soil. Experience has shown that the most highly contaminated areas on a poultry farm is around old stacks and at the entrance to the houses where spillage occurs when houses are cleaned out.

Settling basins for separating solids should be designed to be structurally sound and to be large enough to provide flexibility in the timing of manure application from the basin. Again, assistance can be gained from the NRCS or Cooperative Extension Service Plan Service.

## Effects on Nutrient Management

The amount of nutrients available for use on crops is affected by the method used to store manure, as well as the application method. In estimating the total amount of nutrients available for use annually, the total nutrients excreted must be adjusted for storage and application losses. When applying material from an aerobic lagoon for instance, up to 90% of the excreted nitrogen can be lost during the anaerobic treatment of the waste. This nitrogen is lost to the atmosphere primarily in the forms of nitrogen gas and ammonia. There are also losses of phosphorus and potassium, but unlike nitrogen, these nutrients accumulate in the sludge layer of the lagoon, which must eventually be removed and applied to the land unless some arrangements can be made to remove the sludge from the farm. For this reason, 90 to 95% of excreted phosphorus and potassium should be accounted for in the overall farm nutrient management plan. Five to 10% may be lost in moving the waste material (spillage when loading, leaching when stored outside, etc.) Table 1 shows estimated available nitrogen after storage losses as a percentage of total nitrogen produced for various species and storage methods.

Table 2 illustrates how manure values can vary with system and time and thus result in different recommended or allowable loading rates. The only way to know the exact composition of manure is to have it tested. While the numbers below may represent average values, the variation from one system to another is great, and manure testing is an absolute essential for determining proper application rates.

**Table 1. Estimated available nitrogen after storage losses (% of total nitrogen produced) for different systems.**

| Management System | Dairy | Poultry | Swine |
|---|---|---|---|
| Anaerobic Lagoon | 20-35 | 20-30 | 20-30 |
| Manure Slurry Storage | 65-80 | | 70-75 |
| Manure Stored in Pit Beneath Slats | 70-85 | 80-90 | 70-85 |
| Manure and Bedding in Covered Storage | 65-80 | 55-70 | |
| Manure stored in open lot | 70-85 | | 55-70 |

**Table 2. Average manure accumulation and nutrient values for different swine manure systems** .(These values may be used as planning guidelines.)

| **Nutrient Composition of Swine Manure** | | | | | |
|---|---|---|---|---|---|
| Manure Type | Manure Accumu-lation | Total Nitrogen | Ammonium $NH_4$-N | Phosphorus $P_2O_5$ | Potassium $K_2O$ |
| Fresh | 82 lb/1,000 lb of animal/day | 12 lb/ton | 7 lb/ton | 9 lb/ton | 9 lb/ton |
| Scraped[1] | 58 lb/1,000 lb of animal/day | 13 lb/ton | 7 lb/ton | 12 lb/ton | 9 lb/ton |
| Liquid Slurry[2] | 16.7 gal/1,000 lb of animal/day | 31 lb/1,000 gal | 7 lb/1,000 gal | 12 lb/1,000 gal | 17 lb/1,000 gal |
| Anaerobic Lagoon Sludge | 0.74 gal/1,000 lb of animal/day | 22 lb/1,000 gal | 6 lb/1,000 gal | 49 lb/1,000 gal | 7 lb/1,000 gal |
| Anaerobic Lagoon Liquid | 20.3 gal/1,000 lb of animal/day | 136 lb/acre-inch (5 lb/1,000 gal) | 111 lb/acre-inch (4 lb/1,000 gal) | 53 lb/acre-inch (2 lb/1,000 gal) | 133 lb/acre-inch (5 lb/1,000 gal) |

[1]Collected within 1 week.
[2]Six to 12 months accumulation of manure, urine, and excess water usage, which does not include fresh water for flushing or lot runoff.
Source: North Carolina Agricultural Chemicals Manual.

## Operation and Monitoring of Lagoons and Slurry Storages

Lagoons combine storage and treatment functions and thus are more sensitive to management inputs than are solid or slurry facilities. The establishment and maintenance of desirable microbiological populations in lagoons requires more specific procedures in the way lagoons are loaded and monitored.

### Startup and loading procedures

Lagoon startup is a very important factor in developing a mature lagoon that has an acceptable odor level and will perform in the expected manner over the long term. Lagoons are designed with a "treatment volume" that provides an environment for development and maintenance of a bacterial population that degrades and stabilizes manure. The size of the treatment volume is based on a volatile solids (VS) loading rate, which depends primarily upon temperature. Volatile solids are the "non-mineral" or organic solids in manure that are subject to bacterial degradation. At warmer temperatures, bacteria are more active and VS loading rates are higher. The converse is true for cooler temperatures. For the bacteria to develop and function properly, the actual VS loading rate should be as designed. The proper VS loading rate is achieved only if the lagoon contains a volume of water equal to the treatment volume at startup. A lagoon with only one-tenth of the treatment volume filled at startup will experience an "overload" by a factor of 10 (VS loading rate is ten times greater than designed). Therefore, it is very important to plan a procedure to have sufficient water in a lagoon at startup. The treatment volume should be used as a target. Achieving this goal may require identifying a water source (pond, lake) and implementing the needed pumping procedures to transfer the desired volume of water to the lagoon. Since bacteria are more active at warmer temperatures, consideration should be given to starting a lagoon in the spring or early summer. In this way, bacteria will have a warm season to establish themselves before activity slows during the winter. Spring startup of lagoons often requires special planning of construction schedules and animal procurement.

Problems associated with insufficient volume at startup include excessive odor and high rates of sludge buildup. A lagoon that is started with insufficient volume may take years to recover and may never attain an operating state equal to a lagoon that is started properly.

In addition to startup, long-term loading procedures are critical to lagoon performance. A somewhat common and unfortunate practice in the livestock industry is to expand animal numbers without expanding lagoon size. This results in a proportionate increase in VS loading, and the associated problems can be expected to develop. Volatile solids loading should not be increased beyond the design loading. Alternatives to reduce VS loading (or expand animal numbers) include solids separation, construction of additional lagoon volume, or pretreatment of manure. Lagoons should also receive manure in a consistent manner (no "slug" loading). This is usually accomplished in modern production systems utilizing hydraulic transport of the manure to the lagoon.

### Salt and Nutrient Levels, Testing

Bacterial activity is somewhat sensitive to salt levels in the lagoon. Salts are a natural byproduct of the biological degradation of manure. The removal of some salts as the lagoon is pumped and the addition of fresh water via rainfall, runoff, and wash water combine to generally keep salt levels within an acceptable range. However, some conditions can occur that may lead to elevated salt levels. These include extended periods of dry weather, high rates of evaporation, little or no dilution with lot runoff and wash water, and perhaps overloading of the lagoon. Elevated salt levels inhibit bacterial activity, and lagoon performance is characterized by increased odors or "sour" smells and increased sludge buildup rates. A simple field test called "electrical conductivity" (EC) is effective in monitoring salt levels. A University of Missouri study found that EC values in the range of 8,000 to 12,000 μmho/cm (or S/cm) were associated with greatest bacterial activity. If salt levels rise too high in a lagoon, the most effective remediation is to pump the lagoon and add water from a freshwater source (pond or lake). The availability of such a freshwater source is an enhancement to long-term lagoon operation, and consideration should be given to such a source when planning a lagoon.

While overall salt levels are the primary concern in lagoon health, occasionally other more specific compounds may affect lagoon performance. These might include copper, arsenic, (dietary inputs), certain medications, and perhaps excessive use of harsh cleaning agents. If reduced lagoon performance is suspected due to factors such as these, specific testing may be required to isolate the source.

## Overall Monitoring Activities

Certain activities are advisable and necessary in maintaining a manure storage structure and ensuring that it is performing as expected. Some of these activities may be required by regulation, but all are evidence of good management and stewardship regardless of regulatory requirements.

### Monitoring During Pumping Activities

Experience has shown that unplanned discharges and spills sometimes occur with pumping activities. Sources of such unplanned discharges include burst or ruptured piping, leaking joints, operation of loading pumps past the full point of hauling equipment, and other factors. Hence, pumping activities should be closely monitored, especially in the "start-up" phase, to ensure that no spills or discharges occur. Continuous pumping systems such as drag-hose or irrigation systems can be equipped with automatic shut-off devices (which usually sense pressure) to minimize risk of discharge in the event of pipe failure.

### Liners

Liners in earthen manure storage impoundments are designed and constructed to provide an adequate barrier between the potential contaminants in the impoundment and groundwater. Hence, liner integrity is extremely important in maintaining an environmentally sound manure storage facility. To the extent possible, liners should be regularly inspected for signs of damage, erosion, or other compromising factors. Wave action can cause liner erosion at the level of the liquid in the impoundment. If this condition is severe, consideration might be given to the use of riprap or similar mitigation methods to preserve liner integrity. The area around the pipes that discharge into the impoundment is also subject to erosion, especially if the pipes discharge directly onto the liner surface. A better configuration is to install inlet pipes such that they discharge into at least 4 feet of liquid, which may require a supporting structure for the end of the pipe. Concrete or rock chutes should be used with inlet pipes that discharge onto the liner surface. Agitation is also an activity that can damage liners. Care should be taken to operate agitators a sufficient distance above the liner so that liquid velocities are reduced enough to ensure that erosion does not occur. Heavy or unusual rainfall events can also erode liners, and special attention should be given to liner inspection after such storm events.

**Logbooks and record keeping**

Certain data and record keeping involving manure storage structures can aid in overall maintenance and management, and is also evidence of responsible operation and good record keeping. In addition to the periodic inspections, manure levels in a storage structure should be monitored and recorded. This data can illustrate the effects of excessive rainfall and lot runoff, and help in planning pump-down or other land application activities. Manure levels should be observed and recorded frequently enough to provide a "feel' for the rate of accumulation, and pumping activities should be scheduled accordingly.

When a lagoon is pumped or other manure storage structure is emptied, the date of the activity should be recorded along with the volume or amount of manure removed, locations where the manure is spread, and the nutrient content (lab analysis) of the manure. Calibration of pumping equipment is necessary to accurately estimate amounts pumped. This information may be required by the regulatory agency for interim or year-end reports, or may be useful in the event of litigation.

**Pump-down or Manure-Level Markers**

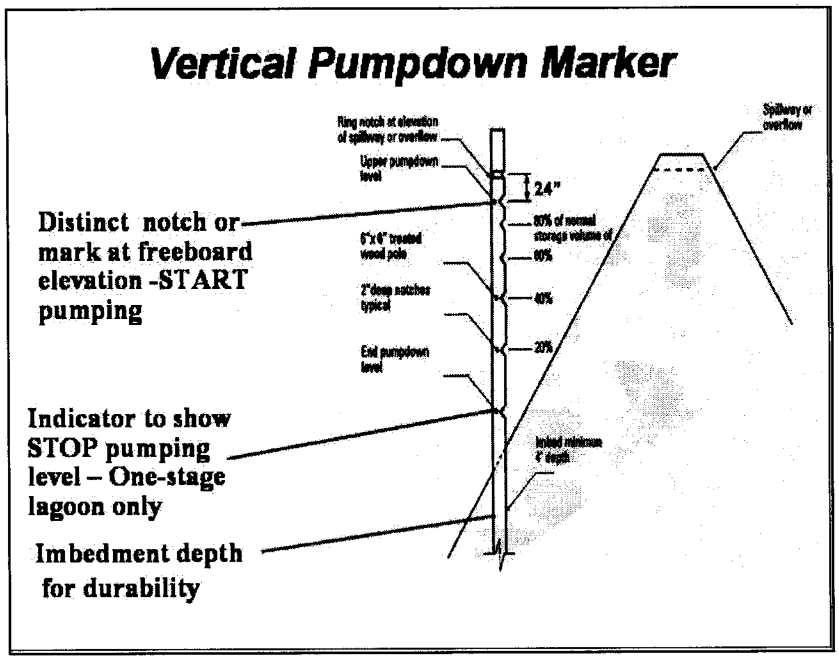
Pump-down or manure-level markers, or indicators, are a simple but important component of a manure storage facility. Such a marker enables the operator to ascertain quickly and easily the degree of fill of the manure storage facility, the point at which pumping or emptying should begin, and the point at which it should end. The presence of a durable, easily read marker gives inspection or regulatory personnel confidence that a manure storage facility is being managed properly.

Experience has shown that pump-down markers must be made of durable materials and properly installed to afford the long life needed. The operator or inspector should be able to ascertain the following information when observing a pump-down marker:

- When pumping operations should begin and end
- Level at which overflow will occur
- Fraction of total storage that is currently filled
- For a multi-stage lagoon or a manure storage basin, the start-pumping level should be indicated, but not necessarily a stop pumping level since the stop pumping level is really the bottom of the lagoon (or as close as it can be pumped.)

A common practice is to install steel fence posts at the upper and lower pump-down levels for earthen impoundments. While this approach provides basic information on beginning and ending pump-down, experience has shown that more knowledge is needed. Also, fence posts installed in this manner are subject to damage and displacement. A good pump-down marker will indicate the level, or elevation, of manure throughout the possible range (from lower pump-down level to overflow, or spillway) in the storage facility. A pump-down marker can be made from PVC pipe with all ends left open to allow water to flow into the pipe. Two examples of how this can be done are shown in Figures 3 and 4. Table 3 gives conversions for sloped to vertical measurements for use in installing level indicators on sloped markers.

**Figure 3. Example of Vertical Pumpdown Marker**



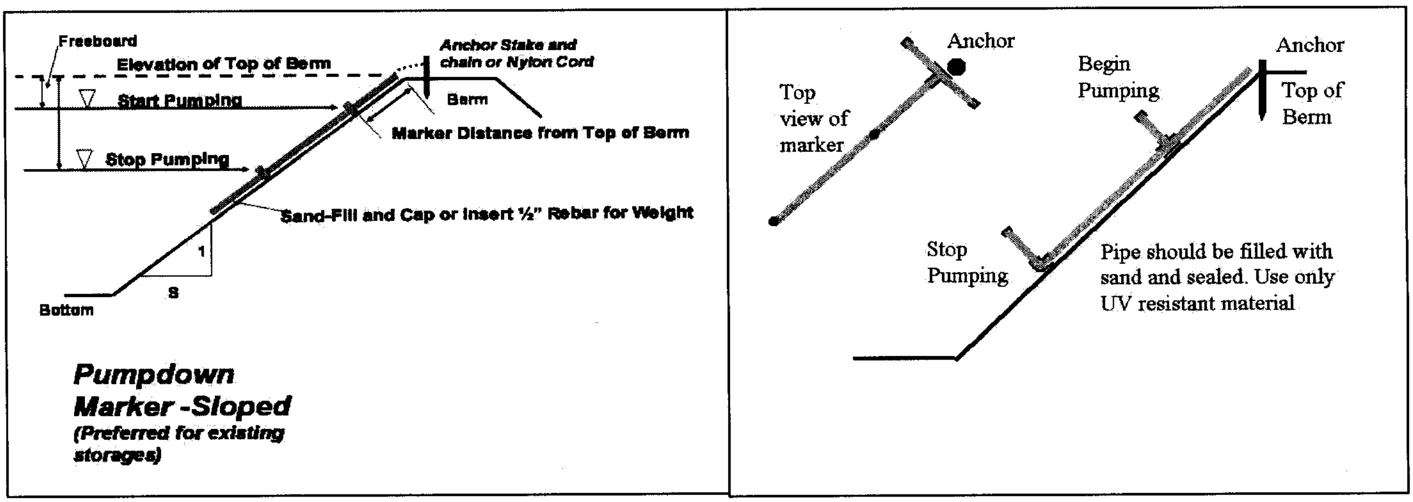




**Figure 4. Example of Sloped pump-down marker in earthen impoundment**

**Table 3. Conversions for sloped to vertical measurements**

| Vertical Distance, ft | Interior Sideslope, Run:Rise | | | | |
|---|---|---|---|---|---|
| | 1:1 | 1.5:1 | 2:1 | 2.5:1 | 3:1 |
| 2 | 2.8 | 3.6 | 4.5 | 5.4 | 6.3 |
| 4 | 5.7 | 7.2 | 8.9 | 10.8 | 12.6 |
| 6 | 8.5 | 10.8 | 13.4 | 16.2 | 19.0 |
| 8 | 11.3 | 14.4 | 17.9 | 21.5 | 26.3 |
| 10 | 14.1 | 18.0 | 22.4 | 26.9 | 31.6 |

## Weather stations

A simple weather station that indicates or records rainfall can be a useful tool in maintaining and managing a manure storage structure. Rainfall has a significant impact on open storage structures and structures serving open lots, so knowledge of rainfall amounts can be very useful. Some permits are written that provide for a "legal" discharge under certain climatic events. A weather station can aid in the documentation of such events without resorting to "off-site" data from stations that may not be descriptive of conditions at the storage facility. Recorded rainfall data is also evidence of good stewardship.

## Aesthetics and appearance

Aesthetics and appearance may not be critical factors in protecting the environment or complying with environmental regulations. However, these characteristics are major factors in the perceptions formed by the general public, tour groups, regulatory or inspection personnel, and others who may not be intimately associated or familiar with the livestock industry. Therefore, aesthetics and appearance should be given major priority for the overall benefit and viability of animal agriculture.

The general cleanliness and sanitation characteristics of a livestock enterprise are often perceived as a measure of the concern of that enterprise for environmental stewardship and environmental compliance. A clean, well-landscaped production area will project a positive image for the operation, while the presence of debris, litter, and poorly maintained buildings will project a negative image. Typical items of concern for livestock production enterprises include leftover construction debris or refuse; old, unused vehicles; worn-out equipment; rusted equipment from the buildings (farrowing crates, pen dividers, feeders); torn and worn-out ventilation curtains; and loose roofing panels, etc. All livestock production operations experience animal death loss. A specific plan managing animal mortalities should be developed and implemented. The visual and olfactory perceptions generated by the presence of dead animals in or around the production facility are highly offensive and likely will be attributed to the industry as a whole by the general public. Additionally, poorly managed mortalities represent a very real health and disease risk to the enterprise.

Few activities undertaken by the producer are as effective as frequent mowing in conveying a positive image of livestock production. Producers who maintain "front yard quality" around the production and manure storage facilities provide a powerful first impression of pride and responsibility. Conversely, the presence of tall grass, weeds, shrubs, and trees in undesirable locations creates an impression of laxity and disrespect for environmental responsibility. Regulatory personnel inspect most livestock production and manure storage facilities at some interval. If tall grass, weeds, brush, and trees hamper the inspector, a positive report is an unlikely outcome. Routine inspections for seepage, rodent burrowing, erosion, or other damage are much more effective if the areas have been mowed at regular intervals.

## Control of Surface Water

As confined production units become larger, control of surface water in the production area is a primary concern. Wider, longer buildings, placed relatively close together, create high rates of discharge from roof and paved areas. Special considerations and landscaping are needed to manage this water in a manner that does not create erosion and unwanted ditches and washed-out culverts or waterways. A surface water management plan should be developed based on a design storm event, expected runoff rates, soil types and erosive velocities, and properly designed and vegetated channels for carrying surface water away from the production area. Some states may require that surface water from production areas be contained and/or checked for contaminant levels before discharge to a watercourse.

## Closure of Waste Impoundments

Anaerobic lagoons have been used for a number of years to treat and store animal waste from swine, poultry, and dairy cattle. Bacteria in the lagoons treat the waste by digesting organic matter and converting much of the mass to gases (ammonia, nitrogen, methane, and many others). A typical active lagoon consists of a large, dilute layer of fresh manure, water, and partially digested manure; and a layer of thick sludge at the bottom, which is primarily material that cannot be broken down by the anaerobic bacteria. The thickness of the sludge layer depends on the age of the lagoon, and on the loading rate and species of animals whose waste is being processed and stored.

If lagoons cease to be used for waste storage and treatment, the dilute top layer cleans itself up to a degree, but the thick solids layer underneath stabilizes and will remain in tact indefinitely. At some point, the solids will need to be removed. Provisions have been written into rules that would require lagoons on Confined Animal Feeding Operations (CAFO's) greater than 1,000 animal units (new or existing) to be properly closed when no longer in service.

The rule citation is as follows:

**Rule 391-3-6-.21 (5) (j)**
**When the owner or operator ceases operation of the AFO, he must notify the Division (EPD) of that fact within three months, and he must properly close all waste storage lagoons within eighteen months. In the case of voluntary closure, a period of twenty-four months from notification is allowed. Proper closure of a lagoon entails removing all waste from the lagoon and land applying it at agronomic rates, and in a manner so as not to discharge to any surface water.**

The regulations also reference the Natural Resources Conservation Service (NRCS) Practice Standards as the guiding document for interpretation of the requirements. The NRCS Conservation Practice Standard that covers this subject is Code 360, Closure of Waste Impoundments. A summary of the document is on the next page.

NRCS Guidance on Lagoon Closure

There are three options for managing the earthen lagoon after closure:

1. ***Complete closure and fill.***
2. ***Breaching the lagoon berm.***
3. ***Conversion to a farm pond or irrigation storage structure.***

In either case, the first steps are the same:

1. Remove all pipes or other structures that convey waste into the structure. Pipes should be dug up and ditches refilled
2. Remove as much of the stored waste and sludge as practical. This can be done by agitating the lagoon and pumping as much material out as possible, refilling with water and repeating until most material ha been removed. Alternatively, the effluent (relatively dilute liquid on top) can be pumped out, and the sludge can be removed using a slurry pump or excavation equipment.
3. All material must be land applied at agronomic rates (such that crops can utilize the nutrients).

If the lagoon is to be completely closed, it should then be filled in and the land returned to its approximate original contours. Soil should be mounded slightly in the lagoon area (5% slope) in order to allov for settling and to encourage surface water to run away from the site. Vegetation should be established on the site to prevent erosion.

If the lagoon berm is to be breached, all surface water runoff should first be diverted away from the lagoon. The breach should have sufficient side slope to prevent erosion. (Maximum 3:1 slope.) The NRCS can help with this design. It should be low enough to allow all water to flow from the structure and prevent ponding. Vegetation should be established on the entire site including the sides of the breach to prevent erosion.

If the lagoon is to be used as a farm pond, a watering source for livestock, or an irrigation storage pond, the structure should meet the requirements for these types of structures. A properly designed lagoon will probably meet those requirements without major alterations, but the NRCS should be able to provide technical assistance to assure this requirement is met. Water quality samples should be taken and submitted to assure safety before allowing livestock to drink from a converted lagoon. Dissolved oxygen (DO) levels should be higher than 3 milligrams per liter and nitrate nitrogen should be below 30 milligrams per liter.

## Summary

Lagoons, manure slurry storage structures, and dry systems each have advantages and disadvantages. Lagoons reduce the nitrogen and organic matter in the waste stream by volatilizing them (converting them to gases and moving them into the air.) They also reduce the odor released compared to a slurry storage, but they are more expensive because of their larger size and must be carefully managed to maintain a healthy bacterial population. Slurry storage structures are smaller (do not include treatment volume or sludge storage), conserve more nutrients in the waste, and are easier to cover if necessary, but they tend to produce more odor if not covered. Dry systems keep manure in a concentrated form making it more transportable and less likely to flow into surface waters, but it must be handled as a solid which usually requires more labor than liquid systems which can use automated pumps. Solids separation devices remove much of the solids going into a liquid system and thus reduce the required volume for treating the waste, but they do require a large financial investment and require two types of manure handling equipment (liquid and dry). Whichever type of system is used, it is important to understand that it cannot perform as designed unless it is managed properly. For a lagoon, that includes starting it about 1/3 full of water before waste is added, preferably in the Spring, loading it evenly, and maintaining the level between the minimum and maximum levels. For a slurry storage, it includes cleaning it out on a regular schedule, according to crop needs, and minimizing the amount of water entering the storage. Solids separating systems must have the solid fraction removed regularly (within the flexibility provided in the design) in order to keep them operating properly, and mechanical systems must be regularly maintained to avoid break downs.

Regular inspections and records of these inspections are vital to maintaining any manure storage and handling facility and to being able to prove that you are doing a good job managing your facility. Inspections should include investigations of existing or potential leaks, aesthetic appearance of facilities, and variations in odor levels. Regular monitoring and recording of lagoon levels requires the use of an easily read marker that shows **at a minimum** the overflow level, maximum storage level, and minimum pump-down level for the lagoon. Lagoon levels and weather forecasts should be studied so that pumping can be scheduled before it has to be done on an emergency basis. Berms should be checked for leaks, rodent burrows, erosion, and tree growth. Aesthetics include regular mowing and establishing vegetative screens where needed to present a pleasing picture to neighbors and those passing the farm.

If a lagoon is no longer used to store animal waste, it should be properly closed, including removal of all waste material. The structure can be filled in and reclaimed, the berm may be breached, or the structure can be converted for use as a farm pond. In any case all conveyances should be removed and exposed ground should be planted in a cover crop to prevent erosion. Until these steps occur, the lagoon should be managed just as it was before closure.

## Appendix A
## Monthly Manure Storage Facility Checklist

Farm:______________________ Facility ID:______________________

Inspected by:______________________________ Date:______________

***Manure Level***

Manure level today: (Distance below maximum fill level)__________ft.

Last observation: ____________ft. Date:________

***Earthen Storage Facilities***

| Item | Low Risk | Potential Problem | Corrective Measures Taken/Planned |
|---|---|---|---|
| Are embankments well-sodded with no bare areas? | Yes | No | |
| Are embankments free of trees or woody shrubs? | Yes | No | |
| Does the berm or embankment have a consistent elevation (i.e., no low or settled areas other than the planned spillway)? | Yes | No | |
| Is the spillway free of erosion? | Yes | No | |
| Are all berms and embankments free of erosion? | Yes | No | |
| Is the base of the embankment free of soggy, damp areas and other evidence of seepage or leaks? | Yes | No | |
| Are the embankments free of burrowing or other rodent damage? | Yes | No | |
| Is the liner free of damage due to rainfall, wind, or wave action? | Yes | No | |
| Is the liner free of erosion damage around inlet/outlet pipes and agitation points? | Yes | No | |
| Does the lagoon contain at least the minimum volume for treatment? | Yes | No | |

***Concrete/Steel Tanks***

| Item | Low Risk | Potential Problem | Corrective Measures Taken/Planned |
|---|---|---|---|
| Are tanks free of visible cracks or structural damage in walls or foundation? | Yes | No | |
| Is the area around the tank free of seepage or other evidence of leakage? | Yes | No | |
| Is the manure loadout area free of spills or accumulations of manure? | Yes | No | |
| Does surface water properly drain away from the manure tank? | Yes | No | |

*Diversions*

| Item | Low Risk | Potential Problem | Corrective Measures Taken/Planned |
|---|---|---|---|
| Is roof water and field runoff diverted? | Yes | No | |
| Are diversion ditches adequately sized to handle runoff without overtopping? | Yes | No | |
| Are diversion channels vegetated and free of erosion? | Yes | No | |
| Is storage available in secondary containment structures if required? | Yes | No | |
| Is there adequate drainage of surface water around production buildings and manure storage facilities? | Yes | No | |

*Components*

| Item | Low Risk | Potential Problem | Corrective Measures Taken/Planned |
|---|---|---|---|
| Are level markers properly installed and easy to read? | Yes | No | |
| Are manure inlet pipes submerged and properly supported? | Yes | No | |
| Are drains, sewer lines, and cleanouts in good condition and operating properly? | Yes | No | |
| Are perimeter drains or tiles open and functioning? | Yes | No | |
| Are recycle pumps, valves, controls, and pressure lines operating properly? | Yes | No | |

*Appearance*

| Item | Low Risk | Potential Problem | Corrective Measures Taken/Planned |
|---|---|---|---|
| Is the manure storage site neat and recently mowed? | Yes | No | |
| Is the manure storage site free of refuse, debris, unused materials, and junk? | Yes | No | |
| Is the manure storage site screened by visual barriers, and are these barriers maintained? | Yes | No | |
| Is the manure storage site free of carcasses, afterbirth, or medical wastes? | Yes | No | |
| Is the manure storage site properly fenced and marked? | Yes | No | |
| Is the lagoon purple and actively bubbling? | Yes | No | |
| Is the manure storage surface free of excessive floating materials or vegetation growth? | Yes | No | |

# Phosphorus Issues

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## Intended Outcomes

The participants will
- Understand how P affects water quality
- Understand why manures present a special problem with P
- Understand how to use the P-index

## Regulatory Background

The current Georgia regulations require for all wet manure operations (swine, dairy, and layer operations for the most part) above 1,000 animal units that Comprehensive Nutrient Management Plans (CNMPs) be developed that meet NRCS standards. These standards require that CMNPs consider the risk of P losses from a field reaching a sensitive stream, river, or lake (NRCS, 1999). New EPA regulations will require that states develop regulations that will include dry manure operations (broiler operations) above 1,000 animal units.

## How P Affects Water Quality

According to a recent survey by the U.S. EPA, accelerated *eutrophication* is the main cause of water quality "impairment" in the U.S. (U.S. EPA, 1996). Eutrophication is the natural aging of lakes or streams brought on by nutrient enrichment. This process is accelerated by human activities which increase nutrient loading rates to water. While both P and N contribute to eutrophication, P is the primary agent in freshwater eutrophication. In salt water estuaries, N is the primary nutrient controlling eutrophication.

Eutrophication restricts water use for fisheries, recreation, industry, and drinking, due to the increased growth of undesirable algae and aquatic weeds and oxygen shortages caused by their death and decomposition. Also, an increasing number of lakes are experiencing periodic algal blooms. These blooms contribute to a wide range of water-related problems including summer fish kills. One of the problems occurs when lake water that has high organic matter levels due to algal blooms is used for drinking water by cities (U.S. EPA, 2003). Water treatment plants commonly add chloride (Cl) to drinking water to kill pathogens but the Cl can combine with the organic matter to produce tetrahalomethanes (THM) and haloacetic acid (HAA), both of which are carcinogens. EPA has put a limit on the annual average concentration of these compounds that are allowed for drinking water plants.

Lakes are more sensitive to P than streams and rivers. According to a survey by the Georgia Department of Natural Resources (DNR), several of the large lakes in Georgia show signs of eutrophication. Due to accelerated eutrophication, the DNR has set limitations for five lakes in

Georgia on the amount of P that can enter from tributaries (Table 1). In 2001, the Cobb County Water Authority, which draws most of it's drinking from Lake Allatoona, came very close to exceeding the limit for HAAs in their drinking water. If the problem continues, finding an alternative treatment to Cl could cost the authority millions of dollars according to an article in the Atlanta Journal Constitution (2002).

**Table 1**. Large lakes in Georgia with the ten highest levels of trophic index (DNR, 1995).

| Lakes | P limit (lb per acre-ft per year) |
|---|---|
| Lake Allatoona | 1.3 |
| Lake Jackson | 5.5 |
| Lake Lanier | 0.25 |
| Lake Walter F. George | 2.4 |
| West Point Lake | 2.4 |

The sources of P entering streams, rivers, and lakes in Georgia include sewage treatment plants and factories that discharge into streams, runoff from lawns with failing septic systems or fertilizer, runoff from agricultural land with manure or fertilizer, and natural background sources such as rock minerals and wildlife.

Ground water is not affected by P because of the absence of algae. Only when ground water returns quickly to a stream, river, or lake, do we need to worry about P leaching to ground water.

### What Happens When P is Added to Soils

Phosphorus is added to agricultural land as fertilizer or manure because it supplies an important element needed for plant growth. Phosphorus in soils exists in a number of mineral and organic forms, but most of it is adsorbed to iron and aluminum oxides in Georgia soils. These oxides have a large, but not unlimited, number of adsorption sites for P and when the adsorption sites start to fill up, there is more and more P dissolved in the soil water. It is mainly this dissolved P that is available to plants, and susceptible to runoff.

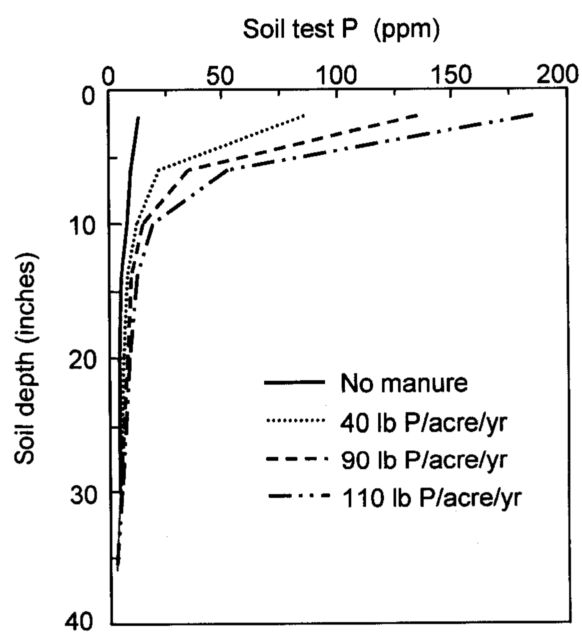



**Figure 1**. Soil test P as a function of depth for different rates of manure application.

P in soils can be expressed as P or $P_2O_5$. To convert P to $P_2O_5$, multiply by 2.29. When discussing plant available forms of soil P as determined by soil testing laboratories, we refer to them as *soil test P* (usually in parts per million or ppm) and identify in each case the specific method of analysis used (Mehlich-1, Mehlich-3, Bray-1, etc). Soil test P can also be expressed in lbs/acre. Based on a six inch soil depth containing 2 million pounds of soil, to convert ppm to lbs/acre, multiply by 2.0.

In most soils, the P content of the topsoil is much greater than the subsoil (Fig. 1). As manure and fertilizers are added to soil, the levels at the surface increase sharply, but there is little effect in the subsoil in most cases. This is because most of the P is tightly adsorbed and doesn't move very far. In addition, P is cycled from roots to aboveground parts of the plant and redeposited in crop residues on the soil surface. In very sandy soils which are low in iron and aluminum oxides, P can move into the subsoil.

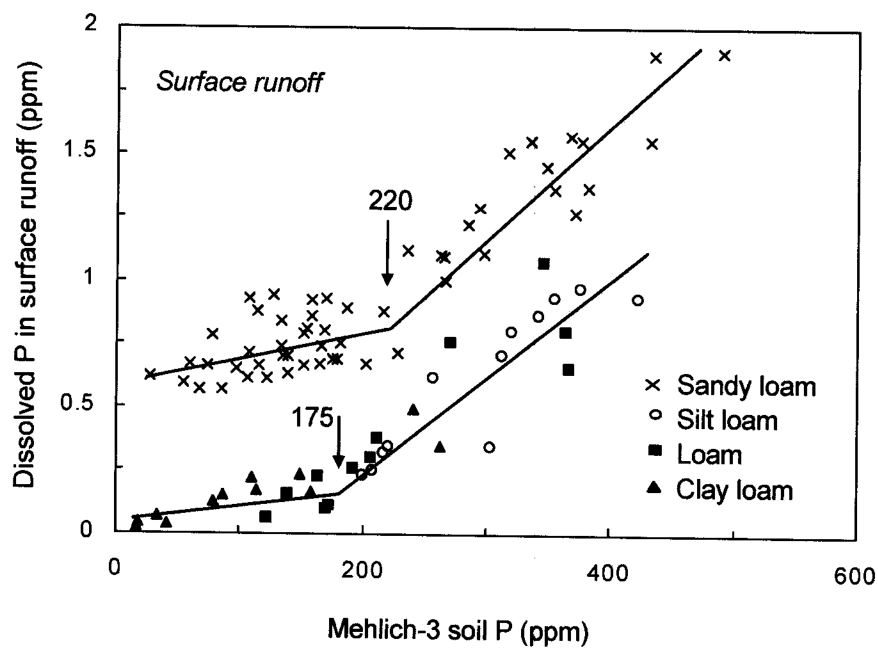



**Figure 2**. Dissolved P as a function of soil test P in four soils.

In recent years, we have learned that the concentration of P in runoff from agricultural fields increases as the soil test P level goes up. Part of the reason for this can be soil erosion where soil particles with high concentrations of adsorbed P are being washed off the field. But even in grass fields, where there is almost no erosion, research has shown that dissolved P concentrations in runoff increase with soil test P (Fig. 2). The reason why P concentrations in runoff increase with soil test P levels is that when rain occurs there is a thin layer of water near the surface that mixes with the soil water and can run off. If the concentration of P in the soil water is high (because most of the adsorption sites near the surface are filled with P), then the concentration in the runoff water will also be high. In Fig. 2, all soils show that P concentrations in runoff increase more sharply beyond a certain level of soil test P. This probably represents the level where most of the adsorption sites near the soil surface are filled.

There is no clear answer to what is an unacceptable concentration for P in runoff. The concentration of total P (adsorbed and dissolved) that is thought to trigger eutrophication in lakes is only 0.05 ppm. In Fig. 2, even the lowest levels of soil test P produce concentrations in this range. Most researchers agree that a realistic target is to try and keep agricultural runoff P concentrations below 1.0 ppm. The level of soil test P above which runoff concentrations exceed 1.0 ppm is sometimes referred to as the *environmental threshold* soil test P. In Fig. 2, the environmental threshold level would be approximately 300 ppm soil test P for the sandy loam and 400 ppm soil test P for the silt loam. By comparison, the *agronomic threshold* level (soil P level above which there is no increase in yield) for most crops using a Mehlich-3 extractant is around 50 ppm. In general, the environmental threshold is 2-4 times higher than the agronomic threshold.

**Why Manures Present a Special Problem for Phosphorus**

For the most part, soil test P levels at the surface in excess of the environmental threshold are unlikely to occur unless manures are being used. Even though farmers have been encouraged to "build soil test P" levels in the past, the cost of fertilizers discourages over-application of P in most cases. Manures present a special problem because the N-to-P ratio in manure is not the same as what most crops need. Most crops use about 8 lbs of N for every lb of P, or a ratio of 8-to-1. But manures usually have a much lower ratio.

**Table 2.** N-to-P ratios for different manures, ratios adjusted for available N, and the resulting over-application of P.

| Type of Manure | N Content[1] | P Content[1] | N-to-P Ratio | Adjusted N-to-P Ratio[2] | Over-application of P |
|---|---|---|---|---|---|
| Anerobic swine lagoon | 128 lbs/acre-in | 22 lbs/acre-in | 5.8 | 2.9 | 2.8 times crop needs |
| Anerobic dairy lagoon | 132 lbs/acre-in | 33 lbs/acre-in | 4.0 | 2.0 | 4.0 times crop needs |
| Anerobic layer lagoon | 179 lbs/acre-in | 20 lbs/acre-in | 9.0 | 4.5 | 1.7 times crop needs |
| Broiler litter | 71 lbs/ton | 30 lbs/ton | 2.4 | 1.2 | 6.7 times crop needs |

[1] from Barker et al. (1994).
[2]adjusted for available N (assumed to be half of the total N).

For example, a typical sample of broiler litter would have 71 lbs of total N and 30 lbs of total P per ton of litter, a ratio of 2.4-to-1 (Table 2). Since only about half of the manure N is usually available to plants (due to losses and limited organic N decomposition), the effective ratio is 1.2-to-1. This means for every 8 lbs of broiler litter N applied, one applies 6.7 lbs of P (8 divided by 1.2), or 6.7 times as much as the crop needs. As a result, excess P builds up at the soil surface in fields that receive repeated manure applications. Average N-to-P ratios vary for different manures and storage methods (Table 3). Values for a given operation need to be determined from periodic manure sample analysis.

As a result of the low N-to-P ratio in manure, excess P builds up at the soil surface in fields that receive repeated applications. This appears to have happened in many grass fields in the Piedmont region of Georgia where broiler litter applications are common. In 1995, 42% of the bermuda grass and 33% of the summer grass soil samples submitted to the University of Georgia Soil Analysis Laboratory tested High or Very High in soil test P.

Dry manures present a special additional problem when they are applied to grass fields and not incorporated. Under these circumstances, there is very little contact between the manure P and the oxides in soils. Rain water mixes directly with the manure causing a high concentration of dissolved P in the runoff. Some of adsorbed organic P also enters runoff as the manure is eroded from the site. Research has shown that runoff P concentrations are unrelated to soil test P in these situations. Runoff P concentrations can be quite high (> 25 ppm) when runoff occurs within a few weeks of manure application.

**Best Management Practices to Reduce P Runoff Losses**

There are a number of best management practices (BMPs) that can be adopted to reduce the risk of P contamination of surface waters. Some of these reduce the source of P in a field and others reduce the transport of P from the field to a stream.

The most obvious BMP for reducing the P source is to base nutrient management plans (NMP) on the crop's need for P rather than N (a P-based vs. a N-based NMP). This means that additional land must be found for manure application or livestock numbers must be reduced. Another way to reduce the P source is to make P in the feed more digestible so that lower levels can fed. This can be done by adding phytase enzyme to feed or through the use of new hybrids of corn that have a highly digestible form of P (Ertl et al., 1998). The P source can also be reduced by adding a compound called *alum* to the manure. The aluminum in alum combines with P in the manure and forms an insoluble compound. As a result, the dissolved P levels in runoff are lower when alum-treated manure is applied to fields (Moore and Miller, 1994). A simple way to reduce the source is not to apply manure during periods when runoff-producing rains are expected, for example in the winter months. If it's possible to incorporate dry manure or inject lagoon slurries, this will also reduce the source.

One of the most important BMPs that affect transport is the use of grass filter strips and stream-side buffers. Grass filter strips are very effective in filtering out P adsorbed to sediment because they slow down the flow of water and cause the sediment to settle out. They have less of an effect on the P dissolved in runoff. Artificially drained fields (tile drains or ditches) present a special danger in that transport from the field to the stream is enhanced. High concentration P water may move to the drains in sandy soils where there is little adsorption. Avoiding manure application to artificially drained fields is the best practice. Transport of P can also be reduced by any BMP that reduces runoff and erosion. Examples would be conservation tillage, terracing, contour plowing, and impoundments.

## Georgia P Index

If the risk for P loss to a sensitive water body is sufficiently high, then a P-based plan should be adopted. But how do we determine the risk and what is *sufficiently high*? In Georgia, we have developed a *P index* that estimates the risk for P losses at the edge of a field. This might be compared to the heat index which gives us a temperature that has been adjusted to take into account both temperature and humidity and more accurately represents how hot it will seem to us.

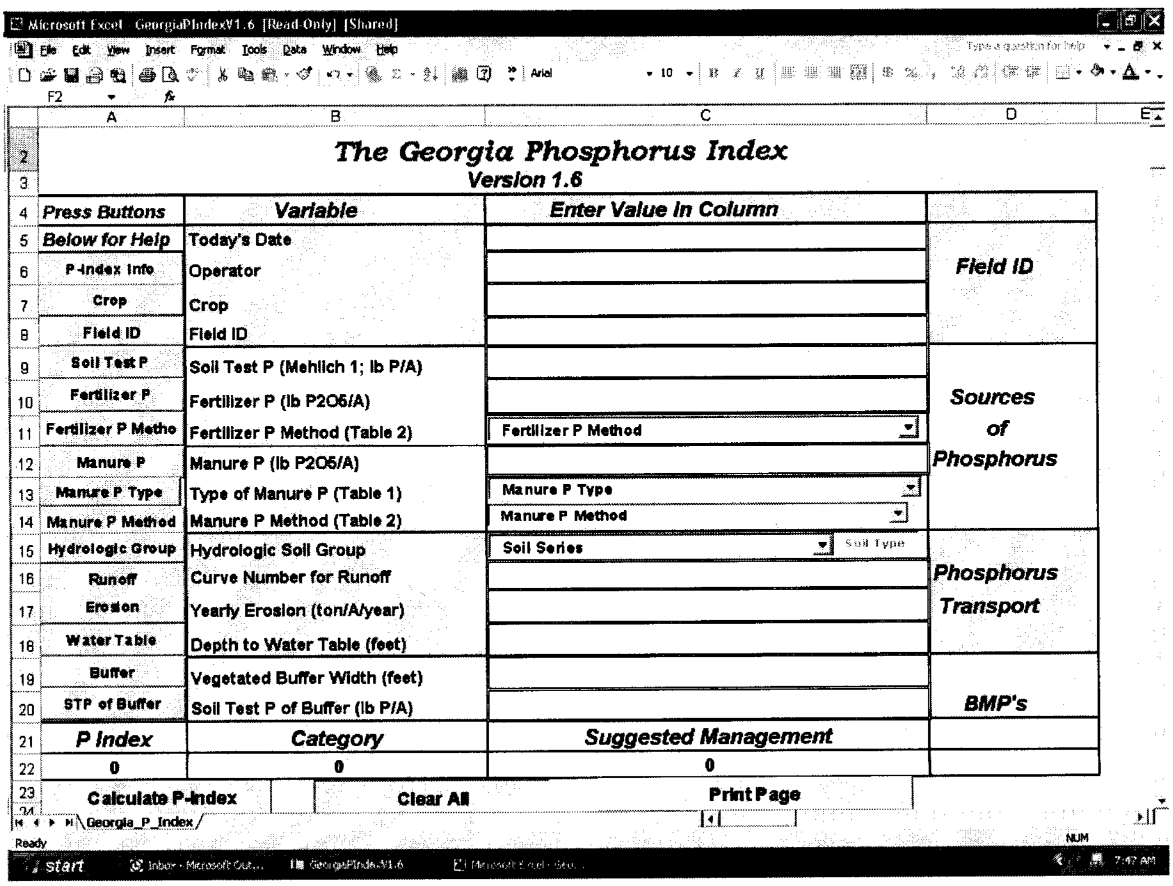



**Figure 3**. Georgia P index source, transport, and BMP factors.

The index is calculated using a spreadsheet and considers source, transport, and BMP factors (Fig. 3). The sources of P include soil test P, fertilizer P, and manure P. The methods of applying fertilizers and manures are also considered. The transport mechanisms include runoff, erosion, and drainage (a function of the soil hydrologic group and the depth to the water table). The only BMP considered (aside from methods of applying fertilizers and manures) is vegetated buffers. To be effective in filtering P, the soil test P in the buffer must not be too high so that too is a factor.

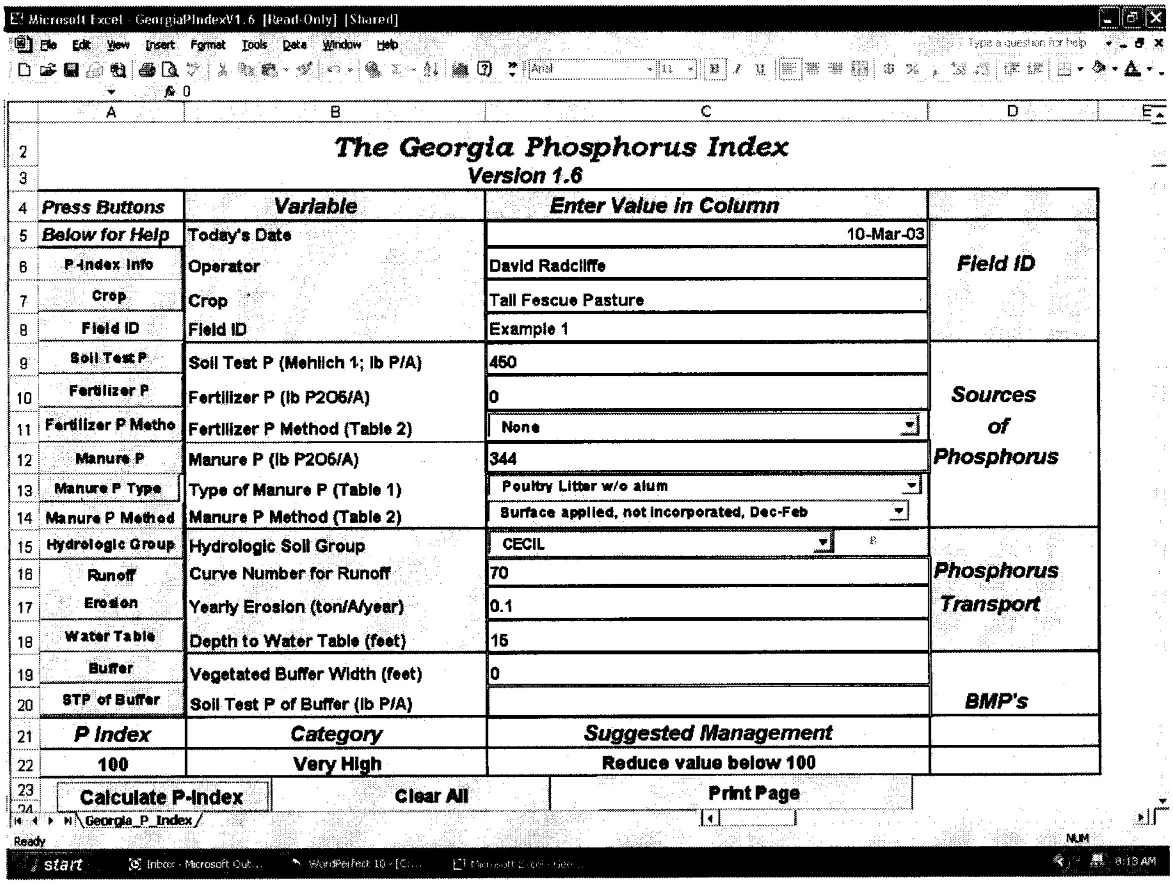
**Table 3.** Interpretation of the Georgia P index.

| P Index Range | Category | Generalized Interpretation |
|---|---|---|
| 0 to < 40 | Low | Low potential for P movement from this site. Nitrogen-based nutrient management planning is usually satisfactory. |
| 40 to < 75 | Medium | Medium potential for P movement from this site. Use conservation practices and P applications that maintain a P Index < 75. |
| 75 to < 100 | High | High potential for P movement from this site. Add conservation practices or reduce P applications to achieve a P Index < 75 in the short term. If this cannot be achieved with realistic conservation practices and reduced P rates in the short term, then a management plan needs to be developed with the goal of achieving a P Index < 75 within 5 years. |
| • to 100 | Very High | Very high potential for P movement from this site. Add conservation practices or reduce P applications to achieve a P Index < 100 in the short term. Develop a management plan with the goal of achieving a P Index < 75 within 5 years. |

The source, transport, and BMP factors are combined to get an overall P index:

*P Index =* *Risk of Soluble P in Runoff + Risk of Particulate P in Runoff + Risk of Soluble P in Leachate*

Depending on the value of the P index, the site is considered to have a Low, Medium, High, or Very High potential for P loss (Table 3). If the P index is low, then N-based NMPs can be used. If the P index is too high, then a management plan to reduce the P index needs to be implemented and could include a P-based NMP.

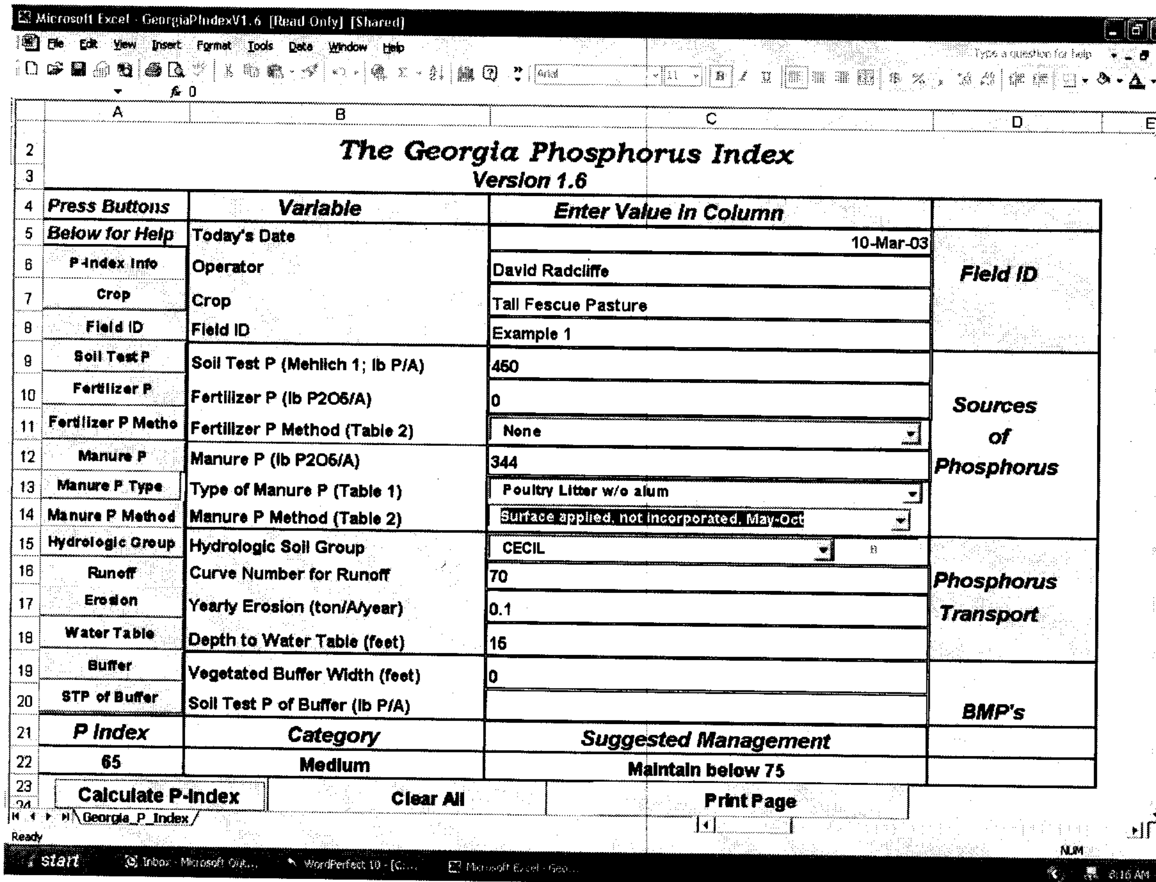


| Press Buttons Below for Help | Variable | Enter Value in Column | |
|---|---|---|---|
| | Today's Date | 10-Mar-03 | Field ID |
| P-Index Info | Operator | David Radcliffe | |
| Crop | Crop | Tall Fescue Pasture | |
| Field ID | Field ID | Example 1 | |
| Soil Test P | Soil Test P (Mehlich 1; lb P/A) | 450 | Sources of Phosphorus |
| Fertilizer P | Fertilizer P (lb P2O5/A) | 0 | |
| Fertilizer P Metho | Fertilizer P Method (Table 2) | None | |
| Manure P | Manure P (lb P2O5/A) | 344 | |
| Manure P Type | Type of Manure P (Table 1) | Poultry Litter w/o alum | |
| Manure P Method | Manure P Method (Table 2) | Surface applied, not incorporated, Dec-Feb | |
| Hydrologic Group | Hydrologic Soil Group | CECIL B | Phosphorus Transport |
| Runoff | Curve Number for Runoff | 70 | |
| Erosion | Yearly Erosion (ton/A/year) | 0.1 | |
| Water Table | Depth to Water Table (feet) | 15 | |
| Buffer | Vegetated Buffer Width (feet) | 0 | BMP's |
| STP of Buffer | Soil Test P of Buffer (lb P/A) | | |
| P Index | Category | Suggested Management | |
| 100 | Very High | Reduce value below 100 | |

**Figure 4**. Georgia P index calculation for Example 1.

Suppose we have a hay field (Example 1) with the following source characteristics: the soil test P level is 450 lb/acre; poultry litter without any alum added is surface applied annually sometime during the period from December to February at a rate of 5 tons/acre; no fertilizer is applied. The amount of P added in the manure must be expressed as lbs of $P_2O_5$ per acre. To do this, multiply the manure rate (5 tons/acre) by the P content per ton from Table 2 (30 lbs P/ton) and then multiply by the conversion factor (2.29) to get 344 lbs $P_2O_5$ /acre. The site has the following transport characteristics: the runoff curve number is 70 (calculated using TR-55 or obtained from NRCS); the soil is a Cecil with hydrologic group B (obtained from Soil Survey database); the estimated annual erosion is 0.1 ton/acre (calculated using USLE or obtained from NRCS farm plan); the depth to the water table is 15 feet; there are no buffers around the field.

The calculated P index is 100, which is in the Very High category and we are advised to change our management plant in order to reduce the P index below 100 in the short-term and below 75 in the long-term (Fig. 4). If we try adding a vegetated buffer at the edge of the field and the soil test P is in this area is the same as in the field (likely to be the case), we don't get any reduction in the P index because the soil test P level is not less than 450 lb/acre (the upper limit for buffers to have a beneficial effect). We can change the time of application of the manure from December and February to November and March when the risk of runoff is lower. This will reduce the P index to 83 and we would satisfy the short-term goal of reducing the P index from the Very High to High category, but we would still have the long-term goal of getting the P index below 75 (to the Medium category). Changing the time of application to the period May to October reduces the P index to 65 and achieves the long-term goal.



The Georgia Phosphorus Index
Version 1.6

| Press Buttons | Variable | Enter Value in Column | |
|---|---|---|---|
| Below for Help | Today's Date | 10-Mar-03 | Field ID |
| P-Index Info | Operator | David Radcliffe | |
| Crop | Crop | Tall Fescue Pasture | |
| Field ID | Field ID | Example 1 | |
| Soil Test P | Soil Test P (Mehlich 1; lb P/A) | 450 | Sources of Phosphorus |
| Fertilizer P | Fertilizer P (lb P2O5/A) | 0 | |
| Fertilizer P Metho | Fertilizer P Method (Table 2) | None | |
| Manure P | Manure P (lb P2O5/A) | 344 | |
| Manure P Type | Type of Manure P (Table 1) | Poultry Litter w/o alum | |
| Manure P Method | Manure P Method (Table 2) | Surface applied, not incorporated, May-Oct | |
| Hydrologic Group | Hydrologic Soil Group | CECIL | Phosphorus Transport |
| Runoff | Curve Number for Runoff | 70 | |
| Erosion | Yearly Erosion (ton/A/year) | 0.1 | |
| Water Table | Depth to Water Table (feet) | 16 | |
| Buffer | Vegetated Buffer Width (feet) | 0 | BMP's |
| STP of Buffer | Soil Test P of Buffer (lb P/A) | | |
| P Index | Category | Suggested Management | |
| 65 | Medium | Maintain below 75 | |
| Calculate P-Index | Clear All | Print Page | |

**Figure 5**. Georgia P index calculation for Example 1 after changing the time of application to May-Oct.

Other examples are provided in Table 4. Example 2 is the same as Example 1, except that the curve number for the soil is raised. This causes more runoff and raises the P index. Example 3 is a broiler litter example (4 ton/acre) where the crop is corn and litter is surface applied and incorporated within 30 days in a soil with a low soil test P. The erosion rate is higher in this example compared to the earlier examples due to tillage, but the P index is in the Medium category. This is due primarily to the effect of incorporation which reduces the risk of P loss in runoff and the low soil test P. Example 4 is the same as Example 3, except the soil test P is quite high and this produces a P index above 75. In Example 5, dairy slurry (3 in/ acre) is applied by a sprinkler system to a pasture with a high soil test P. In all of the examples except Example 3, BMPs or a reduction in the application rate is required to reduce the P index to a satisfactory level.

**Table 4.** Georgia P index Example calculations.

| Example # | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Manure | Broiler litter | Broiler litter | Broiler litter | Broiler litter | Dairy slurry |
| Crop | Pasture | Pasture | Corn | Corn | Pasture |
| Soil test P (lb/acre) | 450 | 450 | 20 | **400** | 400 |
| Manure P applied (lb $P_2O_5$/acre) | 344 | 344 | 275 | 275 | 227 |
| Manure P Method | surface Dec-Feb | surface Dec-Feb | surface incorporated <30 days | surface incorporated <30 days | sprinkler applied |
| Soil series (hydrologic group) | Cecil (B) | Cecil (B) | Cecil (B) | Cecil (B) | Cecil (B) |
| Curve # | 70 | **75** | 80 | 80 | 80 |
| Erosion (T/acre) | 0.1 | 0.1 | 2.0 | 2.0 | 2.0 |
| Water table (ft) | 15 | 15 | 3 | 3 | 15 |
| BMPs | none | none | none | none | none |
| P index | **100** | **148** | **63** | **93** | **84** |
| Alternatives | Change time of application, reduce application rate | | OK | Add buffer, change time of application, reduce application rate | |

The Georgia P index spreadsheet (an Excel file) can be downloaded from the Georgia NRCS web site www.ga.nrcs.usda.gov/gatechnical/afo.htm. There is also a Word file that explains the Georgia P index.

**Summary of Essential Information**

The most essential points in this lesson are listed below.

- The primary water quality concern with P is that it can cause eutrophication of lakes.
- Several large lakes in Georgia already show signs of eutrophication.

- Most of the P in soils is tightly adsorbed in the topsoil; but soil can be eroded with runoff, and a small amount of P is dissolved and also available to runoff.
- As the soil test P level at the soil surface goes up, so does the concentration of P in runoff.
- Manures present a special problem because the N-to-P ratio in manure is not the same as what most crops need – as a result P is over-applied when a N-based NMP is used.
- P-based plans will require substantially lower manure application rates.
- For P contamination to occur, there must be a source of high concentration P and a mechanism for transporting the P to a sensitive water body.
- There are a number of best management practices that limit the source or transport of P.
- The P index will be used to determine which fields in Georgia need to incorporate BMPs or reduce P application rates.
- Fields must have a P index less than 75.

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# Nutrient Budgeting of Manure

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## Intended Outcomes

The participant will

- Be able to determine all the sources and levels of nutrients available in the farm.
- Be able to calculate the amount of nutrients available and compare with the nutrients needed by the crop to obtain the expected yields.
- Understand the farm's nutrient balance and identify management strategy to achieve environmentally sustainable operation.

## Introduction

Animal manure has long been recognized as a source of nutrients for crops. The effluent and solid waste generated from livestock operations can be beneficially reused to improve soil chemical and physical properties. However, if used improperly and at rates that exceed crop nutrient needs, animal wastes can pose problems to soil and water resources. It is important to balance the input of nutrients and salts in manure and other animal wastes applied to land, with the uptake of these by the crops to ensure that nutrient losses are reduced and an environmentally sustainable operation is achieved.

In general, animal wastes contain high concentrations of salt, nitrogen, phosphorus and heavy metals (copper, arsenic, etc.) and therefore, could have a potential impact on soil and water resources if not managed appropriately. Earlier effort was aimed at optimizing manure rates to satisfy crop nutrient requirements and meet yield goals. However, with increasing public concern, legislations, and the potential of greater environmental regulations, the current need is to evaluate the nutrient input-output within the context of the whole farming system, and assess any impacts on the environment.

## Forms of Animal Waste and Its Application

Animal wastes come in different forms and are applied in various ways. Solid manure, liquid manure, litters, composts, and lagoon effluents are the most common types of manure. They are applied to soils through a variety of spreading, tillage, and irrigation practices. Compared to inorganic commercial fertilizers, animal manures are generally bulky, highly variable in composition, and low in nutrient content. However, the large volume of manure that is normally generated on a farm can represent a significant amount of fertilizer value and may satisfy some of the nutrient needs of the crop. The amount of manure required to supply nutrients to a crop can easily be 10- to 100-fold the amount of commercial fertilizer needed. The economics of hauling animal manures to great distances or using manures for alternative purposes such as feed or fuel are not currently feasible. Thus, on-site land application is the most common usage of animal manures. Land application is expected to be the primary way of animal waste disposal until the economic feasibility and practicality of transporting manures long distances or alternative usage improves.

## Nutrient Management

Understanding the sources of nutrients is critical in identifying management strategy for reducing nutrient losses and achieving an environmentally sustainable operation. Balancing the nutrients contained in animal manures with crop needs and determining an appropriate application rate for agronomic purposes is referred to as a "nutrient management plan". Currently, it is more common to view this exercise as a key component of a larger "comprehensive nutrient management plan". Traditionally, manure application rates are calculated to provide nitrogen (N) to crops because most crops require more N than any other fertilizer element. Balancing manure rates with a crop's needs for N is also known as N as a "priority nutrient" or an "N-based plan". For many years, the N-based nutrient management plans were employed to address environmental concern associated with excessive nitrogen applications from manure such as nitrate leaching into groundwater. Recently, environmental concerns have focused more on excessive phosphorous applications from manures and its adverse effect on surface water quality. The "P-based" plan, however, is not currently required but it could be potentially considered in the future as P is increasingly detected in water resources.

## Nutrient Budget

Developing nutrient budget as a management tool for farmers has the potential to effectively reduce excess levels of nutrients on the farm and decrease nutrient inputs. This allows the farmer to compare all the sources of nutrients and nutrient needs of the crops. Application rates need to be selected so that sufficient nutrients are provided to the crop without leaving residues that can contaminate the water resources. Optimum use of these nutrients will help prevent pollution of the environment, preserve soil fertility, reduce damage to natural waters, and help safeguard fish and animal life.

Nutrient budgeting can serve a number of different purposes. The most common purpose will be to determine the proper application rate for a given field in an actual situation using real numbers for crop needs and nutrients in manure. Nutrient budgeting can also be used as a planning tool at the farm level to determine if adequate land base is present for the cropping system planned. Finally, nutrient budgeting can be used as an educational tool to calculate application rates based on various "simulated" scenarios, for example, how much manure one can apply given a particular soil test phosphorous level.

Nutrient budgets or balances can be either calculated by hand or by using a computer program. A "Nutrient Budget Worksheet" is provided at the end of this chapter for hand calculations (Appendix A). This worksheet was originally developed for dairy manure nutrient management in Georgia. Space for calculations based on only one priority nutrient (N or P, not both) is provided. The preferred method of calculating nutrient balances of manure is to use the "Georgia Field Level Nutrient Budget Worksheet" (Appendix B). This spreadsheet can be downloaded as either an Excel or Quattro Pro program by going to the AWARE homepage (http://www.engr.uga.edu/service/extension/agp2/aware/newtools.php). Under the **Field Nutrient Balance Spreadsheets** heading, click on Excel Spreadsheet File (or Corel Quattro Pro)

## Developing a Nutrient Budget

There are three steps required in developing a nutrient budget:

1) Determine crop nutrient requirements

2) Determination of nutrients supplied by manure

3) Balancing crop nutrient needs with nutrients supplied by manure

**Step 1.** *Determine Crop Nutrient Requirements.* The first step of any nutrient budgeting plan is to determine the nutrient needs of the crop to be grown. This is accomplished by knowing the nutrient requirement of the crop and matching it with the residual amount of nutrients in soils. The latter is determined through soil testing. The fertilizer recommendation given in the soil test report is based on the nutrient requirement of the crop that has been determined from historical field research for a particular soil and climate.

Crops vary in their ability to use nutrients. Some examples of the nutrients uptake by common crops are shown in Table A. Note that Table A is generalized for the U.S., and specific data for each region should be obtained from local experts. These values can be used to determine crop nutrient needs in conjunction with soil test results.

When selecting a crop, there are numerous considerations that need to be made such as the suitability and adaptability of the crop to the local environment. When manure is applied, the crop must be able to absorb the nutrients and produce adequate yields, placing an emphasis on the economic value of the crop. Without the crops to actively utilize the nutrients, manure-derived nutrients could be washed directly into surface streams or leached into the groundwater. Also, the vegetative cover from the crops may reduce the potential for runoff and erosion from an area.

Manure-derived nutrients applied either at insufficient or excessive levels can have detrimental effects to crop yields and the quality of the environment. Insufficient nutrient supply from manure may result in deficiencies, which can reduce crop yield and quality. Excessive applications can negatively affect both the plant and the environment. The effect of too much fertilization on plant growth depends on the crop and nutrients involved. In most cases, too much phosphorus (P) and potassium (K) have little effect on plant growth and yield unless so much is applied that results to salt injury. However, too much P in the soil may have negative environmental consequences if significant amounts of P exit the site and reaches water bodies. In the case of excess nitrogen (N), crops may be more susceptible to diseases and insects leading to poor yields. Excess metals, such as copper and zinc, can be also be toxic to plants. In extreme cases, soil concentrations of these metals can be high enough to limit or prevent the growth of certain crops.

Soil testing plays a major role in determining crop nutrient needs. Public or private services can be used as long as the laboratories are considered reputable and use methods adapted for your local region. Most soil testing laboratories give results and recommendations for the major plant nutrients (N, P, K), secondary plant nutrients (Ca, Mg, S), micronutrients (Mn, Zn) and pH. Even though most manure budgets will be based on either N or P, it is important always to test soils and keep good records of all of these essential plant nutrients in order to provide an overall proper balance of soil fertility to the crop.

Table A. Plant nutrient uptake by specified crop and removed with the harvested part of the crop. Table A represents U.S. Averages.

| Crop | N | $P_2O_5$ | $K_2O$ | Units |
|---|---|---|---|---|
| Barley Grain | 0.87 | 0.37 | 0.25 | lbs./bu. |
| (Straw) | 15.00 | 5.04 | 30.12 | lbs./ton |
| Buckwheat(Grain) | 0.79 | 0.34 | 0.26 | lbs./bu. |
| (Straw) | 15.60 | 2.29 | 54.46 | lbs./ton |
| Corn (Grain) | .90 | .36 | .27 | lbs./bu. |
| (Stover) | 22.20 | 9.16 | 32.29 | lbs./ton |
| Oats (Grain) | 1.27 | .51 | .38 | lbs./bu. |
| (Straw) | 12.60 | 7.33 | 40.00 | lbs./ton |
| Rice (Grain) | 0.63 | 0.25 | .12 | lbs./bu. |
| (Straw) | 12.00 | 4.12 | 27.95 | lbs./ton |
| Rye (Grain) | 1.16 | 0.33 | 0.33 | lbs./bu. |
| (Straw) | 10.00 | 5.50 | 16.63 | lbs./ton. |
| Sorghum (Grain) | .94 | 0.46 | 0.28 | lbs./bu. |
| (Stover) | 21.60 | 6.87 | 31.57 | lbs./ton |
| Wheat (Grain) | 1.25 | 0.85 | 0.38 | lbs./bu. |
| (Straw) | 13.40 | 3.21 | 23.37 | lbs./ton |
| **Oil Crops** | | | | |
| Flax (Grain) | 2.29 | 0.71 | 0.57 | |
| (Straw) | 24.80 | 5.04 | 42.17 | lbs./ton |
| Peanuts (Grain) | 36.00 | 3.89 | 6.02 | lbs/1000 lbs. |
| (Vines) | 46.60 | 10.99 | 42.17 | lbs/ton |
| Rapeseed (Grain) | 1.80 | 0.90 | 0.46 | lbs./bu. |
| (Straw) | 89.60 | 19.69 | 81.20 | lbs./ton |
| Soybeans (Grain) | 3.75 | 0.88 | 1.37 | lbs./bu. |
| (Stover) | 45.00 | 10.08 | 25.06 | lbs./ton |
| Sunflower (Grain) | 35.70 | 39.16 | 13.37 | lbs./1000 lbs. |
| (Stover) | 30.00 | 8.24 | 70.36 | lbs./ton |
| **Fiber Crops** | | | | |
| Cotton | 26.70 | 13.28 | 10.00 | lbs./1000 lbs. |
| (Seed Stalk) | 17.50 | 5.04 | 17.47 | 1bs.1000 lbs. |
| Pulpwood | 0.12 | 0.05 | 0.07 | % |
| (Bark & Branches) | 0.12 | 0.05 | 0.07 | % |
| **Forage Crops** | | | | |
| Alfalfa | 45.00 | 10.08 | 45.06 | lbs./ton |
| Bahiagrass | 25.40 | 5.95 | 41.69 | lbs./ton |
| Big Bluestem | 19.80 | 38.93 | 42.17 | lbs./ton |
| Birdsfoot refoil | 49.80 | 10.08 | 43.86 | lbs./ton |
| Bluegrass-pastd. | 58.20 | 19.69 | 46.99 | lbs./ton |
| Bromegrass | 37.40 | 9.62 | 61.45 | lbs./ton |
| Clover-grass | 30.40 | 12.37 | 40.72 | lbs./ton |
| Dallisgrass | 38.40 | 9.16 | 41.45 | lbs./ton |
| Guineagrass | .25.00 | 20.15 | 45.54 | lbs./ton |

| Crop | N | $P_2O_5$ | $K_2O$ | Units |
|---|---|---|---|---|
| Bermuda grass | 37.60 | 8.70 | 33.73 | lbs./ton |
| Indian grass | 20.00 | 38.93 | 28.92 | lbs./ton |
| Lespedeza | 46.60 | 9.62 | 25.54 | lbs./ton |
| Little bluestem | 22.00 | 38.93 | 34.94 | lbs./ton |
| Orchard grass | 29.40 | 9.16 | 52.05 | lbs./ton |
| Panagolagrass | 26.00 | 21.53 | 45.06 | lbs./ton |
| Paragrass | 16.40 | 17.86 | 38.31 | lbs./ton |
| Red Clover | 40.00 | 10.08 | 40.00 | lbs./ton |
| Reed canarygrass | 27.00 | 8.24 | - | lbs./ton |
| Ryegrass | 33.40 | 12.37 | 34.22 | lbs./ton |
| Switchgrass | 23.00 | 4.58 | 45.78 | lbs./ton |
| Tall Fescue | 39.40 | 9.16 | 48.19 | lbs./ton |
| Timothy | 24.00 | 10.08 | 38.07 | lbs./ton |
| Wheatgrass | 28.40 | 12.37 | 64.58 | lbs./ton |
| **Silage Crops** | | | | |
| Alfalfa haylage | 27.90 | 7.56 | 27.95 | lbs./ton |
| Corn silage | 7.70 | 4.01 | 9.19 | lbs./ton |
| Forage sorghum | 8.64 | 2.61 | 7.37 | lbs./ton |
| Oat haylage | 12.80 | 5.13 | 9.06 | lbs./ton |
| Sorghum-sudan | 13.60 | 3.66 | 17.47 | lbs./ton |
| **Sugar Crops** | | | | |
| Sugarcane | 3.20 | 1.83 | 8.92 | lbs./ton |
| Sugar beets | 4.00 | 1.37 | 3.37 | lbs./ton |
| Sugar beet tops | 8.60 | 1.83 | 24.82 | lbs./ton |
| **Tobacco** | | | | |
| All types | 37.50 | 7.56 | 60.00 | lbs./1000 lbs. |
| **Vegetable Crops** | | | | |
| Bell peppers | 8.00 | 5.50 | 11.81 | lbs./ton |
| Beans dry | 62.60 | 20.61 | 20.72 | lbs./ton |
| Cabbage | 6.60 | 1.83 | 6.51 | lbs./ton |
| Carrots | 3.80 | 1.83 | 6.02 | lbs./ton |
| Cassava | 8.00 | 5.95 | 15.18 | lbs./ton |
| Celery | 3.40 | 4.12 | 10.84 | lbs./ton |
| Cucumbers | 4.00 | 3.21 | 7.95 | lbs./ton |
| Lettuce (heads) | 4.60 | 3.66 | 11.08 | lbs./ton |
| Onions | 6.00 | 2.75 | 5.30 | lbs./ton |
| Peas | 73.60 | 18.32 | 21.69 | lbs./ton |
| Potatoes | 6.60 | 2.75 | 12.53 | lbs./ton |
| Snap beans | 17.60 | 11.91 | 23.13 | lbs./ton |
| Sweet corn | 17.80 | 10.99 | 13.98 | lbs./ton |
| Sweet potatoes | 6.00 | 1.83 | 10.12 | lbs./ton |
| Table beets | 5.20 | 1.83 | 6.75 | lbs./ton |

Source: NRCS Agricultural Waste Management Field Handbook 1992.

Another important reason for soil sampling on a routine basis is to track soil pH and follow appropriate lime recommendations. Animal manure such as poultry litter has a slight liming capacity. Therefore, where poultry manures are used, liming may not be recommended as frequently compared to where they are not used. In addition, nutrient availability in soils is dependent on soil pH. If soil pH is not closely monitored (recommend annually for fields receiving manure applications), nutrient availability and uptake may be very different from expected results. Not only is liming important for the availability of essential plant nutrients, liming can also render certain nutrients that are toxic to most plants unavailable; a good example is aluminum.

Even though soils are not tested for N content, N recommendations for crop growth are included on soil test reports. The reason soil N is not analyzed is that this element is highly mobile in the soil and is constantly going through transformations such as mineralization, leaching, volatilization, and immobilization. Some areas in the U.S. are able to utilize soil nitrate testing for pre-plant or pre-sidedress N recommendations. However, on highly weathered, low organic matter, sandy soils of the Southeast, these testing procedures have not been deemed successful. Therefore, N recommendations as found on the soil test reports in the Southeastern U.S. are based on field studies where varying rates of N fertilizer were applied and crop yield response was measured.

Legume plants, such as peanuts, soybeans, clovers and vetches, are not good candidates for receiving manure applications since they fix their own N. When non-legume plants like corn or cotton follow these plants in rotation, the "residual" nitrogen must be accounted for in the nutrient budget. Alfalfa, vetch and clover give an N "credit" of 80 lbs/ac to the following crop, whereas soybeans and peanuts are worth 30 lb N/ac. These values can also be easily referenced in a Table 2 in the UGA computer spreadsheet program.

Fertilizer credits, N, P, and maybe K, need to be accounted for when using commercial fertilizer or any other nutrient source in conjunction with animal manure. A good example of this would be the use of starter fertilizer such as 10-34-0 on corn or cotton. Both the hand and computer versions of the nutrient budget sheets have space just under the input line for "crop needs" to factor in both other fertilizer and residual N credits from legumes. In the computer version, once you enter the values for "Commercial Fertilizer Applications" and "Residual N from Legumes", the final crop nutrient needs of the plant are automatically calculated and appear in the "Net Manure Nutrient Needs of Crop" columns for N, P and K

Final crop yields are not determined by soil fertility alone. Other factors such as soil management, climate, plant population, timing, pest control, and variety selection are also important. Because the amount of nutrients required by a crop usually varies directly with the yield, expected yields must be considered. Fortunately, soil test reports from reputable laboratories in your area should already account for yield goals. In some cases, for example cotton fertilizer recommendations in Georgia, most labs request input on yield goal and adjust accordingly. In other cases, for example corn recommendations from the University of Georgia, different yield goals are used for dryland vs. irrigated. Guidelines are also given to adjust for higher yields. Where yield records are available, you can average the three highest yields in five consecutive crop years to calculate a realistic yield goal for a given field. Using an unrealistic yield goal that is too high can result in over application of nutrients from manure. On the other hand, underestimating yield goal or potential can result in under application of nutrients and possibly crop nutrient deficiencies.

**Step 2.** _Determine Nutrients Supplied by Manure_. The second basic step in developing a nutrient budgeting plan is very similar to the first. In this case instead of having soil analyzed to determine crop nutrient needs, the animal manure is analyzed to determine the nutrient supplying power of the manure. Like with soil sampling, taking a representative sample is important to get an accurate estimate of the nutrient content of the manure (please refer to Manure Sampling and Analysis chapter). Using "book values" to estimate nutrient content of manure should be avoided whenever possible because of high variability between manures as discussed earlier in this chapter. Manure samples may be submitted to a reputable laboratory for analysis.

Most laboratories analyze manure samples for primary nutrients (N, P, and K), secondary nutrients (Ca, Mg, and S) and micronutrients. Primary and secondary nutrients are often reported as % and micronutrients as parts per million (ppm). Most laboratories also report results on an "as is" or "wet basis" so the moisture does not have to be factored back in. Laboratories such as the UGA lab also report P as $P_2O_5$ and K as $K_2O$ so they are already on a "fertilizer" basis. The UGA lab also converts and reports each nutrient from % or ppm to lbs/ton for "dry" manures to lbs/1000 gal for "liquid" manures.

The following conversion factors may be helpful:

lbs of P x 2.29 = lbs of $P_2O_5$

lbs of K x 1.2 = lbs of $K_2O$

parts per million (ppm) and milligrams per liter (mg/l) are assumed to be equal

ppm or mg/l x 0.002 = lbs/ton

ppm or mg/l x 0.226 = lbs/ac-in

ppm or mg/l x 0.008 = lbs/thousand gallons

one acre-inch = 27,000 gallons

The nutrients contained in manures and reported as "total" N, P and K are usually not considered to be 100% available for crop uptake, unlike the inorganic commercial fertilizers where nutrients are assumed to be all available. While inorganic nutrients from fertilizers are already in a form for plant uptake, the nutrients in manures are in "organic" forms that need to be converted first to inorganic forms before they can be utilized by plants. This is particularly important for N. Nitrogen in organic fraction must undergo mineralization process through the action of microbes to become plant available. Mineralization is the conversion of minerals from an organic to an inorganic form.

Some laboratories report manure nutrient results on a "plant-available" basis. The UGA lab for example, reports total N, $P_2O_5$, and $K_2O$. In this case, availability coefficients must be used to calculate the true nutrient supplying capacity of the manure. The first-year availability coefficients of various livestock manures are given in Table B. This table is also identical to Table 1 provided with the UGA computer spreadsheet for manure nutrient budgeting.

Table B. Livestock manure nutrient first-year availability coefficients.

| Type of Manure | Application Method | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil incorporation | | | Broadcast | | | Irrigation | | |
| | N | $P_2O_5$ | $K_2O$ | N | $P_2O_5$ | $K_2O$ | N | $P_2O_5$ | $K_2O$ |
| **Scraped manure** | | | | | | | | | |
| Dairy | 0.6 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| Beef | 0.6 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| Swine | 0.6 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| Sheep/Goat | 0.6 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| Horse, stable | 0.5 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| **Poultry House Litter** | | | | | | | | | |
| All Poultry Litters | 0.7 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| **Liquid manure slurry** | | | | | | | | | |
| Dairy | 0.7 | 0.8 | 1.0 | 0.5 | 0.7 | 1.0 | 0.4 | 0.7 | 1.0 |
| Beef | 0.7 | 0.8 | 1.0 | 0.5 | 0.7 | 1.0 | 0.4 | 0.7 | 1.0 |
| Swine | 0.7 | 0.8 | 1.0 | 0.4 | 0.7 | 1.0 | 0.3 | 0.7 | 1.0 |
| Layer | 0.7 | 0.8 | 1.0 | 0.5 | 0.7 | 1.0 | 0.4 | 0.7 | 1.0 |
| **Lagoon liquid** | | | | | | | | | |
| Dairy | 0.8 | 0.9 | 1.0 | 0.5 | 0.8 | 1.0 | 0.5 | 0.8 | 1.0 |
| Beef | 0.8 | 0.9 | 1.0 | 0.5 | 0.8 | 1.0 | 0.5 | 0.8 | 1.0 |
| Swine | 0.9 | 0.9 | 1.0 | 0.5 | 0.8 | 1.0 | 0.5 | 0.8 | 1.0 |
| Layer | 0.9 | 0.9 | 1.0 | 0.5 | 0.8 | 1.0 | 0.5 | 0.8 | 1.0 |

* Not applicable

In order to choose the correct availability coefficient to use in the calculations, you need to consider the following:

1) type of manure
2) application method

For example, if you are dealing with poultry (broiler) litter that will be broadcast and then soil incorporated within two days, the availability coefficients for N, $P_20_5$ and $K_20$ will be 0.7, 0.8, and 1.0, respectively. If calculating a nutrient budget by hand, you would multiply the values given for total N, $P_20_5$ and $K_20$ by these coefficients to come up with "available" nutrients supplied by the manure. In the case of the computer program, you simply enter the coefficients on the appropriate line and then the "Manure Nutrients Available to Crop" are automatically calculated.

The method of manure application affects nutrient availability in a number of ways. Manure placement affects the ability of crops to utilize most of the applied nutrients and the likelihood of manure runoff from the site. Application to the soil surface typically results in greater potential for N loss through volatilization (escape as a gas) and runoff than where manures are incorporated (mixed with the topsoil) or injected. Uniformity of nutrient applications and distance from the root system can also influence crop response to nutrient applications. The method of application can also affect odor. Careful placement also means irrigating at rates that prevent runoff.

The application method for manures often depends on the type of application equipment that is available or is the method that is most cost or time effective. Many growers choose broadcast nutrient application because of fewer time constraints and lower cost. Again, incorporating manures into soils increases the availability coefficient. Where nutrient utilization is a prime consideration, the handling system may dictate the method of application. For example, solid or semisolid materials cannot be effectively injected into the soil or applied through an irrigation system, while lagoon liquids are most economically applied through an irrigation system. The application rate of the irrigation equipment will also determine if the manure moves into the soil or runs off.

Some labs convert manure nutrient analyses to a "plant-available" basis, so that calculations are not necessary prior to manure application. However, in order for the lab to do this, you must supply them with information concerning type of manure and application method. If you need this information and a lab does report the nutrients in manure on a "plant available" basis, still check their plant available factors to be sure it fits your situation and corresponds to the values listed in Table 2.

Another term that is reported by some labs and may lead to some confusion is plant available nitrogen or "PAN". This term is usually calculated by multiplying the organic N fraction of manure by a mineralization factor and adding that value to analyzed values for the inorganic forms of nitrogen in manure (ammonium-N and nitrate-N). In fact, the UGA lab analyzes manures for ammonium and nitrate N. However, PAN is basically used to describe the portion of the total N that is available for crop uptake just like the N availability factors in Table B. For simplicity, the N supplying capacity of manures should be calculated by multiplying total N by the appropriate availability coefficient, and by using a "PAN" value.

**Step 3**. *Balance Crop Nutrient Needs with Nutrients Supplied by Manure*. The third and final step in calculating a nutrient budget for animal manures is to simply match the nutrient needs by the crop to be grown in step 1 (based on soil test) with the nutrient supplying capacity of the manure calculated in step 2 (total N-P from a manure analysis times appropriate availability coefficients).

The best way to demonstrate how this would be done is with the following examples:

Example #1 - Using broiler litter for cotton production on a medium P testing soil in South Georgia

Given: 100 acres of cotton

Crop Needs based on soil test of 90-60-3 5 (lbs N-$P_2O_5$-$K_2O$ per acre)

Manure analysis shows 60-60-40 (total lbs N-$P_2O_5$-$K_2O$ per ton "as is")

Application method = Soil Incorporated (availability coefficients for

N-$P_2O_5$-$K_2O$ = 0.7-0.8-1.0)

Calculate: 1) Appropriate application rate in ton/a for an N-based plan

2) Appropriate application rate in ton/a for a P-based plan

Answers: 1) 2.14 ton/a (90 lbs N/ac divided by (60 x 0.7) lbs N/ton)

2) 1.25 ton/a (60 lbs $P_2O_5$/ac divided by (60 x 0.8) lbs $P_2O_5$/ton)

Notice that a higher application rate of manure is recommended when N-based compared to P based. This is very common and is due to the fact that most crops require less P than N, plus most manures contain about as much P as N. Based on these rates and since there is 100 acres available, the cotton farmer will be able to utilize 214 tons of litter if N-based (2.14 tons/ac x100 acres), but only 125 tons if P-based (1.25 x 100).

The example above is based on a soil testing in the "medium" range for P using the UGA lab. If the soil test P rating changes, either up or down, the application rate if using an N-based budget will not change. However, if a P-based budget is used and the soil test P is lower, then an application rate higher than 1.25 ton/a will be recommended. On the other hand, if the soil test rating for P increases into the high range, less manure than 1.25 ton/ac will be recommended. Once the soil test rating for P increases into the "very high" range, a manure application rate of 0 ton/a will be recommended for the P-based budget. At this point, this recommendation is for agronomic purposes only, not environmental purposes.

Example 2 - Using broiler litter for tall fescue pasture on a medium P testing soil in North Georgia

Given: 100 acres of tall fescue pasture

Crop Needs based on soil test of 50-30-25 (lbs N-$P_2O_5$-$K_2O$ per acre)

Manure analysis shows 60-60-40 (total N-$P_2O_5$-$K_2O$ lbs per ton "as is")

Application method = Broadcast (availability coefficients for N-$P_2O_5$-$K_2O$ = 0.5-0.7-0.9)

Calculate: 1) Appropriate application rate in ton/ac for an N-based plan

2) Appropriate application rate in ton/ac for a P-based plan

Answers: 1) 1.67 ton/ac (50 lbs N/ac divided by (60 x 0.5) lbs N/ton)

2) 0.7 ton/ac (30 lbs $P_2O_5$ divided by (60 x 0.7) lbs $P_2O_5$/ton)

Notice that both the N-based and P-based application rates are lower in tall fescue than in the South Georgia cotton example above. This is basically due to the lower nutrient demand by tall fescue pasture. Take note also that less nutrients are available from manure in example 2 due to broadcasting (lower availability coefficients) rather than incorporating the litter. Based on these recommended application rate, this livestock producer would only be able to utilize 167 tons (1.67 tons/a x 100 acres) of litter if N-based and 70 (0.7 x 100) tons if P-based on a 100-acre area.

## How To Use The UGA Computer Program

Both the "hand" (Appendix A) and computer (Appendix B) spreadsheets use the basic calculations and procedures as used in the two examples above. In addition, they both require some additional and useful record keeping information (for example farmer name, soil type, yield goal) that is not directly used in calculating the nutrient budget.

The main disadvantage of the "hand" spreadsheet is that all figures have to be recorded by hand, all calculations have to be done using a calculator, and the nutrient budget can only be calculated using either N or P (but not both) as the priority nutrient.

The UGA computer spreadsheet is the preferred method of calculating nutrient budgets for manure because it makes a number of calculations automatically and includes a fertilizer value of manure used in $/ton or 1000 gallons.

Once you've downloaded the spreadsheet, you can enter information for a given field or situation into the spaces provided in the blue shaded area. All information recorded in the top half of the blue section, from the producer's name to the manure application method, are important for record keeping but are not used in any of the calculations.

The key information is entered on the "Crop Nutrient Needs", "Manure Nutrient Concentrations" and "Availability Coefficients" lines. The "Commercial Fertilizer Applications" and Residual N from Legumes" (use the "Legume" tab to go to Table 2) are used to calculate "Net Manure Nutrient Needs of Crop". Default values of 34 cents/lb N, 25 cents/lb P and 16 cents/lb K are automatically entered on the "Equivalent Fertilizer Price" line. These values can be changed to reflect local prices of the fertilizer to be used by your farmer. They are then used to calculate the "Fertilizer Value" of the manure.

Anytime a value in the blue box that is used in a calculation is changed, the affected values below should change. For example, if the "Crop Nutrient Needs" for N is changed, then the recommended manure application rate found in the yellow box below should change. Use both the "Legume" and more importantly the "Availability" tabs for easy reference for input onto the "Residual N from Legumes" and "Availability Coefficients" lines in the blue box. There is also a series of tabs with helpful information for most of the inputs. These can be found in Appendix B as "Additional Instructions on NBW Data Entry". Notice also that there is a "units/a" button for the "Manure Nutrient Concentration" input line that guides the user to lb/ton for dry manure and either lb/ac-in or lb/thousand gallons for liquid manures.

Once you have completed a "worksheet" it can be printed either using the "print" button or by highlighting the desired cells on the spreadsheet and using the print command on the main "File" pull down menu. The individual record can also be saved, using the "save as" command under the "File" menu. Each time you can save the new record with a different and unique filename.

To show what a completed Nutrient Budget Worksheet using the UGA computer program would look like, Examples # I and #2 discussed earlier can be found on the last two pages of this chapter.

Manure type and application method are both used to determine the availability of nutrients in manure. You should enter your manure type and application method based on the selections given below. Table 1 gives details on manure availability coefficients based on selected manure type and application method.

Appendix A

## NUTRIENT BUDGET WORKSHEET

1. Producer ______ County ______ Date ______

4. Farm # ______ 5. Tract # ______ 6. Field # ______ 7. Acres ______

8. Soil Series ______ 9. Leaching Potential ______

10. Tillage Practices ______ 11. Planned Crop ______

12. Yield Expectations ______ 13. Soil Test Rating: (a) P ______ (b) K ______ (c) pH ______

14. Nutrients recommended (lbs/ac): (a) N ______ (b) $P_2O_5$ ______ (c) $K_2O$ ______

15. Lbs/ac starter fertilizer used: (a) N ______ (b) $P_2O_5$ ______ c) $K_2O$ ______

16. Residual nitrogen credit from legumes (see back) ______ lbs/ac

17. Net N needs of crop (14a minus 15a and 16) ______ lbs/ac

18 Net $P_2O_5$ needs of crop (14b minus 15b) ______ lbs/ac

19. Net $K_2O$ needs of crop (14c minus 15c) ______ lbs/ac

20. Type of manure ______

21. Manure nutrient content:
(a) N ______ (lbs/ton) (lbs/ac-in)
(b) $P_2O_5$ ______ (lbs/ton) (lbs/ac-in)
(c) $K_2O$ ______ (lbs/ton) (lbs/ac-in)

22. Manure application method (see back) ______

23. Nutrients in manure available to crop: (21a, b & c multiplied times the availability coefficient) (see back)
Available N ______ (lbs/ton) (lbs/ac-in)
Available $P_2O_5$ ______ (lbs/ton) (lbs/ac-in)
Available $K_2O$ ______ (lbs/ton) (lbs/ac-in)

24. Manure application rate to supply the priority nutrient:
(a) Priority nutrient ______
(b) Amount of priority nutrient needed (17. IS or 19) ______ (lbs/ac)
c) Rate of manure needed (24b divided by 23a, 23b, or 23c) ______ (ton/ac) (in/ac)

25. Pounds per acre of available nutrients supplied at the manure application rate needed to supply the priority nutrient:
(a) N ______ (23a) ______ (24c) (ton/ac or in/ac) lbs/ac
(b) $P_2O_5$ ______ (23b) ______ (24c) (ton/ac or in/ac) lbs/ac
(c) $K_2O$ ______ (23c) ______ (24c) (ton/ac or in/ac) lbs/ac

26. Nutrient balance: (net nutrient need (-) or excess (-) after the application of manure at the calculated rate)
(a) N balance ______ (25a) - ______ (17) = ______ lbs/ac
(b) $P_2O_5$ balance ______ (25a) - ______ (17) = ______ lbs/ac
(c) $K_2O$ ______ (25a) - ______ (17) = ______ lbs/ac

27. Completed by ______ Title ______

Agency The University of Georgia Cooperative Extension Service

Appendix B

# GEORGIA FIELD LEVEL NUTRIENT BUDGET WORKSHEET

A worksheet for managing the Nutrients in Manures from Georgia's Farms

| | | | | | |
|---|---|---|---|---|---|
| **Producer:** | | **County:** | | | **Date:** |
| **Farm #:** | **Tract #:** | **Field #:** | | | **Acres:** |
| **Soil Series:** | | **Surface Soil Texture:** | | | |
| **Planned Crop:** | | **Realistic Yield Expectation:** | | | Units/ac |
| **Soil Test Index:** | **P =** (lbs/ac) | **K =** | | (lbs/ac) | **pH =** |
| **Manure Type:** | | **Application Method:** | | | |
| | | **N** | **P2O5** | **K2O** | |
| **Crop Nutrients Needs:** | | | | | lbs/ac |
| **Commercial Fertilizer Applications:** | | | | | lbs/ac |
| **Residual N from Legumes:** | | | | | lbs/ac |
| **Manure Nutrient Concentration:** | | | | | |
| **Availability Coefficients:** | | | | | NA |
| **Equivalent Fertilizer Price:** | | | | | $/lb |

**Net Manure Nutrient Needs of Crop:** lbs/ac
**Manure Nutrients Available to Crop:** lbs/ton
**Fertilizer Value:** Total = $/ton

Manure application rate for supplying crop: N needs = ton/a
P2O5 needs =

| | **N-based Application** | | **P2O5-based Application** | | |
|---|---|---|---|---|---|
| | Nutrients Applied | Balance | Nutrients Applied | Balance | |
| N | | | | | lbs/ac |
| $P_2O_5$ | | | | | lbs/ac |
| $K_2O$ | | | | | lbs/ac |

Total manure applied to field based on: N needs = ton/ac
$P_2O_5$ needs =

* If peanuts or tobacco are included in your crop rotation be sure to test soil following each manure application for recommendations on avoiding nutrient toxicity from high soil concentrations of Zn, or other micronutrients.

* See Farm*A*Syst Publications for information on applying animal waste, especially around streams, wells and on other environmentally sensitive areas.

* When making liquid manure applications, proper irrigation techniques must be used to to prevent manure liquids from running off into surface water or leaching into groundwater.

Sincerely,

Name
Title
County, District, etc.

Table 1. Livestock manure nutrient first-year availability coefficients.

| Type of Manure | Application Method | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil incorporation[1] | | | Broadcast[2] | | | Irrigation[3] | | |
| | N | $P_2O_5$ | $K_2O$ | N | $P_2O_5$ | $K_2O$ | N | $P_2O_5$ | $K_2O$ |
| **Scraped manure** | | | | | | | | | |
| Dairy | 0.6 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| Beef | 0.6 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| Swine | 0.6 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| Sheep/Goat | 0.6 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| Horse, stable | 0.5 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| **Poultry house litter** | | | | | | | | | |
| All Poultry Litters | 0.7 | 0.8 | 1.0 | 0.5 | 0.7 | 0.9 | * | * | * |
| **Liquid manure slurry** | | | | | | | | | |
| Dairy | 0.7 | 0.8 | 1.0 | 0.5 | 0.7 | 1.0 | 0.4 | 0.7 | 1.0 |
| Beef | 0.7 | 0.8 | 1.0 | 0.5 | 0.7 | 1.0 | 0.4 | 0.7 | 1.0 |
| Swine | 0.7 | 0.8 | 1.0 | 0.4 | 0.7 | 1.0 | 0.3 | 0.7 | 1.0 |
| Layer | 0.7 | 0.8 | 1.0 | 0.5 | 0.7 | 1.0 | 0.4 | 0.7 | 1.0 |
| **Lagoon liquid** | | | | | | | | | |
| Dairy | 0.8 | 0.9 | 1.0 | 0.5 | 0.8 | 1.0 | 0.5 | 0.8 | 1.0 |
| Beef | 0.8 | 0.9 | 1.0 | 0.5 | 0.8 | 1.0 | 0.5 | 0.8 | 1.0 |
| Swine | 0.9 | 0.9 | 1.0 | 0.5 | 0.8 | 1.0 | 0.5 | 0.8 | 1.0 |
| Layer | 0.9 | 0.9 | 1.0 | 0.5 | 0.8 | 1.0 | 0.5 | 0.8 | 1.0 |
| **Anaerobic lagoon sludge** | | | | | | | | | |
| All | * See Lagoon Clean-out and Closure publication. | | | | | | | | |

[1] Surface spread manure plowed or disked into soil within 2 days.

[2] Surface spread manure uncovered for one month or longer.

[3] Sprinkler irrigated liquid uncovered for one month or longer.

Legume crops have the ability to fix N, or convert atmospheric N into a plant available form. Some of this fixed N is available to crops planted behind legumes. As a result, N-fixed by legumes must be accounted for in the Nutrient Budget Worksheet (NBW) to accurately manage this nutrient . Estimates for residual nitrogen provided by legumes grown in rotation can be found in Table 2.

Table 2. Estimated residual nitrogen provided by a good stand of legumes grown in rotation.

| Legume | Residual nitrogen available |
|---|---|
| Alfalfa, Vetch, or Clover[1] | 80 lbs/ac |
| Soybeans, or Peanuts[2] | 30 lbs/ac |

[1]Killed before planting current spring crop.

[2]Legume is planted in previous year/season. More nitrogen will be available if the fall planted crop immediately follows the legume. On sandy soils and in years with normally high precipitation, less nitrogen will be available to spring-planted crops.

## Additional Instructions on NBW Data Entry

**Producer** is either the name of the farm or the name of the producer who owns and/or operates the farm

**Farm #, Tract #, Field#,** and **Acreage** are all available from local Farm Service Agency Office. These are records and do not affect the manure application rates.

**Soil Series and Surface Soil Texture** are both available from local NRCS Office. These records can be helpful in determining runoff and leaching potential. If unknown, they may be left blank.

**Planned Crop** is the crop that will be growing when manure applications are being made.

**Realistic Yield Expectations** are based on the production history of each field - be sure to indicate units.

**Soil Test Index** values are listed on the Soil Test Report for each field tested. For more information on soil testing, consult with your local UGA County Extension Agent.

**Crop Nutrient Needs** are listed in the Recommendations section of a Soil Test Report.

**Fertilizer Applications** are those that have already been made, or any planned for fields receiving manual application(s). In other words, fertilizer application is the sum total of each nutrient (N, $P_20_5$ and $K_20$) as starter fertilizer, mid-season side dress, etc.

**Manure Nutrient Concentration** values can be found on Animal Waste Analysis Reports.

Use the Unit/A button to choose the appropriate manure nutrient concentration unit.

**Equivalent Fertilizer Price** is the price per pound of elemental Nitrogen (N), Phosphate ($P_20_5$), or Potash ($K_2O$). These values are available through local fertilizer dealers.

Print Worksheet Data Entry Instructions Sheet.

Example 1

# GEORGIA FIELD LEVEL NUTRIENT BUDGET WORKSHEET

A worksheet for managing the Nutrients in Manures from Georgia's Farms

| | | | | | |
|---|---|---|---|---|---|
| **Producer:** | Joe Farmer | **County:** | Tift | **Date:** | 10/20/00 |
| **Farm #:** | 1 **Tract #:** 1 | **Field #:** | 1 | **Acres:** | 100 |
| **Soil Series:** | Tifton | **Surface Soil Texture:** Loamy sand | | | |
| **Planned Crop:** | Cotton | **Realistic Yield Expectation:** 1250 lbs/a | | | |
| **Soil Test Index:** | **P** = 60 (lbs/ac) | **K** =170 (lbs/ac) | | | **pH** = 6.2 |
| **Manure Type:** | | **Application Method:** Soil Incorporated | | | |

| | N | P2O5 | K2O | |
|---|---|---|---|---|
| **Crop Nutrients Needs:** | 90 | 60 | 35 | lbs/ac |
| **Commercial Fertilizer Applications:** | 0 | 0 | 0 | lbs/ac |
| **Residual N from Legumes:** | 0 | NA | NA | lbs/ac |
| **Manure Nutrient Concentration:** | 60 | 60 | 40 | lbs/ac-in |
| **Availability Coefficients:** | 0.7 | 0.8 | 1.0 | NA |
| **Equivalent Fertilizer Price:** | 0.34 | 0.25 | 0.16 | $/Lb |
| **Net Manure Nutrient Needs of Crop:** | 90 | 60 | 35 | lbs/ac |
| **Manure Nutrients Available to Crop:** | 42 | 48 | 40 | lbs/ton |
| **Fertilizer Value:** | 14.28 | 12.00 | 6.40 | Total = 32.68 $/ton |

Manure application rate for supplying crop: N needs = 2.1 ton/ac
P2O5 needs = 1.2

**N-based Application**

| Nutrients | Applied | Balance |
|---|---|---|
| N | 88 | -2 |
| P2O5 | 101 | 41 |
| K2O | 84 | 49 |

**P2O5-based Application**

| Nutrients | Applied | Balance | |
|---|---|---|---|
| N | 50 | -40 | lbs/ac |
| P2O5 | 58 | -2 | lbs/ac |
| K2O | 48 | 13 | lbs/ac |

**Total manure applied to field based on:** N needs = 210 ton
P2O5 needs = 120 ton

* If peanuts or tobacco are included in your crop rotation be sure to test soil following each manure application for recommendations on avoiding nutrient toxicity from high soil concentrations of Zn, or other micronutrients.

* See Farm*A*Syst Publications for information on applying animal waste, especially around streams, wells and on other environmentally sensitive areas.

* When making liquid manure applications, proper irrigation techniques must be used to to prevent manure liquids from running off into surface water or leaching into groundwater.

Sincerely,

Name
Title
County, District, etc.

Example 2

## GEORGIA FIELD LEVEL NUTRIENT BUDGET WORKSHEET

A worksheet for managing the Nutrients in Manures from Georgia's Farms

| | | | | | |
|---|---|---|---|---|---|
| **Producer:** | Joe Farmer | **County:** | Clarke | **Date:** | 10/20/00 |
| **Farm #:** | 1 **Tract #:** 1 | **Field #:** | 1 | **Acres:** | 100 |
| **Soil Series:** | Cecil | **Surface Soil Texture:** | Sandy loam | | |
| **Planned Crop:** | Fescue pasture | **Realistic Yield Expectation:** | 200 lbs/ac | | |
| **Soil Test Index:** | P = 40 (lbs/ac) | | K =200 (lbs/ac) | | pH = 6.2 |
| **Manure Type:** | | **Application Method:** | Broadcast | | |

| | N | P2O5 | K2O | | |
|---|---|---|---|---|---|
| **Crop Nutrients Needs:** | 50 | 30 | 25 | lbs/ac | |
| **Commercial Fertilizer Applications:** | 0 | 0 | 0 | lbs/ac | |
| **Residual N from Legumes:** | 0 | NA | NA | lbs/ac | |
| **Manure Nutrient Concentration:** | 60 | 60 | 40 | lbs/ac -in | |
| **Availability Coefficients:** | 0.5 | 0.7 | .8 | NA | |
| **Equivalent Fertilizer Price:** | 0.34 | 0.25 | 0.16 | $/lb | |
| **Net Manure Nutrient Needs of Crop:** | 50 | 30 | 25 | lbs/ac | |
| **Manure Nutrients Available to Crop:** | 30 | 42 | 36 | lbs/ton | |
| **Fertilizer Value:** | 10.20 | 10.50 | 5.76 | Total = 26.46 | $/ton |

Manure application rate for supplying crop: N needs = 1.6 ton/ac
P2O5 needs = 0.7

**N-based Application**

| Nutrients | Applied | Balance |
|---|---|---|
| N | 48 | -2 |
| P2O5 | 67 | 37 |
| K2O | 58 | 33 |

**P2O5-based Application**

| Nutrients | Applied | Balance | |
|---|---|---|---|
| N | 21 | -29 | lbs/ac |
| P2O5 | 29 | -1 | lbs/ac |
| K2O | 25 | 0 | lbs/ac |

| | |
|---|---|
| **Total manure applied to field based on:** | N needs = 160.0 ton<br>P2O5 needs = 70.0 ton |

* If peanuts or tobacco are included in your crop rotation be sure to test soil following each manure application for recommendations on avoiding nutrient toxicity from high soil concentrations of Zn, or other micronutrients.

* See Farm*A*Syst Publications for information on applying animal waste, especially around streams, wells and on other environmentally sensitive areas.

* When making liquid manure applications, proper irrigation techniques must be used to to prevent manure liquids from running off into surface water or leaching into groundwater.

Sincerely,

Name
Title
County, District, etc.

## Helpful Tips on Abbreviations and Units

| | | | |
|---|---|---|---|
| N | = nitrogen | lbs | = pounds |
| $P_2O_5$ | = phosphate | ac | = acre |
| $K_2O$ | = potash | in | = inch |
| P | = phosphorus | lbs/ac-in | = pounds per acre-inch |
| K | = potassium | ton/ac | = tons per acre |
| NBW | = Nutrient Budget Worksheet | gal | = gallon |

## Review Questions

1. What is nutrient budgeting and why is it important in a farm?
2. What are the three steps in developing a nutrient budget?
3. When does soil testing become an important component in nutrient budgeting?
4. In manure testing, how do you convert the nutrients reported as "total" N, P (or $P_2O_5$), and K (or $K_2O$) to values that may represent the <u>true</u> nutrient supplying capacity of manures?
5. What is the difference between "N-based" and "P-based" nutrient plans in balancing manure application rates?
6. Does the method of manure application affect nutrient availability? Cite an example.
7. When legumes are grown in a farm, what nutrient do they contribute to the Nutrient Budget Worksheet? Give examples of these legumes and their potential nutrient contribution.

# Land Application of Animal Manure
## Dr. Mark Risse

This lesson and the material in it are adapted from the National Animal and Poultry Waste Management Curriculum Lessons 30 through 36.

**Intended Outcomes**

The participant will:

- Understand key considerations in selecting and managing land application sites
- Identify activities related to timing of applications that may lead to higher environmental risk
- Become familiar with various land application systems and methods
- Understand the importance of equipment calibration
- Identify appropriate land application BMPs for their farm
- Develop procedures for proper record keeping for land application systems

### Introduction

As agricultural producers strive to develop a more sustainable agriculture, the potential of animal manure to recycle nutrients, build soil quality, and maintain crop productivity becomes more important. At the same time, however, the nature of modern animal agriculture, with its highly concentrated production facilities and reliance upon feed supplements to maintain animal health and productivity, has raised serious questions about the effects of animal manure on the quality of our soil, water, atmosphere, and food supply. Because land application is the only practical alternative for much of animal-based agriculture, the cornerstone of most manure management programs will be a solid understanding of how animal manure and manure-amended soils affect agricultural production and the surrounding environment. The soil is a very effective manure treatment system if manure is applied at the proper rate, time, and location. While farm operators that need the nutrient resource in manure tend to use it better, even those that are using land application as a waste disposal practice can do it in an environmentally sound manner provided they know the impacts of their practices.

Manure utilization planning is a two-part process. In the last section we covered the first component which focused on developing a general cropping plan and estimate the number of acres needed to properly land apply the manure. The second component can be referred to as the *annual plan*. The annual plan refers to the actual implementation of the strategic plan. It covers such things as the planned times for manure applications, the manure application methods, best management practices, and records of manure applications and crop yields.

### <u>Selecting and Managing Land Application Sites</u>

The importance of selecting the best site to apply manure cannot be over emphasized. Site selection is one of the major factors that directly affect the success of an operation. Spend the time up front selecting the best sites so that future, potentially expensive environmental problems and adverse public relations can be avoided. Even though the site may look good initially, its use may result in problems that could easily have been avoided by choosing another site.

Animal manure should not reach wetlands or surface waters of the state by runoff, drift, manmade conveyances (such as pipes or ditches), direct application, or direct discharge during operation or land application. Manure should not be applied to saturated soils, during rainfall events, or when the soil surface is frozen. Slopes steeper than 6% should also be unless there is sufficient crop residue to prevent runoff, or unless manure is injected or incorporated into the soil. Check with local city and county officials for applicable regulations on zoning, health, building code, setback distances, etc.

The earlier section on maps presented some considerations and details but a few good rules to remember in selecting application sites are as follows:

1. Find a site that is as isolated as possible. Buffer or set-back restrictions can significantly reduce available land. Buffers are designed to minimize the potential for impacts to adjacent homeowners as well as impacts to the environment. It is also crucial to consider the direction of the prevailing wind in relation to the site and residential development in the area.
2. Find a site that is not too steep. The flatter the land, the lower the potential for runoff. In addition, flatter slopes generally have better soils and make the maintenance of a cover crop easier.
3. Find a site that is as far away from surface water as possible. This minimizes impacts should some of the wastewater be washed off the site. This extra buffer can be very important.
4. Find a site that has as deep a seasonal groundwater table as possible. This can reduce the risk of potential groundwater contamination.
5. Find a site that has good separation from bedrock. Areas where bedrock is close to the land surface make poor wastewater application sites.
6. Find a site where the soils are suitable for the intended crops to be grown.
7. Find a site where soils that are not too sandy. The clays and organic matter in soils help hold the nutrients and metals found in the wastewater, thereby preventing their movement to the groundwater and maximizing potential for plant uptake.

Obviously, the chances of finding the perfect site may not be easy and in some areas of the state may be difficult or impossible. But as stated earlier, every effort to find this perfect site, or one as close as possible, will definitely be worthwhile. Evaluating the environmental suitability of your application sites is one method you can use to identify those fields where manure application is most appropriate. Table 1 will allow you to measure the relative "risk" to the environment for land application sites. We recommend evaluations such as these be done on each field and included as part of your comprehensive nutrient management plan. Assessments such as Table 1 can also aid producers in determining which fields on their operation to use if several alternatives are available. Other general rules that can be used to select potential application sites include:

- Apply manure with the highest N content in the spring or fall; apply the lowest N manure in the summer.
- Haul the highest nutrient content manure to the furthest fields.
- Apply lowest nutrient content manure to closest fields. If possible, irrigate with collected runoff water and lagoon effluent.
- Apply the highest nutrient manure to crops with high nutrient demands.
- To avoid N leaching to groundwater, limit N applications on sandy soil and avoid soils with high water tables, tile drains or controlled drainage.
- To receive the most value from your manure, apply high-P manure to fields with the lowest soil P test levels.

Table 1 Field assessment for manure application.

| CATEGORY | | Field # ____ *Points* |
|---|---|---|
| **1. Planned crop (check one)** | | |
| a. Continuous corn or corn not following legume | 10 | |
| b. Second-year corn following legume | 8 | |
| c. First-year corn following legume | 1 | |
| d. First-year corn following nonforage legume | 8 | |
| e. Nonforage legume | 2 | |
| f. Small grains (for grain) | 6 | |
| g. Small grain with seeding (removed as grain) | 2 | |
| h. Small grain with seeding (removed as hay or silage) | 4 | |
| i. Prior to direct seeding legume forage | 8 | |
| j. Topdress (good legume stand) | 1 | |
| k. Topdress (fair legume stand) | 2 | |
| l. Topdress (poor legume stand) | 3 | |
| m. Grass pasture or other nonlegumes | 6 | ____ |
| **2. Soil test P (check one for each category)** | | |
| 1. > 200 lbs/acre | 1 | |
| 2. 100–200 lbs/acre | 3 | |
| 3. 30–100 lbs/acre | 5 | |
| 4. < 30 lbs/acre | 10 | |
| **3. Site/soil limitations (check one for each category)** | | |
| **a. Surface or groundwater proximity** | | |
| 1. Applied and incorporated within 10-year floodplain or within 200 feet of surface water or groundwater access | 1 | |
| 2. Application outside these restrictions | 5 | |
| **b. Slope** | | |
| 1. Slope > 12% | 1 | |
| 2. Slope 6-12%; > 12% (incorporated, contoured, or terraced) | 3 | |
| 3. Slope 2–6 %; 6-12% (incorporated, contoured, or terraced) | 5 | |
| 4. Slope < 2%; <6% (incorporated, contoured, or terraced) | 10 | |
| **c. Soil texture** | | |
| 1. Sands, loamy sands | 1 | |
| 2. Sandy loams, loams/sands, loamy sands; spring applied | 3 | |
| 3. Other soils/sandy loams, loams, clays, spring applied | 5 | |
| **d. Depth to bedrock** | | |
| 1. 0–10 inches | 0 | |
| 2. 10–20 inches | 1 | |
| 3. > 20 inches | 5 | + ____ |
| **4. Total Points** (higher field score = higher priority for land application) | | = ____ |

If the producer does not own adequate land to properly use the manure, written agreements with third party landowners or applicators should be considered. You should be able to document where all manure generated on the farm will be used. Several example agreements are presented at the end of this chapter. Producers are encouraged to take samples of groundwater and surface water on farms where animal manure is routinely applied. Samples should be analyzed for nutrients and bacteria and these records should be kept with the other farm records.

**Timing of Manure Applications**

It has been said, with respect to nutrient management, that timing is everything. While there are certainly other factors that affect crop yields and nutrient management, timing is very important. If crops have access to nutrients when they are needed, quality and yields are higher. If, however, nutrients are supplied at times when crop need is low or nonexistent, then these nutrients pose a greater environmental risk, especially in regions with higher rainfall. Also, applications when the soil is saturated may lead to nutrient movement.

Some common crops grown to use nutrients in manure are shown in Table 2. A cropping system with a variety of crops offers the most flexibility for manure application over many parts of the year.

Table 2. Crops useful for manure utilization and their maximum uptake period in the southeastern United States. *

| Crop | Uptake Period[1] |
|---|---:|
| Corn (grain) | April–July |
| Corn (silage) | April–July |
| Sorghum (grain) | April–July |
| Small grains (grain) | Feb.–April |
| Small grains (hay, pasture) | Feb.–April |
| Soybean | July–Sept. |
| Cotton | June–August |
| Bermudagrass (hay, pasture) | April–Sept. |
| Tall fescue (hay, pasture) | Sept.–Nov. & Feb.–April |
| Alfalfa (hay) | May–August |
| Annual ryegrass (hay, silage, pasture) | Feb.–April & Sept.–Oct. |
| Millet (hay, silage) | May–August |

[1] *Application should occur no more than 30 days before planting or green up of perennial forages.*

* Relevant crop growth periods for your local area should be substituted in this table.

**Scheduling manure applications**

Crop growth rates and application conditions are not uniform throughout the year. Likewise, crop nutrient requirement is not uniform. Realizing this fact, you need to understand when it is or is not appropriate to land apply manure. All nutrient sources should be applied at times that will maximize crop use and minimize loss. Ideally, manure nutrients should be applied to an actively growing crop or within 30 days of planting a crop. If crops for human consumption are to be grown, manure should not be applied in the three weeks before harvest. Timing is most important for nutrients applied to soils with a high leaching potential. Applying nitrogen to a sandy soil when there is no crop to remove it will almost certainly result in loss of nitrogen to the shallow groundwater. Recommendations that are used for fertilizer nitrogen conservation (reduced leaching) should also be used for manure nitrogen. Manure that has primarily organic N can be successfully applied in the fall, prior to spring planting, if erosion and runoff control measures are in place but the losses will be greater.

In some cases, manure storage capacity dictates the frequency of manure applications. Low manure storage capacity will require frequent applications and year-round cropping systems, while larger storage volumes may allow less frequent applications to a single crop. Many storage structures are designed for 180-270 days of temporary storage. If the same fields are to be used, this means an actively growing crop must be present in both summer and winter. Double cropping or overseeding of perennial forages can be used to accomplish this, but a higher level of management is required to make this system work properly. For existing facilities, the temporary storage volume should be known, or can be calculated, and used to determine the number of days of temporary storage. Because manure production and storage capacity determine the maximum amount of time between manure applications, these factors strongly influence crop selection.

As seen in Figure 1, there are several months during the year when most crops are dormant. For example, bermudagrass is dormant in January and February, and growth is "slow" during March, November, and December. If the crop is not actively growing, there is little or no nutrient uptake. In this situation, any nitrogen applied to the bermudagrass field could leach through the soil and move down towards the water table. Consequently, land application is not generally recommended during dormant periods.

The risk of encountering an emergency situation can be significantly reduced by utilizing a cropping system that provides the flexibility of extending the application season throughout most of the year. For example, if bermudagrass is overseeded with rye in the winter, you have a cropping system in place that can accept some manure during every month in most years. There may still be one or two consecutive months when fields are too wet to apply manure. In a bermudagrass/rye cropping system, the peak storage duration in the lagoon is only for the wet weather period, rather than the five months or longer required if only bermudagrass is being grown.

**Selecting the Appropriate Application Method**

An environmentally friendly land application system for manure will require careful review of the equipment and management procedures previously used. Critical to this approach is the producer's willingness to treat manure or other livestock by-products as a nutrient resource and not as a waste. Manure application equipment must be selected and managed as fertilizer-spreading equipment as opposed to waste disposal equipment. Efficiency of manure nutrient use will need to be a producer's primary objective.

The proper location and selection of application sites and equipment are no assurance that problems will be eliminated. Manure spreading or spraying activities must be planned and managed to prevent adverse impact on the groundwater, surface water, nuisances, public health, and plants. Here are some considerations in selecting application equipment.

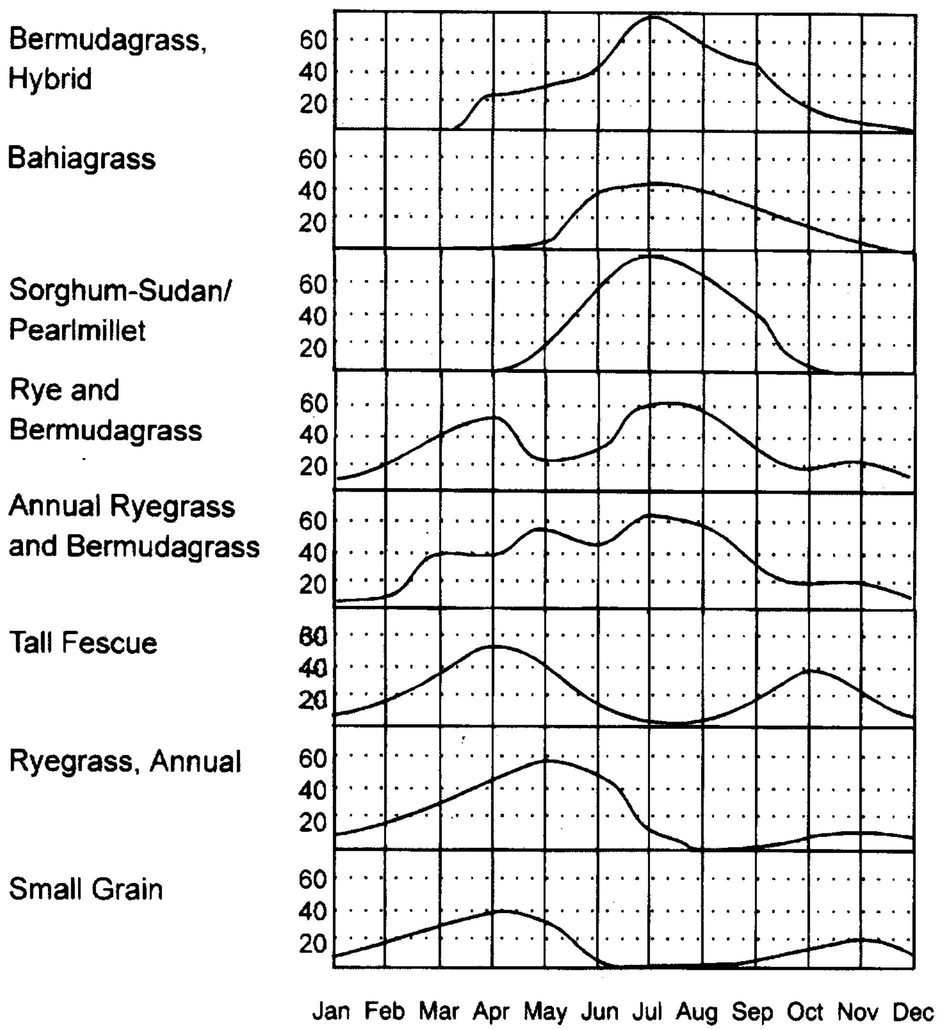



Figure 1. Growth rate of selected forage crops. Growth is expressed as pounds of forage produced per day per acre.

*Manure spreader as a fertilizer applicator.* The fundamental principle underlying both best management practices and future regulatory requirements for manure application will be efficient crop use of applied nutrients. Manure spreaders will need to be managed as any other fertilizer or chemical applicator. Spreaders and irrigation equipment will need to provide a uniform application of manure, a consistent application rate between loads, and a simple means of calibration. Appropriate equipment selection and careful operator management will contribute to efficient use of manure nutrients.

*Timeliness of manure nutrient applications.* The ability to move large quantities of manure during short periods of time is critical. Limited times of opportunity exist for application of manure to meet crop nutrient needs and minimize nutrient loss. Investments and planning decisions that enhance the farm's capacity to move manure or that store manure in closer proximity to application sites will enable improved timing of manure applications.

*Conservation of nitrogen.* The availability of nitrogen and phosphorus in manure does not meet crop needs. Typically, high soil phosphorus levels results from long-term applications of manure. The ammonium fraction, originally representing roughly half of the potentially available nitrogen, is lost by long-term open lot storage of manure, anaerobic lagoons, and surface spreading of manure. Systems that conserve ammonium nitrogen and provide nutrients more in balance with crop needs increase the economic value of manure.

*Odor Nuisances.* Odor nuisances are the primary driving factor of more restrictive local zoning laws for agriculture. Application systems that allow you more flexibility in application timing and location can reduce odor nuisances. Manure application systems that minimize odor deserve consideration and preference where neighbors live close to application sites.

*Soil Compaction.* Manure spreaders are heavy. The manure alone in a 3,000-gallon liquid manure tank weighs more than 12 tons. In addition, manure is often applied at times of the year, late fall and early spring, when high soil moisture levels and the potential for compaction are common. Impact of manure application on potential soil compaction deserves consideration.

Table 3. Environmental rating of various manure application systems.

| | Uniformity of Application | Conservation of Ammonium | Odor | Compaction | Timeliness of Manure Application |
|---|---|---|---|---|---|
| ***Solid Systems*** | | | | | |
| Box spreader: tractor pulled | Poor | very poor | fair | fair | poor |
| Box spreader: truck mounted | Poor | very poor | fair | fair | fair |
| Flail-type spreader | Fair | very poor | fair | fair | poor |
| Side-discharge spreader | Fair | very poor | fair | fair | poor |
| Spinner Spreader | Fair | very poor | fair | fair | fair |
| Dump truck | very poor | very poor | fair | poor | fair |
| ***Liquid Systems: Surface Spread*** | | | | | |
| Liquid tanker with splash plate | Poor | poor | poor | poor | fair |
| Liquid tanker with drop hoses | Fair | fair | good | poor | fair |
| Big gun irrigation system | Good | very poor | very poor | excellent | excellent |
| Center pivot irrigation system | Excellent | very poor | very poor | excellent | excellent |
| ***Liquid Systems: Incorporation*** | | | | | |
| Tanker with knife injectors | Good | excellent | excellent | poor | fair |
| Tanker with shallow incorporation | Good | excellent | excellent | poor | fair |
| Drag hose with shallow incorporation | Good | excellent | excellent | good | good |

## Equipment Calibration

You can avoid the potential adverse effect on ground and surface water caused by over fertilization by applying only the amount of manure, effluent, or wastewater necessary to maintain soil fertility for crop production. A nutrient management plan is of little use if the designed application rate can not be met. Calibration of manure-application equipment is important because it lets you know the amount of manure and wastewater you are applying to an area. The calibration rate and nutrient concentration of manure nutrients lets you know the amount of plant-available nutrients you are applying. Then you can adjust your application rate to avoid over fertilization. Calibration will also:

- Verify actual application rates
- Troubleshoot equipment operation
- Determine appropriate overlaps
- Evaluate the uniformity of application
- Monitor changes in equipment operations (age and "wear and tear")
- Changes in manure "thickness"

The remainder of this chapter deals with different types of application equipment. Each section is followed by detailed descriptions of calibration techniques that can be used with that equipment.

**Solid Manure Application Systems**

Manure of 20% solids or more is typically handled by box, side discharge, or spinner-type spreaders. Box-type spreaders range in size from under three tons (100 cubic feet) to 20 tons (725 cubic feet). Box spreaders provide either a feed apron or a moving gate for delivering manure to the rear of the spreader. A spreader mechanism at the rear of the spreader (paddles, flails, or augers) distributes the manure. Both truck-mounted and tractor-towed spreaders are common. Flail-type spreaders provide an alternative for handling drier manure. They have a partially open top tank with chain flails for throwing manure out the side of the spreader. Flail units have the capability of handling a wider range of manure moisture levels ranging from dry to thick slurries. Side-discharge spreaders are open-top spreaders that use augers within the hopper to move wet manure toward a discharge gate. Manure is then discharged from the spreader by either a rotating paddle or set of spinning hammers. Side-discharge spreaders provide a uniform application of manure for many types of manure with the exception of dry poultry litter. Spinner-type spreaders are similar to hopper-style spreaders used to apply dry commercial fertilizer or lime and are traditionally used to apply dry poultry litter. Manure placed in the storage hopper is moved toward an adjustable gate via a chain drive. Manure then falls out of the spreader onto two spinning discs that propel the litter away from the spreader. Uniform application can easily be achieved with spinner spreaders by either varying the spinner speed or angle. Application rates can be adjusted by changing the travel speed and opening or closing the opening on the spreader gate.

With the growing concern about manure contamination of water and air resources, spreaders must be capable of performing as fertilizer spreaders. Typically, such equipment has been designed as disposal equipment with limited ability to calibrate application rates or maintain uniform and consistent application rates. Several considerations specific to solids application equipment follow:

- The operator must control application rate. Feed aprons or moving push gates, hydraulically driven or PTO powered, impact the application rate. Does the equipment allow the operator to adjust rate of application and return to the same setting with succeeding loads?
- Uniformity of manure application is critical for fertilizer applicators. Variations in application rate both perpendicular and parallel to the direction of travel are common.

- Transport speed and box or tank capacity impact timely delivery of manure. Often 50% or more of the time hauling manure is for transit between the feedlot or animal housing and field. Truck-mounted spreaders can provide substantial time savings over -pulled units for medium- and long-distance hauls. Trucks used for manure application must also be designed to travel in agriculture fields. Available four-wheel drive and duel or flotation-type tires should be considered for trucks that will apply manure. Increased box or tank capacities speed delivery. Spreaders must be selected to move and apply manure quickly.
- Ammonia losses are substantial for solid manure application that is not incorporated. Most of the ammonia nitrogen, representing between 20% and 65% of the total available nitrogen in manure, will be lost if not incorporated within a few days. Practices that allow for incorporating manure into the soil on the same day as applied will reduce ammonia losses and increase nitrogen available to crops.

**Calibrating Manure Spreaders**

Calibration of your spreader is a simple, effective way of improving utilization of nutrients in manure more effectively. Only by knowing the application rate of your spreader can you correctly apply manure to correspond to your crop needs and prevent water quality problems. Applicators can apply manure, bedding, and wastewater at varying rates and patterns, depending on forward travel and/or PTO speed, gear box settings, gate openings, operating pressures, spread widths, and overlaps. Calibration defines the combination of settings and travel speed needed to apply manure, bedding, or wastewater at a desired rate and to ensure uniform application. A brief calibration procedure is given below. An extension publication is also available at: http://www.ces.uga.edu/pubcd/C825-W.HTML

*Solid and Semisolid Manure Spreaders*

To calibrate a spreader for solid manure (20% or more solids), the following materials are needed:

1. Bucket
2. Plastic sheet, tarp, or old bed sheet. An even size, 8 feet by 8 feet, 10 feet by 10 feet, or 12 feet by 12 feet, will make calculations easier.
3. Scales

Solid and semisolid spreaders are rated by the manufacturer either in bushels or cubic feet (multiply bushels by 1.25 to get cubic feet). Most spreaders have two rating capacities: (1) struck or level full and (2) heaped. Calibration of solid manure spreaders based on its capacity (volume) is difficult to estimate accurately because the density of solid and semisolid manure is quite variable. Density is the weight of the manure per volume of manure (pounds per cubic foot). Manure density varies depending on the type and amount of bedding used as well as its storage method. Therefore, if you estimate spreader application rates as the volume of the manure the spreader holds, you are overlooking the fact that some manure weighs more than other manure. This can cause a significant error when calculating manure application rates.

Since manure and litters have different densities, an on-farm test should be done. To determine the load (tons) of a manure spreader,

1. Weigh an empty 5-gallon bucket.

2. Fill the bucket level full with the material to be spread. Do not pack the material in the bucket but ensure that it settles similar to a loaded spreader.
3. Weigh the bucket again. Subtract the empty bucket weight from this weight to calculate the weight of the contents.
4. Multiply weight of contents by 1.5 to calculate pounds per cubic feet, density.
5. Multiply the manure density by the cubic feet capacity of the spreader and divide by 2,000 to get the tons of material in a spreader load.

$$\text{Spreader load (tons)} = \frac{\text{weight of 5 gal manure} \times 1.5 \times \text{spreader capacity}(\text{ft}^3)}{2{,}000}$$

*Calibration method*

1. Locate a large, reasonably smooth flat area where manure can be applied.
2. Spread the plastic sheet, tarp, or bed sheet smoothly and evenly on the ground.
3. Fill the spreader with manure to the normal operating level. Drive the spreader at the normal application speed toward the sheet spread on the ground, allowing the manure to begin leaving the spreader at an even, normal rate.
4. Drive over the sheet at the normal application speed and settings while continuing to apply manure. If a rear discharge spreader is used, three passes should be made: First, drive directly over the center of the sheet; then make the other two passes on opposite sides of the center at the normal spreader spacing overlap.
5. Weigh the empty bucket and plastic sheet, tarp, or blanket.
6. Collect all manure spread on the sheet and place it in the bucket.
7. Weigh bucket and manure, and subtract the weight of the empty bucket and ground sheet. This will give you the pounds of manure applied to the sheet.
8. Repeat the procedure three times to get a reliable average.
9. Determine the average weight of the three manure applications.
10. Calculate the application rate using the following formula or Table 4:

$$\text{Application rate (tons/acre)} = \frac{\text{lb manure collected} \times 21.78}{\text{sheet length (ft)} \times \text{sheet width (ft)}}$$

11. Repeat the procedure at different speeds and/or spreader settings until the desired application rate is achieved.

Table 4. Calibration of solid manure spreaders.

| Pounds of Manure Applied to Sheet | Tons of Manure Applied/Acre | | |
|---|---|---|---|
| | Size of Ground Sheet | | |
| | 8' × 8' | 10' × 10' | 12' × 12' |
| 1 | 0.34 | 0.22 | 0.15 |
| 2 | 0.68 | 0.44 | 0.30 |
| 3 | 1.02 | 0.65 | 0.45 |
| 4 | 1.36 | 0.87 | 0.61 |
| 5 | 1.70 | 1.09 | 0.76 |
| 6 | 2.04 | 1.31 | 0.91 |
| 7 | 2.38 | 1.52 | 1.06 |
| 8 | 2.72 | 1.74 | 1.21 |
| 9 | 3.06 | 1.96 | 1.36 |
| 10 | 3.40 | 2.18 | 1.51 |
| 15 | 5.10 | 3.27 | 2.27 |
| 20 | 6.81 | 4.36 | 3.03 |

Many times it may be necessary to adjust the rate in which waste is applied from the way it is normally spread. Changes in application rate can be accomplished by increasing or decreasing the speed at which the waste is being applied. To perform these calculations, the spreader load (tons), duration of application (minutes), and the average width (feet) of a normal application needs to be known. The application rate and travel speed can be found using the following equations:

$$\text{Application rate (tons/acre)} = \frac{\text{spreader load (tons)} \times 495}{\text{time (min)} \times \text{width (ft)} \times \text{travel speed (mph)}}$$

$$\text{Travel speed (mph)} = \frac{\text{spreader load (tons)} \times 495}{\text{time (min)} \times \text{width (ft)} \times \text{application rate (tons/acre)}}$$

*Example #1:*
What is the application rate (tons per acre) if you collect 8.5 pounds of manure on a 10-foot by 10-foot tarp during a calibration run?

$$\text{Application rate (tons/acre)} = \frac{8.5 \text{ lb manure} \times 21.78}{10 \text{ ft} \times 10 \text{ ft}} = 1.85 \text{ tons/acre}$$

*Example #2:*
What speed should you run if you wish to apply 4 tons of manure per acre with a 3-ton spreader? Your spreader application width is 20 feet, and your spreader empties in 6 minutes.

$$\text{Travel speed(mph)} = \frac{3\,\text{tons} \times 495}{6\,\text{min} \times 20\,\text{ft} \times 4\,\text{tons/acre}} = 3.1\,\text{mph}$$

When using this type of example, select the gear in the tractor or truck that most closely matches the required speed (do not adjust PTO speed). If the travel speed is too high or too low, then you will need to change the flow rate to alter the time it takes to empty the tank. This is accomplished by changing PTO rpm, by changing valve or gate settings, or by installing an orifice in the flow line. Any time you make adjustments, change the rpm, or use thicker manure you should re-calibrate the unit.

**Spreader Pattern Uniformity and Determining Overlap**

To determine the uniformity of spread and the amount of overlap needed, place a line of small pans or trays equally spaced (2 to 4 feet) across the spreader path. The pans should be a minimum of 12 inches by 12 inches (or 15 inches in diameter) but no more than 24 inches by 24 inches and 2 inches to 4 inches deep. Make one spreading pass directly over the center pan. Weigh the contents caught in each pan or pour the contents into equal-sized glass cylinders or clear plastic tubes and compare the amount in each.

The effective spread width can be found by locating the point on either side of the path center where manure contents caught in the containers are half of what it is in the center. The distance between these points is the effective spreader width. The outer fringes of the coverage area beyond these points should be overlapped on the next path to ensure a uniform rate over the entire field. "Flat-top," "pyramid," or "oval" patterns are most desirable and give the most uniform application. "M," "W," "steeple," or "offset" patterns (Figure 2) are not satisfactory, and one or more of the spreader adjustments should be made. Often, a manufacturer's representative should be contacted to assist in the correction of undesirable application patterns.

**Slurry Manure Application Systems (Sludge)**

Application of liquid or slurry manure has traditionally been performed by tank wagons. While this method has allowed disposal of manure at a relatively low financial cost, it includes some hidden cost including soil compaction, loss of ammonium nitrogen and odor. Many unique approaches to land application of liquid or slurry livestock manure have appeared recently. Alternative delivery systems that speed movement of manure, unique options for incorporating manure, and systems that minimize mixing of manure and air will enhance liquid application of manure.

*Remote Manure Storages*

Remote manure storage (or storages) is an integral part of many unique delivery systems. Location of the manure storage near the fields that receive manure as opposed to near the animal housing has several potential advantages. Manure is transported by pump or tanker to a remote storage throughout the year, minimizing the labor for moving manure during field application. Remote sites may provide location options where odor or visual nuisances are less of a concern or soil permeability is such that storage construction costs can be reduced.

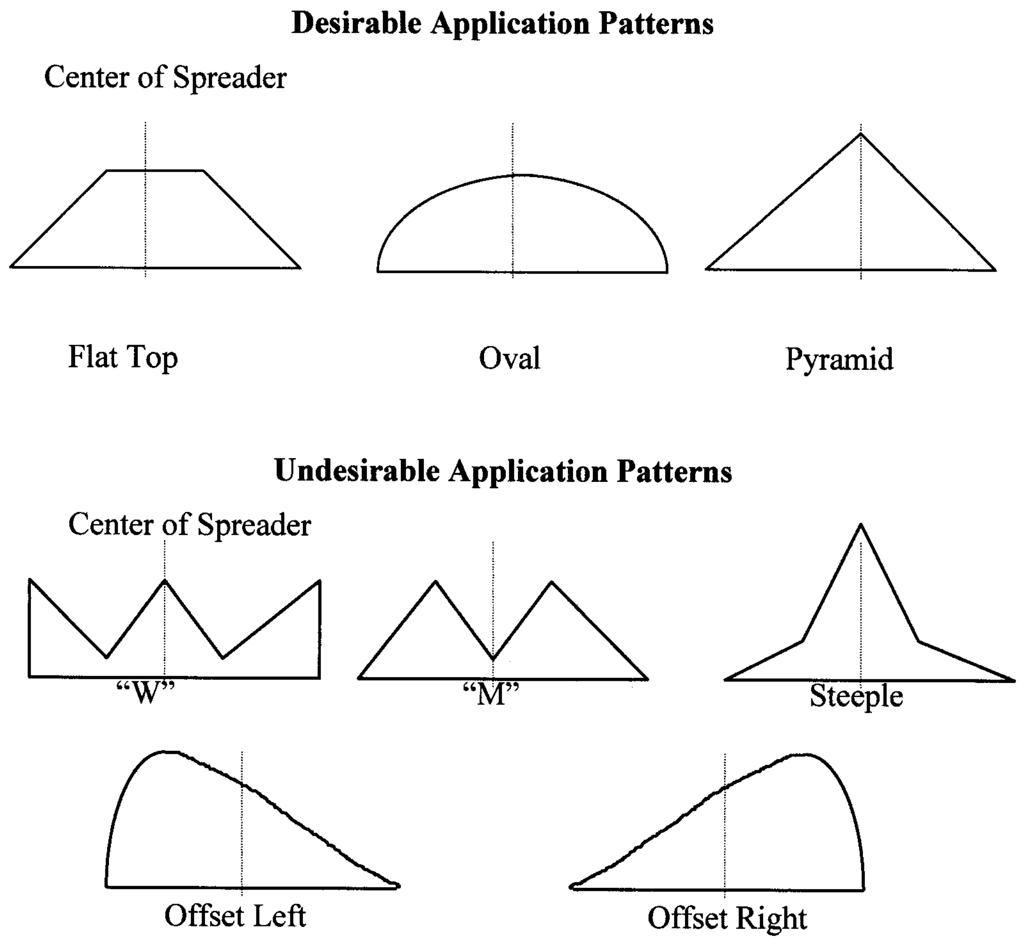



Figure 2. Desirable and undesirable application uniformity.

*Hauling Liquid Manure*

The standard 2,000- to 4,000-gallon tractor-pulled tanker cannot move manure fast enough for some livestock operations. In some regions, over-the-road tankers are being employed to shuttle manure from the manure storage to the edge of the field. Manure is then transferred to separate liquid application equipment or remote storage. Often, used semi-tractor milk or fuel tankers with capacities of 6,000 gallons or more are purchased for shuttle duty. Prior to implementing this approach, an individual should check licensing and inspection requirements and carrying capacity of local bridges.

*Flexible Hose Systems*

Pumping of liquid manure from the manure storage to the field is becoming increasingly common. Manure of up to 8% solids is being pumped several miles to a remote storage or field application equipment. Pipe friction is the primary limiting factor. Manure at solids content below 4% can be treated as water in estimating friction losses. An additional allowance for friction loss is required for pumping manure with a solids content above 4%. Manure handling systems that involve addition of significant dilution water or liquid-solids separation equipment provides a slurry that is most appropriate for this application.

To pump manure (> 4% solids) longer distances requires heavy-duty equipment. Aggressive chopper units are often installed just prior to the pump when solids separation equipment is not used. Industrial slurry pumps are selected to overcome the pipe friction losses and avoid potential wear problems. Buried PVC piping with higher pressure ratings (e.g., 160 psi) is generally selected. Because manure leaks are far more hazardous than water leaks, joints must be carefully assembled and tested. Special care must also be given to crossing streams and public roads. If public roads are to be crossed, appropriate local governments maintaining these roads should be approached early in the planning process.

Flexible hose delivery systems tied to a field implement or injector unit pulled by a tractor provides an alternative method for moving liquid manure quickly (Figure 3). These systems offer both odor/nutrient conservation and soil compaction benefits. A common approach begins with a high-volume, medium-pressure pump located at the liquid manure reservoir. Manure is delivered to the edge of the field (at the field's midpoint) by standard 6- or 8-inch irrigation line. At this point, a connection is made to a 660 foot long, 4 inch diameter soft irrigation hose. Often two lengths of hose are used. Manure is delivered to a tractor with toolbar-mounted injectors or splash plates immediately in front of a tillage implement. A flexible towed hose system distributes manure at rates of up to 1,000 gallons per minute so a one million gallon storage can be emptied in a matter of three to four days. Cost is often higher with these types of systems but they are applicable under certain conditions.

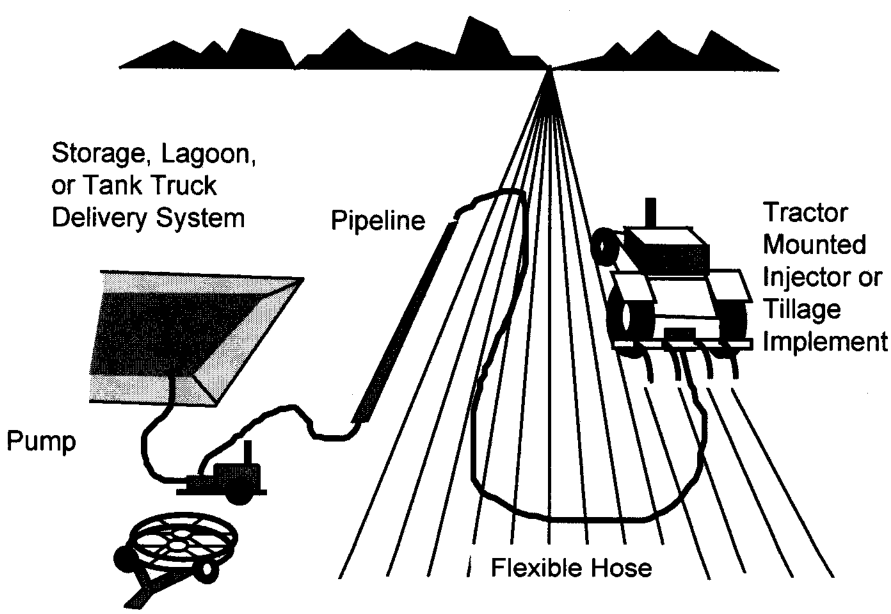



Figure 3. Towed hose systems move manure from storage to field via a pump, pipeline, and soft hose that are pulled behind the tractor and application equipment.

*Surface Broadcast of Liquid Manure*

Surface application of liquid slurries provides a low-cost means of handling the manure stream from many modern confinement systems. Tank wagons equipped with splash plates are commonly used to spread a lot of manure. However, surface application suffers from several disadvantages including

- Ammonia losses. Surface application of slurries results in losses of 10% to 25% of the available nitrogen, due to ammonia volatilization (Table 5).
- Odor. Aerosol sprays produced by mixing manure and air carry odors considerable distances.
- Uniformity. Splash plates and nozzles provide poor distribution of manure nutrients.

A few recent developments attempt to address these concerns. Boom-style application units for attachment to tank wagons or towed irrigation systems are appearing commercially for the first time. These systems use nozzles or drop hoses for distributing a slurry. They offer the opportunity to reduce odor concerns and improve uniformity of distribution.

Table 5. Nitrogen losses during land application. Percent of total nitrogen lost within 4 days of application.

| Application Method | Type of Waste | Nitrogen Lost, % |
|---|---|---|
| Broadcast | Solid | 15-30 |
| | Liquid | 10-25 |
| Broadcast with | Solid | 1-5 |
| immediate incorporation | Liquid | 1-5 |
| Knifing | Liquid | 0-1 |
| Sprinkler irrigation | Liquid | 0-1 |

**Direct Incorporation of Liquid Manure**

Options for direct incorporation of liquid manure are growing (Figure 4). Injector knives have been the traditional option. Knives, often placed on 20- to 25-inch centers, cut 12- to 14-inch deep grooves in the soil into which the manure is placed. Limited mixing of the soil and manure and high power requirements are commonly reported concerns.

Injector knives with sweeps that run four to six inches below the soil surface allow manure placement in a wider band at a shallower depth. Manure is placed immediately beneath a sweep (up to 18 inches wide), improving mixing of soil and manure. Location of the manure higher in the profile minimizes potential leaching and reduces power requirements. Sweeps can be used to apply a higher rate of manure than a conventional injector knife.

Other shallow incorporation tillage implements (s-tine cultivators and concave disks) are increasingly available options on many liquid manure tank wagons. These systems are most commonly used for pre-plant application of manure. Manure is applied near the tillage tool, which immediately mixes the manure into the soil. Speed of application, low power requirements, and uniform mixing of soil and manure have contributed to the growing popularity of this approach. In addition such systems are being used to side dress manure on row crops without foliage damage. Side dressing expands the season during which manure can be applied and improves the use of manure nutrients. All soil incorporation systems also offer the advantage of ammonia conservation and minimal odors.

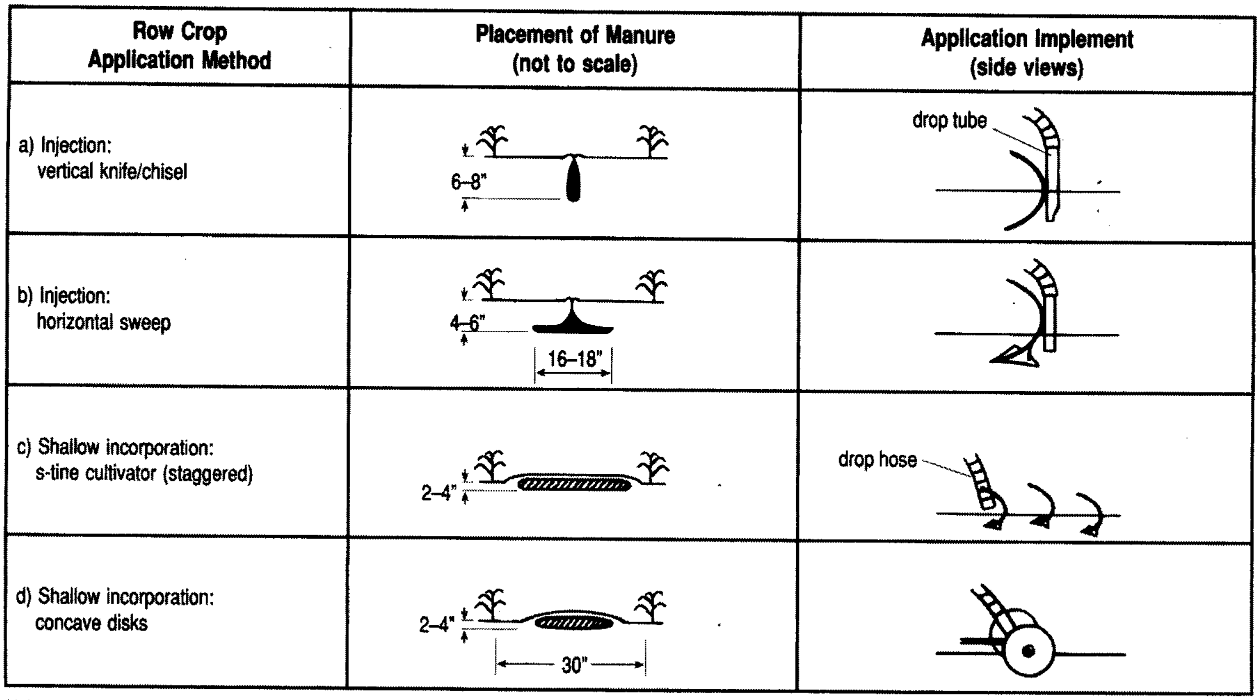



Figure 4. Options for incorporation of manure in the soil.

## Calibrating Liquid Manure Spreaders

Liquid tank spreaders must be accurately calibrated to apply wastes at proper rates. Calibration is the combination of settings and travel speed needed to apply wastes at a desired rate and to ensure uniform application. To calibrate, you must know the spreader capacity, which is normally rated by the manufacturer in gallons.

*Calibration method*

1. Spread at least one full load of waste, preferably in a square or rectangular field pattern for ease of measuring, with normal overlaps.
2. Measure the length and width of coverage, recognizing that the outer fringe areas of the coverage will receive much lighter applications than the overlapped areas.
3. Multiply the length by the width and divide by 43,560 to determine the coverage area in acres.

$$\text{Coverage area (area of rectangle in ft}^2) = \text{length (ft)} \times \text{width (ft)}$$

$$\text{Coverage area (acres)} = \frac{\text{length (ft)} \times \text{width (ft)}}{43{,}560 \text{ ft}^2 \text{ per acre}}$$

4. Divide the gallons of wastewater in the spreader by the acres covered to determine the application rate in gallons per acre.

$$\text{Application rate for spreader (gal or tons/acre)} = \frac{\text{spreader load volume (gal or tons)}}{\text{coverage area (acres)}}$$

Reminder: Liquid spreader capacities are normally rated by the manufacturer in gallons. Multiply by 0.0042 to get tons.

**Example #3:**
Your waste application method is a tractor-drawn tanker (honeywagon) with a 2,500-gallon capacity. You apply a load to a field and measure the application area as 22-feet wide by 280-feet long. What is the application rate in gallons per acre?

First, figure the coverage area:

$$\text{Coverage area (acres)} = \frac{280 \text{ ft} \times 22 \text{ ft}}{43{,}560 \text{ ft}^2} = 0.14 \text{ acre}$$

Then figure the application rate:

$$\text{Application rate for spreader (gal/acre)} = \frac{2{,}500 \text{ gal}}{0.14 \text{ acre}} = 17{,}857 \text{ gal/acre}$$

*Drag-Hose Injectors*

This method calculates the required speed to travel when pulling a drag hose application system (Figure 5) around the field. If you are not using a flow meter, you will have to operate the system for at least one hour before you can get an accurate reading of what you have removed from the storage tank or basin.

To calculate the required speed, you need to know

- The **volume** applied per hour (in gallons per hour) from a flow meter, the manufacturer's information or the amount removed from manure storage.
- The desired application **rate**, in gallons/acre
- The **width** of application, in feet

$$\text{Speed (miles/hr)} = \frac{8.25 \text{ x Volume/hr.}}{\text{Rate x Width}}$$

Select the appropriate gear in the field tractor to match the calculated speed. If the calculated speed is too fast, you could reduce the volume applied per hour by decreasing the power to the main pump. At the same time, you may also have to reduce the nozzle (or orifice) size to keep adequate pressure in the drag hose. Another way to compensate for an excessive calculated tractor speed is to increase the width of application. This could be accomplished by using a boom-style application.

**Example #4:**
A custom manure applicator measured pumped manure at a rate of 24,000 gallons per hour. His injector boom is 22 feet wide. He wants to apply 5,500 gallons per acre.

$$\textit{Speed} = \frac{\textit{8.25 x 24,000 gal./hr.}}{\textit{5,500 gal/acre x 22 ft.}}$$

$$\textit{Speed} = \textit{1.6 miles/hr.}$$

He selected a gear giving a speed of 1.8 miles per hour.

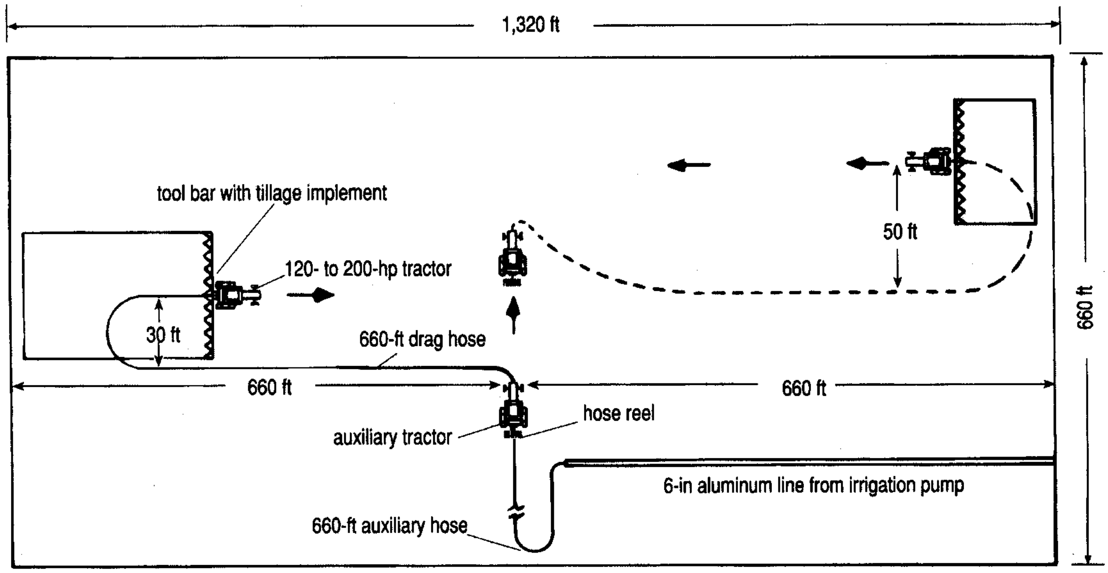



Figure 5. Hose-drag setup for 20-acre field.

*Spot Check Applied Rate Across the Width of Application*

All of the previous options give you the average application across the width. To check the variation across the width of application or along the length of application, you need to place a series of containers in the application path. Table 6 gives you the information to convert the depth of liquid in a straight-walled container to the application rate. Because such small depths are involved, the depth method only gives an approximation of application rate. A more accurate method is to weigh the contents of the container and convert this weight to an application rate.

Table 6. Chart to convert depths in straight wall container to application

| Depth of Manure in Pail | Application Rate, Gallons/Acre |
|---|---|
| 1/10 inch | 2,250 |
| 1/8 inch | 2,800 |
| 1/4 inch | 5,650 |
| 3/8 inch | 8,500 |
| 1/2 inch | 11,300 |
| 5/8 inch | 14,150 |
| 3/4 inch | 17,000 |
| 1 inch | 22,650 |

**IRRIGATION**

Direct irrigation of manure slurry through a large-diameter sprinkler nozzle is an alternative for farms that produce larger quantities of manure and have nearby pasture or cropland. Irrigation of liquid manure requires less labor, time, and operating expense than hauling and does not have the soil compaction problems.

Centrifugal pumps that can deliver at least 30 psi pressure at the sprinkler nozzle are needed for irrigation. In addition, due to the high solids content of the slurry, a lift pump or chopper-agitator pump is needed to help the centrifugal pump maintain its prime. Internal pump chopper mechanisms can help avoid clogging. Slurries with more than 4% solids cause higher friction losses in the pipes, requiring more pump pressure and horsepower. It is essential that the irrigation lines be flushed with clean water after slurry pumping. With proper management, slurry manure up to 7% total solids can be irrigated.

Over application of nutrients is a concern with slurry irrigation systems. Moving sprinklers frequently helps to avoid this. Thus, traveling irrigators are usually recommended. A properly designed irrigation system provides uniform wastewater application at agronomic rates without direct runoff from the site. However, a "good design" does not guarantee proper land application. Management is also critical. You should be familiar with the system components, range of operating conditions, and maintenance procedures and schedules to keep your system in proper operating condition.

**Types of Systems**

As with water irrigation, there is no one system that is superior over another system. The following systems can be used for effluent irrigation:

- Stationary volume gun
- Solid set sprinkler
- Traveler
- Center pivot and linear move systems
- Hand-move sprinkler
- Side roll
- Furrow/Flood irrigation

Each of these systems are described in the next few pages. Although the equipment required for pumping and distributing lagoon effluent may be similar to conventional irrigation equipment, the smaller volume of water handled in most livestock lagoons and holding basins generally allows the use of smaller, less costly systems. It also is possible to use an application system for both effluent and fresh water irrigation. The type of irrigation system chosen depends on many farm specific parameters including the particle size of the solids in the effluent, the amount of available capital and how much time and labor is available for pumping, and the land available for application. Nevertheless, knowledge of the potential options available and their advantages and disadvantages could lead you to better decisions.

*Stationary Volume Gun*

This system can be used in many small effluent application systems. The system includes a pump and a main line similar to the hand-move systems, but with a single or multiple large-volume gun sprinklers. Advantages of the volume gun systems include larger flow rates and a larger wetted area so less labor is required in moving the sprinkler. Some volume guns are wheel mounted to facilitate moving the unit. Stationary volume guns typically have nozzle sizes that range from 0.5 to 2 inches, and operate best at pressures of 50 to 120 psi. Coverage areas of 1 to 4 acres can be obtained with proper selection of nozzle size and operating pressure. Gun sprinklers typically have higher application rates; therefore, adjacent guns should not be operated at the same time (referred to as "head to head"). Although stationary volume guns cost more than smaller hand-carry systems, the reduced labor cost and higher flow rates may offset the higher cost.

A typical volume gun that discharges 330 gpm at 90 psi pressure wets a 350-foot diameter circle (2.2 acres) with an application rate of 0.33 inches per hour. The power requirement is about 30 horsepower. This system requires labor for movement from one set or location to another to ensure that the soil does not become saturated resulting in runoff.

Table 7. Characteristics of Stationary Guns.

| ***Advantages*:** | ***Limitations:*** |
|---|---|
| Few mechanical parts to malfunction<br>Few plugging problems with large nozzle<br>Flexible with respect to land area<br>Pipe requirements are slightly less than with small sprinklers<br>Moderate labor requirement | Moderate to high initial investment<br>Water application pattern is easily distorted by wind<br>Tendency to over-apply effluents with high nutrient concentrations |

*Stationary Sprinkler Systems*

Stationary systems for land application of lagoon liquid are usually permanent installations (lateral lines are PVC pipes permanently installed below ground) (Figure 6). One of the main advantages of stationary sprinkler systems is that these systems are well suited to irregularly shaped fields. Thus, it is difficult to give a standard layout, but there are some common features between systems. To provide proper overlap, sprinkler spacings are normally 50% to 65% of the sprinkler-wetted diameter. Sprinkler spacing is based on nozzle flow rate and desired application rate. Sprinkler spacings are typically in the range of 80 feet by 80 feet, using single-nozzle sprinklers. Most permanent systems use Class 160 PVC plastic pipe for mains, submains, and laterals and either 1-inch galvanized steel or Schedule 40 or 80 PVC risers near the ground surface where an aluminum quick coupling riser valve is installed. In grazing conditions, all risers must be protected (stabilized) if left in the field with animals.

The minimum recommended nozzle size for wastewater is 1/4 inch. Typical operating pressure at the sprinkler is 50 to 60 PSI. Sprinklers can operate full or partial circle. The system should be zoned (any sprinklers operated at one time constitutes one zone) so that all sprinklers are operating on about the same amount of rotation to achieve uniform application.

Table 8. Characteristics of Stationary Sprinkler Systems.

| ***Advantages*:** | ***Limitations:*** |
|---|---|
| Good for small or irregular-shaped fields<br>Flexible with respect to land area<br>Do not have to move equipment<br>Low labor requirement | High initial investment<br>Must protect from animals in fields<br>Small-bore nozzles likely to get plugged or broken<br>No flexibility to move to other (new) fields |

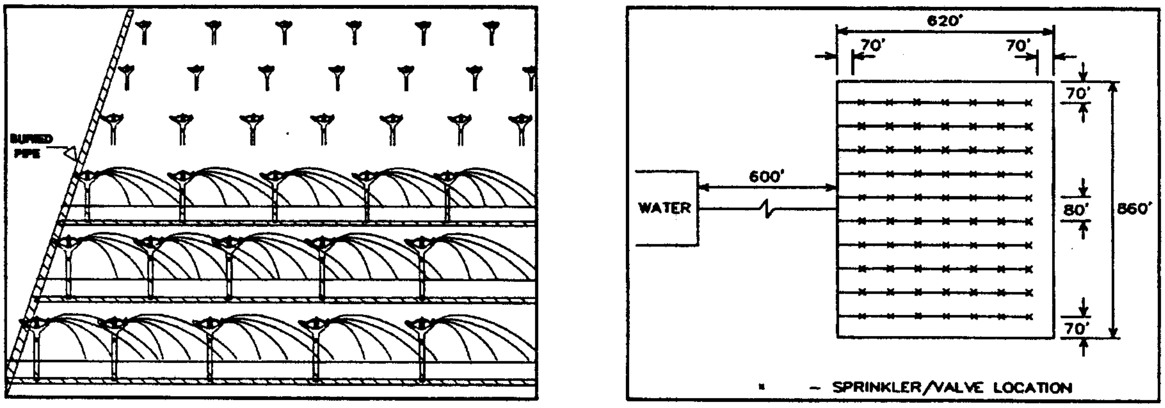



Figure 6. Stationary Sprinkler System

*Traveling Sprinklers*

Traveling sprinkler systems can be cable-tow traveler, hard-hose traveler, center pivot, or linear-move systems. The cable-tow traveler consists of a single-gun sprinkler mounted on a trailer with water being supplied through a flexible, synthetic fabric, rubber, or PVC-coated hose. Pressure rating on the hose is normally 160 PSI. A steel cable is used to guide the gun cart. The hose-drag traveler consists of a hose drum, a medium-density polyethylene (PE) hose, and a gun-type sprinkler. The hose drum is mounted on a multiwheel trailer or wagon. The gun sprinkler is mounted on a wheel or sled-type cart referred to as the gun cart. Normally, only one gun is mounted on the gun cart. The hose supplies wastewater to the gun sprinkler and also pulls the gun cart toward the drum. The distance between adjacent pulls is referred to as the lane spacing. To provide proper overlap, the lane spacing is normally 70% to 80% of the gun-wetted diameter.

The hose drum is rotated by a water turbine, water piston, water bellows, or an internal combustion engine commonly referred to as an auxillary drive unit. Regardless of the drive mechanism, the system should be equipped with speed compensation so that the sprinkler cart travels at a uniform speed from the beginning of the pull until the hose is fully wound onto the hose reel. If the solids content of the wastewater exceeds 1%, an engine drive should be used.

Nozzle sizes on gun-type travelers are 1/2 to 2 inches in diameter and require operating pressures of 75 to 100 PSI at the gun for uniform distribution. The gun sprinkler has either a taper bore nozzle or a ring nozzle. The ring nozzle provides better breakup of the wastewater stream, which results in smaller droplets with less impact energy (less soil compaction) and also provides better application uniformity throughout the wetted radius. But, for the same operating pressure and flow rate, the taper bore nozzle throws water about 5% further than the ring nozzle, i.e., the wetted diameter of a taper bore nozzle is 5% wider than the wetted diameter of a ring nozzle. This results in about a 10% larger wetted area such that the precipitation rate of a taper bore nozzle is approximately 10% less than that of a ring nozzle.

A gun sprinkler with a taper bore nozzle is normally sold with only one size nozzle, while a ring nozzle is often provided with a set of rings ranging in size from 1/2 to 2 inches in diameter. This allows the operator flexibility to adjust flow rate and diameter of throw without sacrificing application uniformity. However, there is confusion that using a smaller ring with a lower flow rate will reduce the precipitation rate. This is not normally the case. Rather, the precipitation rate remains about the same because while a smaller nozzle results in a lower flow, it also results in a smaller wetted radius or diameter. The net effect is little or no change in the precipitation rate. Furthermore, on water drive systems, the speed compensation mechanism is affected by flow rate. There is a minimum threshold flow required for proper operation of the speed compensation mechanism. If the flow drops below the threshold, the travel speed becomes disproportionately slower, resulting in excessive application even though a smaller nozzle is being used. System operators should be knowledgeable of the relationships between ring nozzle size, flow rate, wetted diameter, and travel speed before interchanging different nozzle sizes. As a general rule, operators should consult with a technical specialist before changing nozzle size to a size different than that specified in the certified waste management plan.

Table 9. Characteristics of Hard Hose Traveler Systems.

| ***Advantages*:** | ***Limitations:*** |
|---|---|
| Few or no plugging problems with the large nozzle<br>Flexible with respect to land area<br>Moderate labor requirement | High initial investment<br>High power requirement<br>More mechanical parts than the other systems, especially with an auxiliary engine<br>High application rates |

*Center Pivots and Linear Move Systems*

The use of center-pivot systems for wastewater irrigation is increasing. Center pivots are available in both fixed-pivot point and towable machines. They are available in size from single tower machines that cover around 2 acres to multi-tower machines that can cover several hundred acres. Center pivot manufactures can offer almost completely automated systems that use rotary sprinklers, small guns, or spray nozzles. There are several disadvantages including high cost, small sprinklers, and fixed land area covered. Drop-type spray nozzles offer the advantage of applying wastewater close to the ground at low pressure, which results in little wastewater drift due to wind. Linear-move systems are similar to center pivot systems, except that travel is in a straight line. Depending on the type of sprinkler used, operating pressure ranges from 10 to 50 PSI. Low-pressure systems reduce drift at the expense of higher application rates and greater potential for runoff. Low-pressure systems in the 20 psi range with nozzles less than ¼ inch diameter are not recommended for livestock effluent because they could be plugged by solids in the effluent.

*Hand-move Sprinkler Systems*

The least costly sprinkler system for effluent irrigation are the hand-move types that require labor to set up and move the system. Although considerable labor input is required, these systems may be desirable for small lagoons. Used hand-move systems may be available, but small nozzles in the sprinklers may not be suited for effluent irrigation. A screened inlet pipe will reduce problems with small nozzles. Nozzle sizes used for moderately to heavily loaded lagoons are generally in the 1/2- to l-inch range and typically cover 1/2 to 2 acres per sprinkler, depending on nozzle size and system operating pressure.

*Side-Roll Systems*

These systems roll sideways across a rectangular field but are limited to low-growing crops. Crop clearance is slightly less than one-half the diameter of the wheel. These systems use small sprinklers, require rectangular fields, and have several mechanical devices.

*Furrow or Gated Pipe Irrigation*

These systems consist of a pump or gravity flow arrangement from a lagoon storage basin to a distribution pipe that has holes at intervals along its length. Effluent is discharged through the holes at a rate compatible with the land slope and soil infiltration rate. The gated distribution pipe usually is laid as level as possible across the upper end of a sloped soil-plant filter or manure receiving area. Gate pipe systems are suitable for lands from 0.2% to 5.0% slope. Flatter slopes result in ponding or manure at the discharge point of the gated pipe, while steeper slopes cause effluent runoff with little opportunity for infiltration into the soil.

The advantages of gated pipe systems are relatively low cost, low operating pressures, and even distribution of effluent if the holes in the pipe are properly located and sized. The disadvantages of the gated pipe systems are high labor and management to ensure the proper operation of the systems. Gated pipe systems do not perform well on uneven or steeply sloped land. Traditionally, gated pipe has been used to irrigate row crops. However, properly designed and managed gated pipe systems have been successfully used to apply lagoon effluent to grassed areas.

**Calibrating Irrigation Systems**

Operating an irrigation system differently than assumed in the design will alter the application rate, uniformity of coverage, and subsequently the application uniformity. Operating with excessive pressure results in smaller droplets, greater potential for drift, and accelerates wear of the sprinkler nozzle. Pump wear tends to reduce operating pressure and flow. With continued use, nozzle wear results in an increase in the nozzle opening, which will increase the discharge rate while decreasing the wetted diameter. Clogging of nozzles or crystallization of main lines can result in increased pump pressure but reduced flow at the gun. Plugged intakes will reduce operating pressure. An operating pressure below design pressure greatly reduces the coverage diameter and application uniformity. Field calibration helps ensure that nutrients from liquid manure or lagoon effluent are applied uniformly and at proper rates.

The calibration of a hard hose or cable tow system involves setting out collection containers, operating the system, measuring the amount of wastewater collected in each container, and then computing the average application volume and application uniformity.

An in-line flow meter installed in the main irrigation line provides a good estimate of the total volume pumped from the lagoon during each irrigation cycle. The average application depth can be determined by dividing the pumped volume by the application area. The average application depth is computed from the following formula:

$$\text{Average application depth, inches} = \frac{\text{Volume pumped, gallons}}{27{,}154\ (\text{gal/ac-in}) \times \text{Application area, acres}}$$

The average application depth is the average amount applied throughout the field. Unfortunately, sprinklers do not apply the same depth of water throughout their wetted diameter. Under normal operating conditions, application depth decreases toward the outer perimeter of the wetted diameter. Big gun sprinkler systems typically have overlap based on a design sprinkler spacing of 70% to 80% of the wetted sprinkler diameter to compensate for the declining application along the outer perimeter. When operated at the design pressure, this overlap results in acceptable application uniformity.

When operated improperly, well-designed systems will not provide acceptable application uniformity. For example, if the pressure is too low, the application depth will be several times higher near the center of sprinkler and water will not be thrown as far from the sprinkler as indicated in manufacturers' charts. Even though the average application depth may be acceptable, some areas receive excessively high application while others receive no application at all. When applying wastewater, it is important to determine the application uniformity so that you have some idea of nutrient application uniformity. Collection containers distributed throughout the application area must be used to evaluate application uniformity. In the following pages, we present the calibration methods for a traveling gun system and a center pivot. Procedures for calibrating other systems are available and can be obtained from your county agent, irrigation dealer, or from the authors.

Many types of containers can be used to collect flow and determine the application uniformity. Standard rain gauges work best and are recommended because they already have a graduated scale from which to read the application depth. Pans, plastic buckets, jars, or anything with a uniform opening and cross section can be used, if the container is deep enough (at least 4 inches deep) to prevent splash and excessive evaporation, and the liquid collected can be easily transferred to a scaled container for measuring. All containers should be the same size and shape to simplify application depth computations. All collection containers should be set up at the same height relative to the height of the sprinkler nozzle (discharge elevation). Normally, the top of each container should be no more than 36 inches above the ground. Collectors should be located so that there is no interference from the crop. The crop canopy should be trimmed to preclude interference or splash into the collection container.

Calibration should be performed during periods of low evaporation. Best times are before 10 a.m. or after 4 p.m. on cool days with light wind (less than 5 miles per hour. The volume (depth) collected during calibration should be read soon after the sprinkler gun cart has moved one wetted radius past the collection gauges, minimizing evaporation from the rain gauge. Where a procedure must be performed more than once, containers should be read and values recorded immediately after each setup.

*Traveling Gun Systems*

Hard hose and cable-tow traveling guns are calibrated by placing a row (transect) of collection containers or gauges perpendicular to the direction of travel (Figure 6). The outer gauge on each end of the row should extend past the furthest distance the gun will throw wastewater to ensure that the calibration is performed on the "full" wetted diameter of the gun sprinkler. Multiple rows increase the accuracy of the calibration.

Containers should be spaced no further apart than 1/16 of the wetted diameter of the gun sprinkler not to exceed 25 feet. At least 16 gauges should be used in the calibration. Sixteen gauges will be adequate except for large guns where the wetted diameter exceeds 400 feet. (Maximum recommended spacing between gauges, 25 feet X 16 = 400 feet.) As shown in Figure 7, gauges should be set at least one full wetted diameter of throw from either end of the travel lane. The system should be operated such that the minimum travel distance of the gun cart exceeds the wetted diameter of throw.

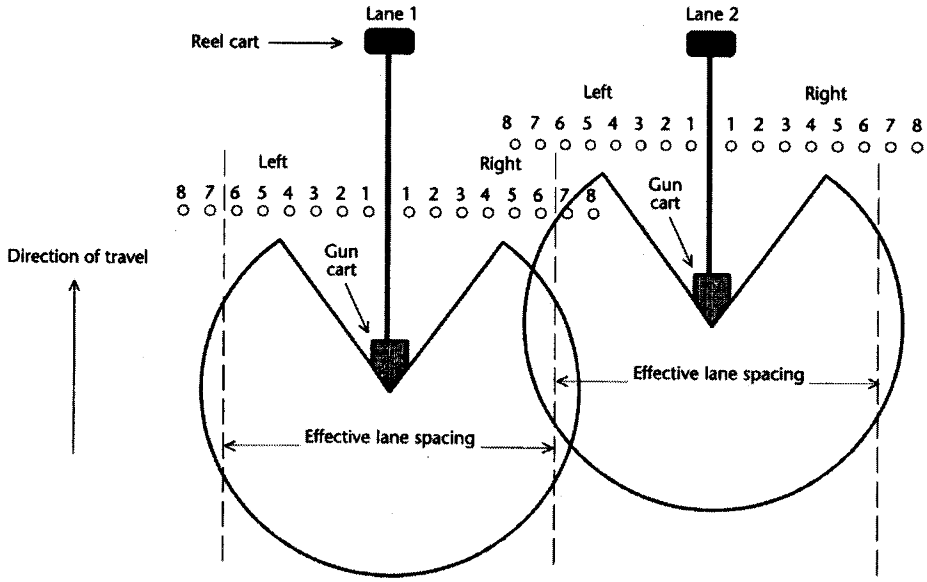



Figure 7. Calibration setup for hard hose travelers.

*Calibration Method*

1. Estimate the wetted diameter of the gun. Check the actual operating pressure at the sprinkler and verify the nozzle type and size. Determine wetted diameter from manufacturer's charts.
2. Determine the number of collection gauges and spacing between gauges. For a wetted diameter of 320 feet, the rain gauge spacing should not exceed 20 feet (320 ft/16 = 20 ft).
3. Label gauges outward from the gun cart as either left or right (L1, L2, L3, etc; R1, R2, R3, etc.)
4. Set out gauges along a row as labeled and shown in Figure 6, equally spaced at the distance determined in item 2 (20 feet). The row should be at least one wetted diameter from either end of the pull. The first gauge on each side of the travel lane should be ½ the gauge spacing from the center of the lane. For a gauge spacing of 20 feet, L1 and R1 should be 10 feet from the center of the lane.
5. Operate the system for the time required for the gun to completely pass all collection containers. Record the "starting" time when wastewater begins to be applied along the row of gauges, and the "ending" time when wastewater no longer is being applied anywhere along the row. Also record the distance traveled in feet for the time of operation.
6. Immediately record the amounts collected in each gauge.
7. Identify those gauges that fall outside the effective lane spacing. This volume is the overlap volume that would be collected when operating the system on the adjacent lane.

8. Superimpose (left to right and vice versa) the gauges just outside the effective width with the gauges just inside the effective width. Add the volumes together.
   For the layout shown in Figure 6, add the volume (depth) collected in gauge R8 (outside the effective lane spacing) to volume (depth) collected in gauge L5 (inside the effective lane spacing). Similarly, R7 is added to L6; L8 is added to R5; and L7 is added to R6. This is now the application volume (depth) within the effective lane spacing adjusted for overlap.
9. Add the amounts collected in all gauges and divide by the number of gauges within the effective area. This is the average application depth (inches) within the effective lane spacing.

$$\text{Average application depth} = \frac{\text{Sum of amounts collected in all gauges}}{\text{Number of gauges within effective width}}$$

10. Calculate the deviation depth for each gauge. The deviation depth is the difference between each individual gauge value and the average value of all gauges (#9). Record the absolute value of each deviation depth. Absolute value means the sign of the number (negative sign) is dropped, and all values are treated as positive. The symbol for absolute value is a straight thin line. For example, |2| means treat the number 2 as an absolute value. It does not mean the number 121. Because this symbol can lead to misunderstandings, it is not used with numbers in the worksheets. The symbol is used in formulas in the text.

$$\text{Deviation depth} = |\text{Depth collected in gauge I} - \text{average application depth}|$$

"I" refers to the gauge number

11. Add amounts in #10 to get "sum of the deviations" from the average depth and divide by the number of gauges to get the average deviation.

$$\text{Avg deviation depth, inches} = \frac{\text{Sum of deviations (add amounts computed in \#10)}}{\text{Number of gauges within effective lane spacing}}$$

12. The precipitation rate (inches/hour) is computed by dividing the average application depth (inch) (#9) by the application time (hours) (#5).

$$\text{Precipitation rate, inches/hour} = \frac{\text{Average application depth, inch}}{\text{Application time, hours}}$$

13. Compute the average travel speed.

$$\text{Average travel speed} = \frac{\text{Distance traveled, feet}}{\text{Time, minutes}}$$

14. Determine the application uniformity. The application uniformity is often computed using the mathematical formula referred to as the Christiansen Uniformity Coefficient ($U_c$). It is computed as follows:

$$U_c = \frac{\text{Average depth (\#9)} - \text{Average deviation (\#11)}}{\text{Average depth (\#9)}} \times 100$$

15. Interpret the calibration results. The higher the Uniformity Coefficient, the more uniform the application. A value of 100 would mean that the uniformity is perfect; the exact same amount was collected in every gauge.

For travelers with proper overlap and operated in light wind, an application uniformity greater than 85 is outstanding and very rare. Application uniformity between 70 to 85 is in the "good" range and is acceptable for wastewater application. Generally, an application uniformity below 70 is considered unacceptable for wastewater irrigation using travelers. If the computed $U_c$ is less than 70, system adjustments are required. Contact your irrigation dealer or technical specialist for assistance.

*Center Pivot*

As Figures 8 and 9 show, center pivot and linear move irrigation systems are calibrated by placing one or more rows (transect) of collection containers parallel to the system. For center pivot systems with multiple towers, place the first collection container beside the first moving tower (140 to 180 feet from the pivot point). This will miss the area between the pivot point and first tower, but it is necessary to omit this system through this zone. The area missed will be less than 3 acres and will usually represent less than 10% of a typical sized system. If the system has only one moving tower, place the first container 100 feet from the pivot point tower. Place containers equally spaced to the end of the system. For lateral move systems, place containers throughout the entire length of the system.

Containers should be spaced no further apart than 1/2 the wetted diameter of rotary impact sprinklers, 1/4 the diameter of gun sprinklers, or 50 feet, whichever is less. On systems with spray nozzles, collection containers should be spaced no further than 30 feet. A 20- to 25-foot spacing is generally recommended for all types of sprinklers, which will result in six to eight collection containers between each tower. Collection containers should be placed such that they intercept discharge from a range of lateral distances from the sprinkler (midpoint, quarter point, directly under sprinkler, etc.). This can be accomplished by selecting a catch can spacing different from a multiple of the sprinkler spacing along the lateral. Where end guns are used, the transect of collection containers should extend beyond the throw of the gun.

The system should be operated so that the minimum travel distance exceeds the sprinkler wetted diameter for the containers closest to the pivot point tower. Application volumes should be read as soon as all gauges stop being wetted.

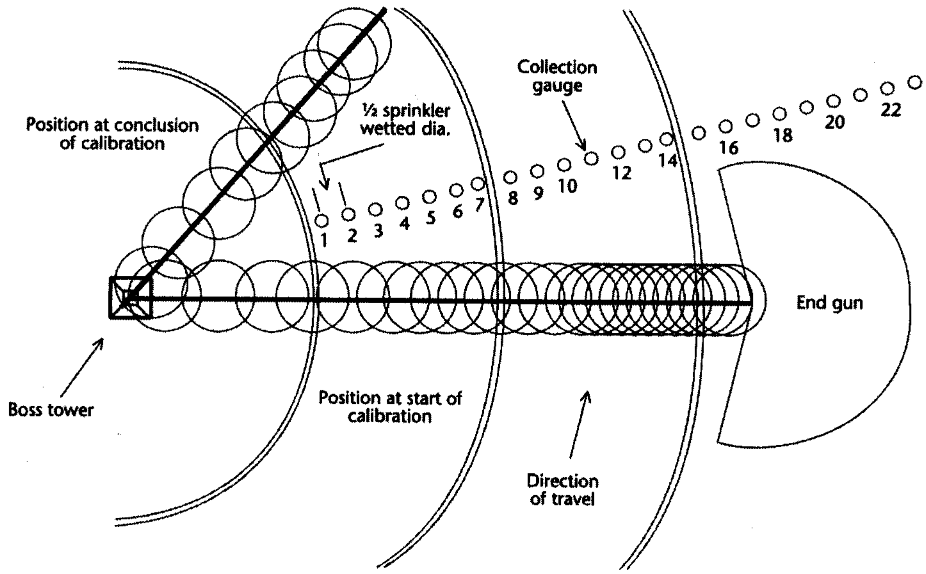



Figure 8. Collection container layout for calibration of a center pivot irrigation system.

*Calibration Procedures*

1. Determine the wetted diameter of the sprinkler, gun, or spray nozzle.
2. Determine the necessary spacing between collection gauges. The spacing should not exceed 50 feet. Twenty-five feet or less is generally recommended.
3. Determine the number of gauges required. Label gauges outward from the pivot point tower.
4. Place gauges along a row as labeled and shown in Figure 8, equally spaced at the distance determined in item 2. The row should be in the direction of system travel and at least one-half sprinkler wetted diameter from the sprinkler nearest the pivot point tower.

*Note*: The alignment of the row relative to the center pivot system does not matter as long as the system operates completely over each collection gauge. For most setups, the gauges closest to the pivot point tower will control how long the system must be operated to complete the calibration.

5. Operate the system for the time required for the sprinkler nearest the pivot point tower to completely pass the collection containers. Record the time of operation (in minutes) and distance traveled (in feet) at a reference point along the system.
6. Immediately record the amounts collected in each gauge.
7. Add the amounts in item 6 and divide by the number of gauges. This is the average application depth (inches).

$$\text{Average application depth} = \frac{\text{Sum of amounts collected in all gauges}}{\text{Number of gauges}}$$

8. Where an end gun is used, identify those gauges at the outward end where the depth caught is less than 1/2 the average application depth computed in item 7. The distance to the last usable gauge is the effective diameter of the system from which the effective acreage is computed.

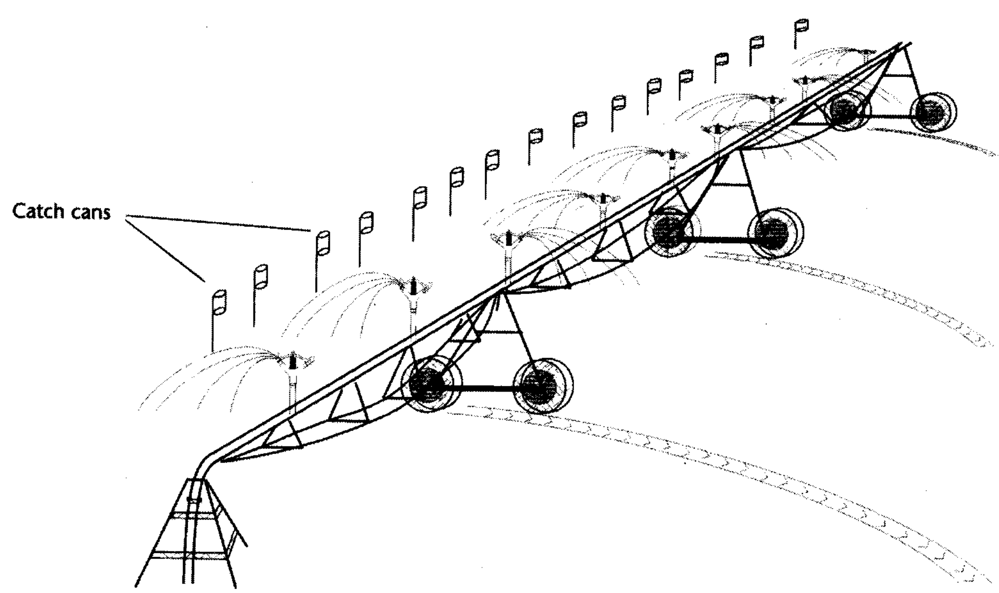



Figure 9. Calibration layout for center pivot irrigation systems.

9. Recompute the average application depth for the "usable" gauges identified in item 8 that fall within the effective width of the system. (Eliminate gauges on the outer end of the system where the depth caught is less than half the average application depth.)

*Note*: All gauges interior to the "effective width" of the system are included in the computations regardless of the amount caught in them.

10. Compute the reference travel speed and compare to the manufacturer's chart.

$$\text{Travel speed, ft/min} = \frac{\text{Distance traveled, ft}}{\text{Time, min}}$$

11. Calculate the deviation depth for each "usable" gauge. The deviation depth is the difference between each individual gauge value and the average value of all gauges (item 9). Record the absolute value of each deviation depth. (Absolute value means the sign of the number [negative sign] is dropped, and all values are treated as positive).

    Deviation depth = |Depth collected in gauge I – average application depth|
    "I" refers to the gauge number

12. Add amounts in item 11 to get the "sum of the deviations" from the average depth and divide by the number of gauges to get the average deviation.

$$\text{Average deviation depth} = \frac{\text{Sum of deviations (add amounts computed in item11)}}{\text{Number of usable gauges}}$$

13. Determine the application uniformity. The application uniformity is often computed using the mathematical formula referred to as the Christiansen Uniformity Coefficient. It is computed as follows:

$$U_c = \frac{\text{Average depth (item 7)} - \text{Average deviation (item12)}}{\text{Average depth (item 7)}} \times 100$$

14. Interpret the calibration results. The higher the Uniformity Coefficient, the more uniform the application. A value of 100 would mean that the uniformity is perfect, that the exact same amount was collected in every gauge.

For center pivot and linear move systems operated in light wind, an application uniformity greater than 85 is common. Application uniformity between 70 to 85 is in the "good" range and is acceptable for wastewater application. Generally, an application uniformity below 70 is considered unacceptable for wastewater irrigation using center pivots and linear move systems. If the computed $U_c$ is less than 70, system adjustments are required. Common problems include clogged nozzles, sprinklers not rotating properly, inadequate system pressure, sprinklers installed in the wrong order, end gun not adjusted properly, wrong end gun nozzle, and/or worn nozzles. Contact your irrigation dealer or technical specialist for assistance.

**Best Management Practices**

Best Management Practices (BMPs) refers to a combination of practices determined to be effective economical approaches to preventing or reducing pollution generated by nonpoint sources. BMPs can be structural as in the construction of terraces, dams, pesticide mixing facilities, or fencing or they can be managerial like crop rotation, nutrient management, and conservation tillage. Both types of BMPs require good management to be effective in reducing the generation or delivery of pollutants from agricultural activities. Preventive practices such as these are the most practical approaches to reducing nonpoint source pollution. In a nutrient management plan, it is important that you indicate the BMPs that will be used on all land application areas.

*Factors controlling BMP effectiveness*

BMPs are used to reduce the effects of all forms of pollutants. They use a variety of mechanisms that result in varying degrees of effectiveness. When selecting BMPs, you should use a systematic approach to insure that the practice you select will solve your problem. The following questions can help you in the selection process.

*What pollutants are contributing to the problem?*
Sediment, Nutrients, Bacteria, etc.
*Where are the pollutants being transported?*
Surface or Ground Water
*How are the pollutants being delivered?*
Availability, transport paths, in the water or on sediment

You also need to remember that the most effective plan will probably consist of several different BMPs that target different mechanisms. Some BMPs may solve a surface water quality problem but create a ground water quality problem. This should be considered when the selection is being made rather than after a new problem arises. The BMPs for your operation should be designed (and the installation reviewed) by an expert trained in these systems. Finally, if a BMP is not economically feasible and well suited for the site, you probably shouldn't use it. Consider all costs including effects on yield, production and machinery costs, labor and maintenance, and field conditions when selecting BMPs. Often a very effective BMP will rapidly become a problem if all the costs are not considered before implementation.

All activities within a watershed affect NPS pollution but control of soil erosion is probably the best opportunity for preventing pollution since sediment is not only a pollutant itself, but also carries nutrients and pesticides with it. While soil erosion is a natural process, it is accelerated by any activity that disturbs the soil surface. The amount of soil erosion that occurs is related to five factors; the rainfall and runoff, the soil erodibility, the slope length and steepness, the cropping and management of the soil, and any support practices that are implemented to prevent erosion. Man can do very little to change the rainfall a location receives and has little effect on the natural properties of the soil that affect erosion. However, man can manage to reduce the impact of these factors. For example, increasing the amount of rainfall the goes into the soil (infiltration) is an indirect means of reducing erosion. Knowledge of rainfall patterns will also allow farmers to insure that the soil is protected during the periods of the year when they receive the largest amounts of rainfall. Traditionally, farmers have controlled soil erosion through modifications in slope steepness and slope length and in cropping and management. Since the dawn of agriculture, man has known that longer and steeper slopes produce more soil erosion and has used methods such as the construction of levies and terraces to reduce slope length and steepness. More recently, practices such as strip cropping and vegetated waterway construction have been used to reduce runoff velocities and slope length. Crop canopy and surface cover or residue acts as a buffer between the soil surface and the raindrops, absorbing much of the rainfall energy and ultimately reducing soil erosion. Therefore, crops that produce more vegetative cover, have longer growing seasons, or produce a persistent residue will have less soil erosion. Any cropping system with less tillage or greater amounts of vegetative production, such as perennial systems, will result is less sediment leaving the field.

While most BMPs reduce soil erosion and transport, some BMPs use other mechanisms to reduce the impact of a pollutant. There are three stages to the pollutant delivery process: availability, detachment, and transport. BMPs may be effective by addressing any of these three factors. Availability is a measure of how much of a substance in the environment can become a pollutant. For example, an effective BMP for reducing the amount of animal waste entering surface water may be to simply decrease the amount that you are land applying to an area so that less is available. Once a substance is available; however, it must be detached from the target site to become a pollutant. Pollutants may be detached as individual particles in the water or attached to soil particles. If a pollutant is soluble, then detachment occurs when it is dissolved in water. For example, dry manures applied to the surface are more easily detached than the same amount of liquid manure that has soaked into the soil. Transport is the final link in the pollutant delivery chain. To become a pollutant, the element must travel from the point where it was applied to the surface or ground water. Pollutants are often transported by surface runoff or infiltration, however, this transport can often be reduced through BMPs. For example, using a filter strip to collect sediment before entering a stream is an example of reducing the amount of pollutant transport.

BMPs, when properly carried out, improve water quality. Generally, an animal operation will have a combination of several BMPs. Best management practices relating to manure management are those practices that optimize nutrient uptake by plants and minimize nutrient impact on the environment. They will change over time as technology and understanding of the complex environment improve. Likewise, BMPs are very site specific, and a BMP in one place may not be useful for another location. Key BMPs for land application are listed in Table 10.

Table 10. Common BMPs for land application of manure

| BMP | Mode of Action |
|---|---|
| Soil, Manure or Plant Analysis | Insures that proper crop nutrient requirements are met and manure is not over applied: Amount |
| Nutrient Management Plan | Insures that proper crop nutrient requirements are met and manure is not over applied: Amount |
| Calibration of Application Equipment | Insures that proper crop nutrient requirements are met and manure is not over applied: Amount |
| Manure treatments such as alum | Reduces availability of nutrients to runoff |
| Manure injection or incorporation | Places nutrients in the root zone and reduces availability to runoff: Availability |
| Critical area protection/ Vegetated waterways | Removes areas prone to runoff and erosion from production and manure application; Availability |
| Water diversions | Diverts water from running onto fields; Availability |
| Terraces or Contour planting | Reduces erosion and encourages infiltration; Transport |
| Riparian Buffers or Filter Strips | Acts as trap to remove pollutants before entering waterways; Transport |
| Cover crops, "scavenger crops, or crop rotation | Reduces erosion and encourages infiltration, improves soil quality and provides additional uptake; Transport and availability |
| Conservation or Reduced Tillage | Reduces erosion and encourages infiltration, improves soil quality and provides additional uptake; Transport and availability |
| Ponds or retention structures | Acts as trap to remove pollutants before entering waterways; Transport |
| Rotational Grazing/ Pasture Management | Reduces runoff and erosion, increases plant uptake; Transport and availability |

*BMPs to Reduce Nutrient Losses*

Managing the amount, source, form, placement, and timing of nutrient applications are activities that will accomplish both crop production and water quality goals. This holds true for all nutrient sources including manure, organic wastes, chemical fertilizers, and crop residues. Nutrient management plans are essential to apply the right amount of nutrients, in the right place, and at the right time to maximize yield and environmental protection. Proper nutrient management encompasses more than simply applying the right amount of nutrients. It is also important to make sure these nutrients are applied at the right time and in the proper locations. Proper maintenance and calibration of the application equipment is critical since a precisely calculated application rate does little if your machinery is not functioning properly. Nutrients also need to be applied when the vegetation can use it, during the spring or before periods of rapid growth. Avoid applying any nutrients during periods when the soil is saturated or frozen. It does little good to spend a lot of time and money on nutrients that will be washed off the soil surface with the first large rainfall so avoid land application immediately preceding large rainfall events. If possible, incorporation is the best way to insure that the plant nutrients remain in the soil.

A summary of the major nutrient management practices to enhance surface water and groundwater quality includes

1. Application of nutrients at rates commensurate with crop uptake requirements is one of the single most important management practices used for reduction of off site transport of nutrients.
2. Maintaining good crop growing conditions will reduce both surface runoff losses and subsurface losses of plant nutrients. Preventing pest damage to the crop, adjusting soil pH for optimum growth, providing good soil tilth for root development, planting suitable crop varieties, and improving water management practices will increase crop efficiency in nutrient uptake.
3. Timing of nutrient application to coincide with plant growth requirements increases uptake efficiency and reduces exposure of applied nutrients to surface runoff and subsurface leaching. Optimum time of application depends on the type of crop, climate, soil conditions, and chemical formulation of fertilizer or manure. Consult a certified crop advisor or professional agronomist to discuss when manure/nutrients should be applied to maximize crop uptake.
4. Certain soil and water conservation practices will reduce sediment-associated nutrient losses. Contouring, terraces, sod-based rotations, conservation tillage, and no-tillage reduce edge-of-field losses of sediment-bound-nitrogen and sediment-bound-phosphorus by reducing sediment transport.
5. Proper selection and calibration of equipment will ensure proper placement and rate of nutrient delivery. Improper calibration and equipment maintenance will result in over or under application of nutrients or uneven nutrient distribution. Appropriate handling and loading procedures will prevent localized spills and concentration of manure nutrients.
6. Crop sequences, cover crops, and surface crop residues are useful tools for reducing runoff and leaching losses of soluble nutrients. Winter cover crops may theoretically capture residual nutrients after harvest of a summer crop. Nutrient credits for "green manures" and cover crops must be taken to determine the appropriate rate of additional manure application. A suitable cover crop should be planted to scavenge nutrients especially in sandy, leachable soils. On soils with a high potential for leaching, multiple applications at lower rates should be used.
7. Deep-rooted crops, including alfalfa and to a lesser extent, soybeans, will scavenge nitrate leached past the usual soil-rooting zone. Used in crop rotation following shallow-rooted or heavily fertilized row crops, deep-rooted crops will recover excess nitrate from the soil and reduce the amount available for leaching to groundwater.
8. Use commercial fertilizer only when manure does not meet crop requirements.
9. Manure should not be applied more than 30 days prior to planting of the crop or forages breaking dormancy. Incorporate manure to reduce N loss, odors, and nutrient runoff for crops where tillage is normally used.
10. Applications of animal manure should not be made to grassed waterways. If applications are made, they should be conducted at agronomic rates and during periods of low rainfall to minimize runoff from the site.
11. On manure application sites that are grazed, reduce nitrogen rate by 25% or more to account for nutrient cycling through the grazing animals.

*Pasture Management*

There are several keys to maintaining adequate and sustainable pastures. Plant selection is critical as the plant must be adapted to both the soil and climate to insure adequate cover throughout the year. Determining proper stocking rates that will not damage the vegetative cover and result in increased soil erosion is also essential. Controlling animal traffic can help to prevent bare spots that could lead to the formation of gullies. If application sites are grazed, producers are encouraged to develop a grazing plan. Plans should encourage controlled frequent rotational grazing, multiple drinking water sites, and strategic harvesting to optimize manure and urine distribution by grazing animals. These practices will minimize potential point sources from stock camps, shade trees, water tanks, and heavy use areas. It is also essential to reduce manure application rates as nutrient removal rates are much lower for grazed pastures than for hayfields.

*Water Control Structures*

No matter how well you manage a operation, there will be times when runoff occurs. Since all water flows downhill, the total amount of surface runoff going past a given point will increase as you move downhill. As the runoff concentrates in rills and gullies its erosive force and its ability to transport pollutants continues to increase. Often structural practices such as terraces, diversions, grassed waterways, sediment basins, subsurface drainage, or even farm ponds can be used control the flow of water and protect water quality. While these practices are often costly to install, they usually have production and aesthetic benefits in addition to their environmental benefits.

Steep slopes and irregularities on the land surface contribute to increased flow concentrations and the formation of rills and gullies. Terraces and diversions can be used on steep or long slopes. Both of these practices are effective because they slow the runoff down by encouraging flow across the hillside rather than down the steeper hill slope.A grassed waterway is a natural or constructed channel, usually broad and shallow, planted with perennial grasses to protect soils from erosion by concentrated flow. These waterways serve as conduits for transporting excess rainfall and diverted runoff from the fields or pastures without excessive soil erosion. The vegetation also acts as a filter to remove suspended sediment and some nutrients. Grassed waterways require careful maintenance and periodic reshaping, especially after large or intense storms.

The use of sediment basins or small farm ponds is one final method of preventing off-farm pollution. A sediment basin is a barrier or dam constructed across a waterway to reduce the velocity of the runoff water so that much of the sediment and associated nutrients settle to the basin bottom. Small sediment basins require regular sediment removal while larger basins can almost appear to be a pond and may support fish and wild life. A well-placed pond can collect all of the runoff from a farm and have a positive impact on water quality. It acts as a detention basin by removing sediment and nutrients from the flow and reducing the volumes of flow occurring at peak conditions. It can also filter many nutrients if aquatic vegetation or fish are used. Finally, the pond can act as a buffer between the farm and the external environment.

**Summary of Essential Information**
Site Selection is critical to preventing environmental problems with dedicated land application sites. Ideal sites should be isolated, on slopes less than 7% slope, away from streams, rivers and wells, have deep seasonal groundwater tables, with soils that are suitable for maintaining good vegetative growth.

When determining which manure to place on which fields, remember, manure with the highest nutrient content should go to fields that are further away and have the highest nutrient demand. High P manure should be placed on fields with the lowest soil test P.

Keys to limiting nutrient movement include placing the right amount of nutrient, in the right time, and at the right spot. This will minimize losses and maximize nutrient use. The right amount is determined through soil and manure analysis and nutrient management budgeting. The right time is when the plants can use the nutrients and when the risk of pollution is lowest (ie. Avoiding applications prior to large storms and periods of high rainfall). The right place is in a location where plant roots can reach the nutrients and buffering critical areas such as stream banks and wells. Timing of application should be dictated by plant need and not the capacity of the storage structure.

When choosing an application method, you should consider initial cost, labor and operating costs, uniformity and precision of application equipment, timeliness of use, conservation of nutrients, odor, and soil compaction. Reliability is also important. Which system handles equipment failures better?

Calibration of application equipment is essential. It will verify actual application rates, troubleshoot equipment problems, determine appropriate overlaps, evaluate application uniformity, and monitor changes in equipment operation and manure properties.
Solid treatment and application methods are generally preferred to liquid and slurry systems because there are usually great utilization options and lower transportation and handling costs.

To determine actual application rates, you need to know the amount applied and the area it was applied on. This can be accomplished at various scales from field scale to collection in a rain gage. Application uniformity requires measurement of the distribution and requires several measurements of application rates at specific points. Knowledge of uniformity is essential for determining proper overlap and also for evaluating application system capabilities.

Surface applications of manure result in much greater nitrogen losses. Manure broadcast as a solid generally loses 15 to 30% of its nitrogen while liquids lose 10 to 25%. Immediate incorporation can reduce this to 1 to 5%. Nitrogen losses and odor are much lower with injection or low pressure irrigation.

Best Management Practices are effective economical approaches for preventing or reducing pollution generated from non-point sources. To be effective, BMP's must be properly planned, designed, and implemented or installed. This requires knowledge of the sources of pollutants, their transport mechanisms, and the effects on water quality. These are the tools that the agricultural community has to protect water quality. While the tools can be effective, good management and desire are the most important aspects of preventing agricultural nonpoint source pollution. These principles can not be mandated or implemented by anyone other than the landowner so it is ultimately their responsibility to become an environmental steward and protect our water for future generations.

Reducing soil erosion is critical because sediment is a pollutant and also because it often carries nutrients and other pollutants with it. The amount of runoff and soil erosion at a given point is dependent on the climate (rainfall), soil type, cover and management and the slope length and steepness. Anything you can do to increase vegetative or residue cover, increase infiltration into the soil, or slow down the runoff coming off a field will decrease pollutant transport off the field.

Some BMP's like filter strips and buffers are effective at trapping pollutants and limiting transport offsite. Farm ponds and sedimentation basins are also excellent traps.

## FIELD IRRIGATION APPLICATION RECORD

Field Name (#)

Spreadable Acres - 1

Annual PAN Needs (lb/acre)

| Date | Volume (acre-in) | Total Nutrients Applied (lb) N | $P_2O_5$ | $K_2O$ | N Avail. Coeff. | Total Applied (lb/acre) N | PAN | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | 0 | 0 | 0 | 0 |
| Total | 0.00 | 0.00 | 0.00 | 0.00 | | 0 | 0 | 0 | 0 |
| | | | | Additional PAN Needed | | | 0 | | |

Crops Grown

**N Availability Coefficients**

**(Irrigation)**

**Slurry or lagoon sludge**

| | |
|---|---|
| Dairy | 0.4 |
| Beef | 0.4 |
| Swine | 0.3 |
| Layer | 0.4 |

**Anaerobic lagoon liquid**

| | |
|---|---|
| Dairy | 0.5 |
| Beef | 0.5 |
| Swine | 0.5 |
| Layer | 0.5 |

## IRRIGATION PUMPING RECORD

Note: 1 acre -in = 27,156 gal

| Date | Appl. Time (minutes) | Flow Rate (gal/m) | Nutr. Conc. (lb/acre-in) N | $P_2O_5$ | $K_2O$ | Volume (acre-in) | Total Nutrients Pumped N | $P_2O_5$ | $K_2O$ | Field # | Weather |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | | | | 0.00 | 0 | 0 | 0 | | |
| | | | Total Pumped | | | 0.00 | 0 | 0 | 0 | | |

**Example of Manure Agreement**

## *MANURE UTILIZATION AGREEMENT FOR LEASED LAND*

I, ____________________________, hereby give ___________________ permission to apply waste from his poultry production facility on ________ acres of my land for the duration of the time shown below.

I understand that this manure contains nitrogen, phosphorus, potassium, and trace elements, and when properly applied should not harm my land or crops. I also understand that the use of animal manure will reduce my need for commercial fertilizer.

Adjacent Landowner: ________________________________ Date: _________

Manure Producer: __________________________________ Date: _________

Technical Representatives: ___________________________ Date: _________

Term of Agreement: _____________________,2000___ to __________, ____.

## Example of third party form

### *Manure Utilization - Third Party Applicator Agreement*

I, ______________________________ hereby acknowledge that I have received a copy, have read, and understand the Nutrient Management Plan dated ________________ that was developed for/by __________________________________ for their facility located at ____ ______________________________________________________________________________in _________________ County.

I hereby agree to manage and land apply the manure that I received from this facility in a manner consistent with all Federal, State and local laws.

Third Party Receiver: _______________________________ Date: _________

Manure Producer: __________________________________ Date: _________

Technical Representatives:

Term of Agreement: ______________________,20___ to _________, _20__

# Emergency Action Plans

**Dr. Mark Risse**
Adapted from Lesson 50 of National Animal and Poultry Waste Management Curriculum

Manure spills and discharges largely just don't happen, they are caused. Behind most spills is a chain of events that leads up to an unsafe act, improper judgement, unsafe conditions, or a combination of factors. Manure spills and discharges are the most common cause of regulatory penalties in Georgia and the Nation. Preventing and properly responding to discharges on the farm is everyone's concern. Communication between the farm owner, supervisors, agencies with emergency response responsibilities and employees generates ideas and awareness that leads to accident prevention and quick response in the event a spill occurs. Education programs, response plans, and regular inspections of your manure management and application system are essential in providing the lines of communication that lead to a safe, accident-free operation.

**Intended Outcomes**

The producer will:

- Recognize the need for developing an Emergency Action Plan
- Identify the steps involved in reporting and responding to a manure spill
- Identify activities related to their manure management system that may lead to higher environmental or human health risk
- Be prepared to develop an Emergency Action Plan for their facility

**What is an Emergency Action Plan?**

A basic, yet thorough, common sense plan that will help you make the right decision during an emergency.

**Why have an Emergency Action Plan?**

Murphy's Law: accidents will happen.
If it is written down, you will use it.
Plan before potential emergencies.
To protect you and other against environmental damage.
It should be part of a Comprehensive Farm Plan.

Emergency action plans are needed to minimize the environmental impact in the event of manure spills, discharges or mishaps. In several states these plans are required on all livestock operations, especially those with liquid manure management systems. According to Georgia swine regulations, an emergency action plan is a required component of a CNMP. The plan should be available to all employees and they should be trained in its use. This plan will be implemented in the event that manure or other wastes from your operation are leaking, overflowing, or running off the site. You should NOT wait until manure or wastewater reaches a stream or leaves your property. You should make every effort to ensure that this does not happen.

**Prevention**

*The most important part of the plan is preventing spills from occurring in the first place.*

Many "emergencies" can be prevented using routine maintenance. Inspections are often a key to finding problems before they turn into emergencies. Inspections of all manure storage or lagoons should be conducted on a regular basis; at least monthly but preferably weekly. Embankment areas should be keep mowed and free of trees and shrubs to allow for visual inspection of the embankment for any sign of seepage or cracks. If you notice any seepage, consult NRCS or the engineer who designed the facility to discuss the extent of seepage or cracking and what measures can be taken to further investigate or repair the situation. Consult NRCS, professional engineers, or tank manufacturers before making any modifications or repairs to your storage structure or lagoon. In many instances, specific procedures must be taken to insure that the structural integrity of the unit or embankment is not compromised in the process of making any modification or repair. Major spills and lagoon breeches have been caused by failing to follow these procedures.

Several livestock producers across the country are using electronic monitoring devices to assist them in managing their lagoon or storage basin levels. These monitors (Figure 1) consist of a liquid level sensor, microcomputer, rain gauge and phone connection. Lagoon levels and rainfall values are recorded twice a day and transmitted to a service provider who prepares weekly records. The monitors can also warn producers by either phone or pager of potential environmental or operating hazards such as approaching or reaching maximum storage levels or regulatory freeboards. Breech alarms can also be set on the monitors to contact producers in the event of a tank rupture or lagoon spill. Some lagoon monitors can also be modified to monitor livestock buildings in case of power outages. Similar power and liquid level monitoring devices can be used on other areas of the manure handling system such as pumping/lift stations. Livestock facilities should also consider secondary containment around existing storage facilities, pumping/lift stations, recycle pumps or production houses. These structures should be designed to collect the spilled manure and excess rainfall that may collect in an area. The collected liquid can then be transported and applied to cropland at agronomic rates.

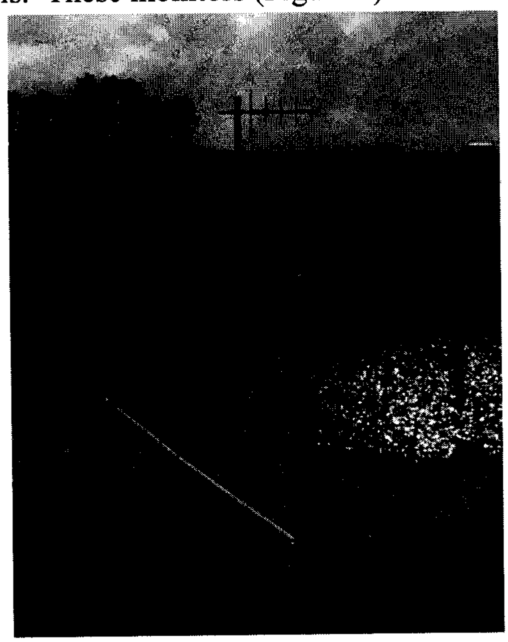


**Figure 1 Remote lagoon monitoring**

Another prevention practice is the installation of low-pressure, low-flow or other automatic shut-off switches on pumping equipment for liquid irrigation systems. If these devices are not used, you should keep radio or cellular communications with someone who will remain close to the pump. Check all irrigation lines prior to pumping and look for defects, insecure or worn connections. Place solid pipes over any watercourses, wetlands, ditches or containment areas so that they are always visible for inspection.

Types of Emergencies

Your response to emergency situations will be governed by site- and situation-specific circumstance, which your own plan should address. However, there are responses you should consider based on the type of emergency you are experiencing. These responses can be broken down according to three stages of emergency defined as imminent pollution or emergency, pollution in progress, and pollution discovered after the fact. These instructions should be available to all employees at the facility, as accidents, leaks, and breaks can happen at any time.

**Imminent Pollution**
In this type of situation, there have not yet been any leaks or spills. However, ignoring the fact that an emergency exists will probably result in a spill or leak within a short time. The main sources of this type of emergency are when lagoons, holding ponds, or pits are nearing capacity, or when there is potential for wastes to run off an application field.

*Storage capacity about to be exceeded.* Long periods of excessive rain or malfunctioning livestock water systems may cause your storage to unexpectedly reach capacity. Your response should be to prevent the release of wastes. Depending on your situation, this may or may not be possible, but suggested responses to this type of problem include:

- Add soil to the berm to increase the elevation of the dam.
- Planned emergency utilization of manure by pumping onto fields at acceptable rates.
- Stop all additional flow to the storage (waterers).
- Call a pumping contractor.
- Make sure no surface water is entering the storage.
- Consider maintaining some grassland near the storage for emergency manure application.

These activities should be started when your lagoon has exceeded the temporary storage level as defined for the lagoon. Waiting for the lagoon to reach the freeboard level may result in spills as you never know when the pumping equipment will malfunction. Start early!

*Potential runoff from application field.* This situation could result from unexpected rains during field application of manure. Again, the response is to prevent the release of wastes to neighboring areas. Possible solutions include:

- Immediately stop additional waste application.
- Create a temporary diversion or berm to contain the waste on the field.
- Incorporate waste to prevent further runoff.

*Hurricanes and tropical storms.* These severe storms are unpredictable in nature, and depending on their intensity, they can cause a great deal of damage to an area. They normally occur from June 1 to November 30 and can produce tornadoes and cause severe flash flooding. Tropical storms and hurricanes can also deliver large amounts of rainfall in very short periods of time. Areas that are prone to these storms should prepare for their possibility months beforehand. Before the hurricane season begins, temporary storage levels in lagoons and storage basins should be as low as possible. Be prepared for multiple storms. In September 1999 many livestock producers in the coastal regions of North Carolina, South Carolina, and Virginia received over 30 inches of rainfall from two hurricanes and one tropical storm.
Regardless of their size, hurricanes should be respected! The National Hurricane Center issues a hurricane watch when there is a threat of hurricane conditions within 24-36 hours. Hurricane warnings are issued when hurricane conditions (winds of 74 miles per hour or greater) are expected in 24 hours or less.

*Seasonal heavy rainfall.* From year to year, many areas of the county may receive periods of high rainfall that may be atypical of long term averages. These wet periods may delay crop planting, thus manure removal from storage facilities exceeding the design storage capacity of the structure. In these situations discuss your options for manure removal with your comprehensive nutrient management planner, technical specialist and design engineer. Remember, it is probably better to pump manure nutrients when they are not needed than to risk overtopping and lagoon failure.

*Flooding.* Several floods in the mid-west and eastern states have shown the vulnerability of livestock facilities located in or near floodplains. Before the floodwaters begin to rise, you should consider several items:

- Will the farm be isolated due to road flooding?
- How many days of protected feed storage is on the farm?
- How will animals be evacuated from the farm?
- How will animal mortalities be managed? Is an upland site dedicated if burial is the preferred option?
- Which is at a higher risk of flooding - buildings, manure storage, feed storage or mortality disposal sites?

**Pollution in Progress**

In this type of situation, the storage or waste handling system is actively leaking. Your main goals here are to stop the flow and minimize the impact of the leak on the environment.

*Leaking or broken pipe, pit wall, or lagoon berm.* These leaks may be seepage or flowing wastes. Response will depend on the level of the impact from the leaking waste (is it on your property or off?). Possible solutions include:

- Stop flow into pipe, pit, or lagoon.
- Prevent additional leaking of material by turning off recycle flushing system and irrigation pumps; closing valves controlling outflows; and preventing siphon effect.
- Dig a holding area or construct a berm to contain waste waters.
- Repair defective component.

Lagoon problems may require the consultation of an individual experienced in the design and installation of lagoons for permanent repair measures.

*Tankwagon leak or overturn.* There is a good chance that this emergency will be off your property and may include personal injuries (e.g., automobile accident). If there are injuries in any livestock waste emergency, they take precedence over all other responses. Once injury response is taken care of, limiting the environmental impact becomes the main goal in responding to this type of emergency. Possible solutions include:

- Stop additional spill of material.
- Contain material that has spilled.
- Begin clean-up procedures.
- Contact appropriate agencies if waste is on or off your property or there is surface or ground water impact.

**Pollution Discovered After the Fact**

This situation occurs when a leak or spill is discovered several days after it occurs. There is a potential for increased environmental impact due to the late discovery of waste leakage. Response should be swift in order to minimize damage as much as possible. Responses should include:

- Stop additional leakage.
- Contain spilled wastes.
- Attempt application of spilled wastes on cropland.
- Notify agencies and local authorities.
- Assess environmental impact of fish kill, surface water pollution, well or ground water impact, and amount of waste released and for what duration.

**Components of Emergency Action Plans**

While every emergency is different, response actions should be similar. As stated earlier, human health and injuries take precedence and should be dealt with first. Also, you should never put someone in life threatening or risky situations as part of your response plan. These following steps should provide a framework for developing your plan.

1. Eliminate the source. Depending on the situation, this may or may not be possible.

2. Contain the spill and minimize manure movement off the farm or downstream.

3. Assess the extent of the spill and note any obvious damages.

- Did the waste reach any surface waters?
- Approximately how much was released and for what duration?
- Any damage noted, such as employee injury, fish kills, or property damage?
- Distance and direction to nearest neighbor or town or public well of the release?
- Did the spill leave the property?
- Does the spill have the potential to reach surface waters?
- Could a future rain event cause the spill to reach surface waters?
- Are potable water wells, spring, or groundwater recharge areas in danger?

Review any actions that were taken to contain or minimize the spill or discharge.

4. Contact appropriate agencies.

State law requires that "Whenever, because of an accident or otherwise, any toxic or taste and color producing substance, or any other substance which would endanger downstream users of the waters of the State or would damage property, is discharged into water, or is so placed that it might flow, be washed, or fall into them, it shall be the duty of the person in charge of such substances at the time to forthwith notify the Environmental Protection Division in person or by telephone of the location and nature of the danger, and it shall be such person's further duty to immediately take all reasonable and necessary steps to prevent injury to property and downstream users of said water." This means that you must notify the EPD as soon as possible. Your phone call should include: your name, facility, telephone number, the details of the incident from item 2 above, the exact location of the facility, and the location or direction of movement of the spill, weather and wind conditions, what corrective measures have been undertaken, and the seriousness of the situation.

GEORGIA STATEWIDE NUMBER FOR REPORTING SPILLS IS: 800-241-4113

If spill leaves property and enters surface waters where health could be in danger, call local Emergency Medical Services (EMS) or fire department. Instruct EMS to contact local Health Department if necessary. If none of the above works, call 911 or the Sheriff's Department and explain your problem to them. Ask them to contact the agencies as listed above.

5. Clean-up the spill and make repairs.

Perform any modifications that were recommended by the Department of Natural Resources and technical assistance agencies or professional engineers to rectify the damage, repair the system, and reassess the manure management plan to ensure the problem will not happen again in the future. The emergency action plan must include provisions for emergency spreading or transfer of manure from all storage structures in the system. This may include emergency pumping or spreading (to prevent overtopping of a storage structure) during periods when the soil or crop conditions are not conducive to normal spreading or application. You should contact the Department of Natural resources or local soil and water conservation district for guidance to apply manure in this instance. You should consider which fields are best able to handle the manure and wastewater without further environmental damage. Application rates, methods, and minimum buffer distances must all be addressed. If transferring waste to another location for application, consider the limitations that may be involved with the transfer of waste to that site and application considerations at that location.

**Creating a Community Response Plan**

When an emergency arises you may need the assistance of neighboring farmers, fire departments or other county services. Communities have developed and are encouraged to develop Community Response Plans that assist livestock producers in the event of manure spills or catastrophic animal deaths. These plans allow livestock producers to review or develop the components of their farm's Emergency Action Plan with the assistance of neighboring livestock producers and farmers as well as community emergency response personnel. Collectively, this process gives producers the opportunity to find out who in the community (producers, farmers or community services) owns equipment that may be available locally to use in the event of a manure spill. Large equipment that may be necessary to respond to and clean up a manure spill include graders, bulldozers, back hoes, front-end loaders, portable electric generators, portable diesel pumps and irrigation pipe, vacuum tank wagons, and dump trucks.

As with most emergencies, it is always better to be prepared than to "test" a response plan during an actual emergency. Several communities have taken this lesson to the farm. Mock "spills" have to be conducted to train Manure Spill Teams and test the effectiveness of a community's response plan. Livestock producers, farmers, volunteer fire departments, county health department and local police or sheriff office work together to form the Manure Spill Teams. These exercises are not meant to address every possible type of spill or area that may be affected by a spill. Rather these drills allow the Manure Spill Team (or responding agencies or groups) to work together, develop communication protocols and establish general procedures that will need to be implemented to protect human health, minimize environmental impact, and foster a quick clean-up.

## Post-Spill Assessment and Reporting

State law requires that "Whenever, spills occur which would endanger downstream users of the waters of the State or would damage property, it shall be the duty of the person in charge at the time to notify the Environmental Protection Division (EPD) in person or by telephone of the location and nature of the danger, and it shall be such person's further duty to immediately take all reasonable and necessary steps to prevent injury to property and downstream users of said water." This means that you must notify the EPD as soon as possible. Your phone call should include: your name, facility, telephone number, the details of the incident from item 2 above, the exact location of the facility, and the location or direction of movement of the spill, weather and wind conditions, what corrective measures have been undertaken, and the seriousness of the situation.

THE GEORGIA STATEWIDE NUMBER FOR REPORTING SPILLS IS: 800-241-4113
THE STATE OPERATIONS CENTER IN ATLANTA IS: 404-656-4300

On permitted operations, the reporting requirements will be specified in the permit. In most cases, reporting of spills or any other non-compliance that would endanger human health or the environment is required by telephone within 24 hours and in writing within five working days of the discharge. The reports will need to include:

- Description of the discharge including its cause, flow path, receiving water body, and an estimate of the amount discharged.
- Time and location of discharge
- Analysis of discharge for chemical and biological parameters or valid reasons for not sampling
- Steps taken or planned to reduce, eliminate, and prevent the recurrence of the discharge.

Assessments or "follow-up" reports give you and the regulatory agency an opportunity to reflect and learn from the events that lead up to the spill and those actions that were taken following the spill. Some of the questions you should consider answering in the report are listed below.

- Assess the extent of the spill and note any obvious damages.
- Did the waste reach any surface waters, wetlands, tile drains or wells?
- Approximately how much manure was released and for what duration?
- Any damage noted, such as employee injury, fish kills, habitat degradation or property damage?
- Response to spill.
- When and where was the spill contained?
- What measures were taken to avoid additional contamination?
- Did a technical specialist or any local group assist in the clean-up?
- What specific corrective actions are necessary to repair any damage to your storage structure, manure transfer or application equipment to prevent another spill?
- Can you determine the cause of the spill or discharge?
- If appropriate, were signs present of the condition before the accident occurred?
- When were local and state agencies contacted notifying them of the spill?
- Did a representative of the state water quality agency or health department respond to the notification? List names, titles and agencies.
- Were you given and "special" instructions from state or local representatives?

Developing an Emergency Action Plan

Every farm should have an Emergency Action Plan, although they are even more important on farms that store liquid manure or slurry. On animal feeding operations where CNMP's are required, these plans should be a part off the CNMP. This plan is your first response to spill even before it occurs. Simple things, such as collecting phone numbers and listing hazardous chemicals on the farm, will shorten the response time in the event of an emergency. Whether the emergency is a lagoon breach, fire, flood or overturned spreader your emergency action plan should help you prepare to reduce the risk to you, your coworkers, the farm and to the environment.

At the end of this chapter there are two emergency action plans that can be implemented on your farm. The first is a "simple" emergency action plan example that all farms could use. The second focuses on liquid manure and spill prevention and should be used in conjunction with the first on operations with liquid systems. Review them both before preparing your own. Use these examples to prepare a plan that will be used on your farm. These templates can be modified as you see fit to tailor it to your operation. Extension employees, NRCS specialist, and consultants should also be able to assist you with development of these plans if necessary.

Once completed, this plan should be available and understood by all employees at the farm. The main points of the plan (order of action) along with the relevant phone numbers should be posted by all telephones at the site. A copy should also be available in remote locations or vehicles if the land application sites are not close by the facility office. It is the responsibility of the owner or manager of the facility that all employees understand what circumstances constitute an imminent danger to the environment or health and safety of workers and neighbors. The employees should be able to respond, and have the authority to initiate containment and cleanup activities, during emergencies as well as notify the appropriate agencies of conditions at the facility. Lastly, post emergency contact phone numbers by every phone on the farm.

**Manure Spills, Accidents and Discharges .... real stories, real issues.**

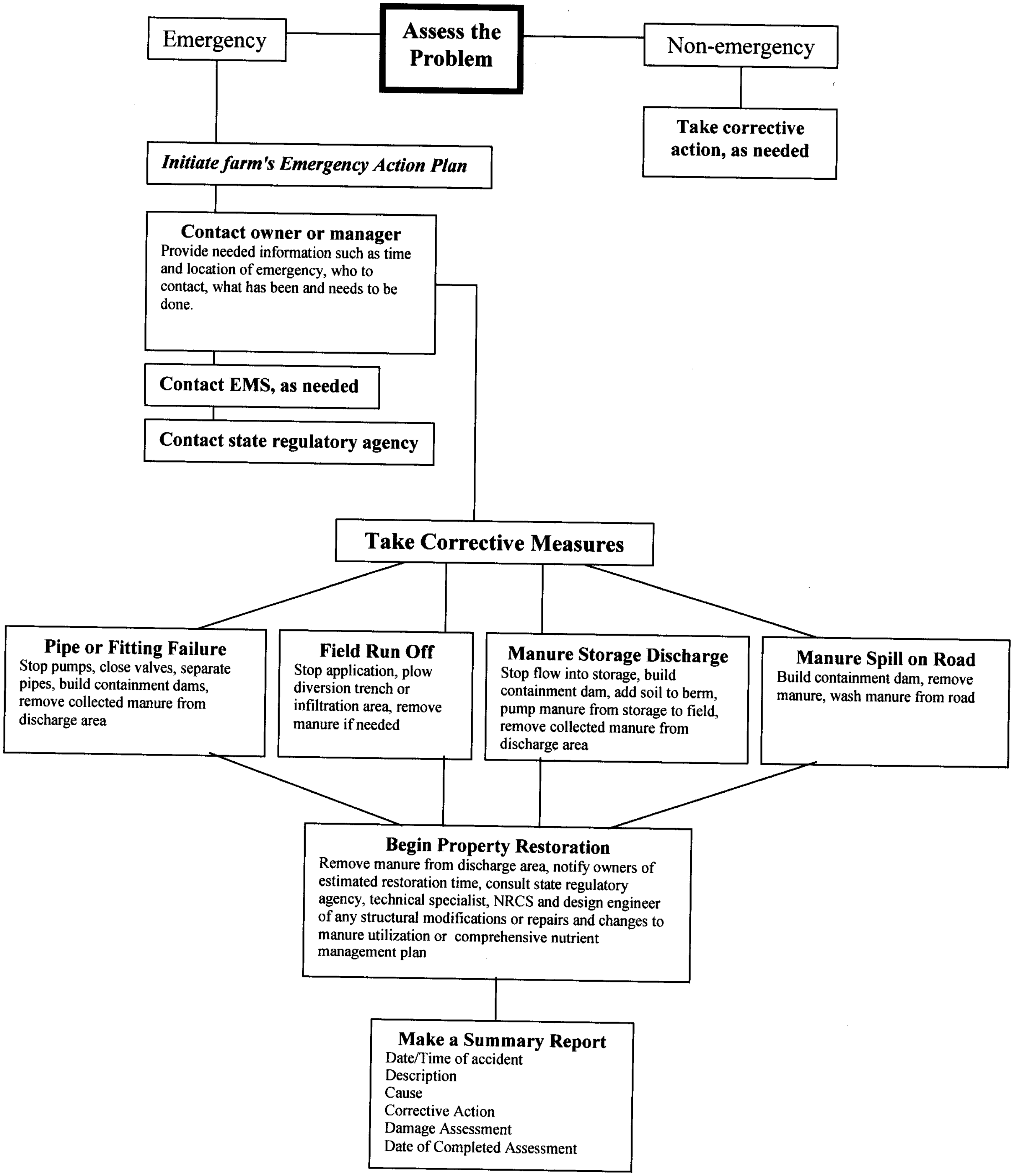
Learning from the mistakes in the past gives us the opportunity to make appropriate changes in the future. The following is a collection of case studies that reviews several manure spills that have occurred on livestock operations. These are real events and unfortunately they are not the only examples of manure discharges and spills into our surface and ground waters.

As you read these case studies of real farms, ask yourself:

- Was the manure spill an accident?
- What could have been done to prevent this spill from happening?
- Could this happen on my farm?
- Would I know how to handle or have the resources to address a similar spill on my farm?
- Do I have an emergency action plan if a spill occurs?
- Would an Emergency Action Plan have been helpful?

# Typical Steps in Responding to Manure Spill or Discharge

*Adopted from the NPPC Environmental Assurance Program*



Case Study #1

# .... *Equipment Failure*

**Location: Ontario, Canada**
**Operation: Swine**

### Background:

- A portable irrigation system was laid out over a stream to reach a field for the application of swine lagoon effluent.
- When the pump was turned on, a section of pipe over the bridge became disconnected.
- The farmer wired the pipes back together then continued the manure application.
- No attempt was made to collect the effluent released into the stream.
- The farmer had never notified regulators of the incident two days after the event occurred.

### Result:

- Lagoon effluent leaked from the separated pipes and flowed directly into the stream below.
- Fish were killed in the creek downstream of the spill.

### Response:

- Ontario investigators confirmed the spill had caused the fish kill in the creek.
- Charges were laid onto the farmer citing a lack of 'due diligence' and 'failure to notify' regulatory authorities in a timely manner.

### Action:

- No further action was taken by the farmer.
- The farmer was convicted and fined.

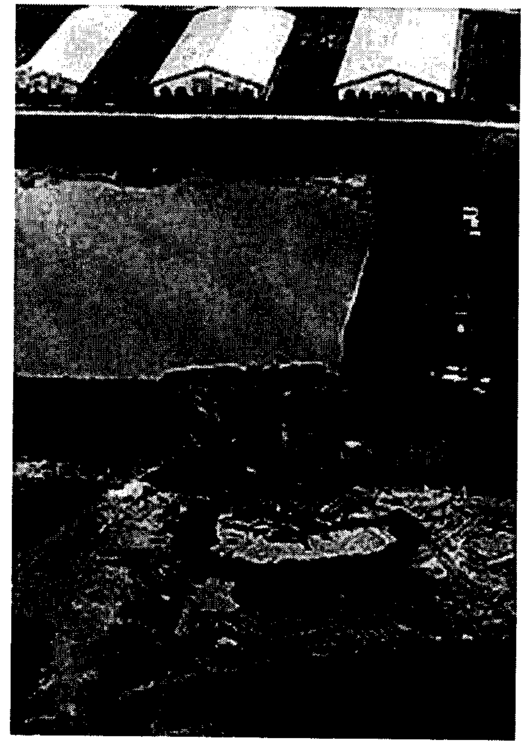
### How Could this Spill have been Avoided?

- Use a section of flexible pipe to carry manure over streams and bridges.
- Monitor the pipeline during application.
- Be prepared to shut down immediately if a problem develops by having manpower and radios on hand.
- Notify the appropriate state and local authorities as soon as possible.

Case Study #2

# .... Improper Modification of Storage Structure

**Location: Southeastern North Carolina**
**Operation: Swine**



### Background:

- 7.3 Acre lagoon exceeded its temporary liquid storage
- Irrigation equipment was not on site nor was sufficient land cleared for application if a pump and equipment was available
- Approximately a week before the spill, farm workers improperly installed a pipe in the lagoon embankment
- Rainwater from a tropical storm ponded above then scoured out the embankment near where the pipe was installed
- The lagoon breached releasing lagoon effluent and sludge

### Result:

- Over 22 million gallons of effluent and sludge were discharged into a river nearby.
- Approximately 4,000 fish were killed in the river downstream of the spill.

### Response:

- Television and print media reported the lagoon spill all over the state and country. The spill was reported in newspapers as far away as Den Hague, Netherlands.
- State water quality investigators confirmed the spill had caused the fish kill in the creek..
- Charges were laid onto the farmer for violating state water quality standards.

### Action:

- The farm was required to depopulate until repairs were made to the lagoon, irrigation equipment was purchased and sufficient land application field were cleared and planted.
- The farmer was convicted and fined.
- Repairs and land clearing were completed approximately one and a half years after the lagoon breach.

### How Could this Spill have been Avoided?

- Consult and follow plans provided by NRCS or a professional engineer before installing any pipe or electrical line on a lagoon embankment
- Ensure trenches on embankment are dug in a "V" shape and backfill soil should be mechanically tamped. Excess soil should be placed over the backfilled trench to allow for any settling.
- Ensure land application fields are cleared and planted prior to populating a new farm or delivering manure to a new storage basin or lagoon.
- More frequent inspections by farm personnel, technical specialists and regulatory agencies.
- Implementation of Emergency Action Plan and notification of spill to local emergency services

Case Study #3

# ... Over Application of Manure

**Location: Southern, Ohio**
**Operation: Dairy**

### Background:

- The gasoline powered drive engine on a travelling gun irrigation system ran out of fuel while the irrigation pump was still running
- Excessive amounts of liquid manure were applied to a level untilled field

### Result:

- Manure leached down to a tile system and drained into a open drainage ditch
- The water quality was impaired by low dissolved oxygen levels downstream in the drainage ditch and adjoining stream
- The farmer observed discolored water and foam discharging from the field tile into the open drain

### Result:

- State water quality officials responded to an anonymous call
- Water samples were taken to identify the source of contamination
- Discolored water and foam were found discharging from a field tile outlet into the drainage ditch
- The dairyman was charged with applying manure at a rate that exceeds his manure utilization plan and for violating the water quality standards of the state.

### Action:

- No further action was taken by the farmer.
- The farmer was convicted and fined.

### How Could this Spill have been Avoided?

- Check engine fuel and oil levels before each "pull" on a travelling gun irrigation system
- Delay manure application until field tiles stop flowing
- Inspect irrigation systems during application events. Ensure drive engines and turbines are operating.
- Check soils for their "antecedent" moisture condition before selecting application rates and pumping duration
- Postpone irrigation of manure and wastewater until drainage from tile drains cease.

Case Study #4

# .... Lack of Storage Capacity

**Location: Southeastern Virginia**
**Operation: Poultry Layer**

- An 8,500-gallon tanker was hauling sludge from a poultry layer lagoon to an application site three miles from the farm.
- The tanker failed to check for on-coming train as it crossed a railroad track beside the application field.
- A slow moving train severed the tanker, releasing the high strength sludge into a ditch.
- The startled but unharmed driver immediately contacted company supervisors and the local fire department.

### Result:

- Lagoon sludge released from the tanker flowed directly into a nearby stream.
- Fish were killed in the stream downstream of the spill.

### Response:

- Supervisors from the sludge application contractor contacted state water quality agents.
- The soil was placed into the stream to contain the spilled sludge and contaminated water. Vacuum tanker, already on site, pumped and applied the material to the application field.
- The spill was confirmed to have caused a fish kill in the stream.

### Action:

- The contractor received only a warning due to the company's quick response to mitigating the spill.

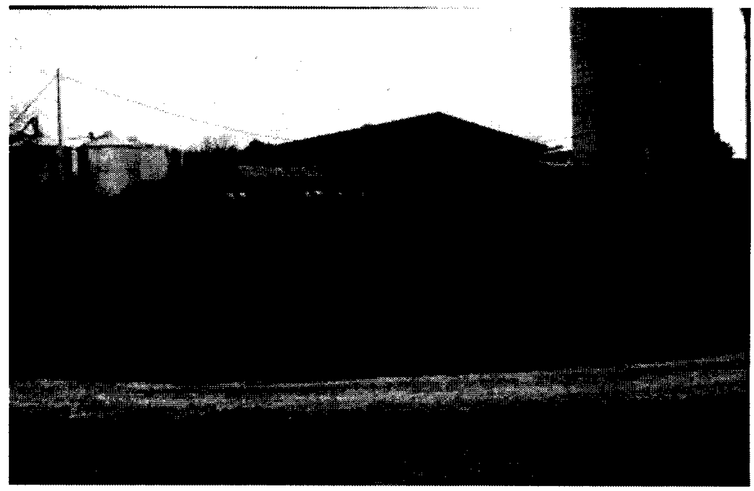
### How Could this Spill have been Avoided?

- Special care should be taken when transporting manure and sludge in on public roads.
- Minimize transport of manure in areas of high traffic, high speeds or railroad crossings.

Case Study #5

# .... Lack of Storage Capacity

**Location: Southern Pennsylvania**
**Operation: Dairy**



### Background:

- Farm's manure storage basin was overflowing into a field
- An irrigation gun and tank wagon was used to apply manure on a bottomland field of wheat stubble
- Application occurred in the evening and at night in November, following several days of rain and snow
- Application rates of 7,200 gal/acre were reported, but were believed to be higher by investigators

### Result:

- Manure from the overflowing storage basin entered a nearby field tile system which drained into a ditch that crossed the property line, and then into a stream on the neighbor's property
- Liquid manure entered the ditch via a tile blowout and open catch basins, eventually contaminating two in-stream ponds on the neighbor's property

### Response:

- State water quality officials were informed by the producer and investigated the following day
- Water samples were taken identifying the source of contamination
- The producer was charged with failing to provide adequate storage and discharging manure into surface waters

### Action:

- The stream was temporarily dammed to prevent further movement of manure laden water downstream
- The producer pumped contaminated water from the stream and applied onto adjacent fields under the supervision of state investigators
- Producer paid a fine with no contest

### How Could this Spill have been Avoided?

- Ensure adequate storage to allow flexibility in application due to weather
- Do not apply manure when soil is nearly saturated from snow or rain
- Inspect fields regularly, especially before manure application, to ensure tile blowouts are repaired
- Monitor tiles during and after manure application
- If a problem occurs, notify your state water quality agency as soon as possible.

# G1: General Emergency Action Plan

Farm Name:
Owner/Operator: **Phone Number:**
2nd Contact Person if owner/operator is not available:
Name: **Phone Number:**
Permit Number (if applicable):
Size and type of operation:

**Fire Emergency Response Information**
Farm Fire Protection District:
911 Coordinates for farm:
Electrical Power Company Name:
Electrical Power Company Phone Number:
Is there a disconnect between the meter base and the buildings? Y N
If so, where?
Size of Electrical Service:
Do you have a standby alternator? Y N
Give the location (sketch preferable) of electrical panels in buildings:

Propane Company Name:
Propane Company Phone Number:
Location and size of propane tanks:

Other fuels and locations:

Are there hazardous materials stored in facilities: Y N
If yes, provide the location(s) and list of materials:

(If you have any medical conditions the EMS personnel should know about, please list them below):
Name: Condition:
Name: Condition:
Name: Condition:

# Emergency Action Plan Checklist

**As part of this plan, the following is made available and each employee is trained and aware of the following procedures.**

- ☐ **Emergency Phone Number List Posted at Each Phone**: An emergency phone notification list, *which includes telephone number of the operator, local offices for fire dept, sheriff dept., EMS, Public Health Office, State Water Quality Agency and State Dept of Agriculture.*

- ☐ **General Farm Information Sheet** and **Facility Map**: *Draw facility layout including location of: telephone locations, location of shutoffs for water, electric, natural gas and propane tanks, re-cycle systems, schematic of waste management system, pumping pits,* ***areas of no entrance without assisted breathing devices****, hazardous materials, ingress/egress for emergency vehicles, identity of immediately adjacent landowners with emergency phone numbers.*

- ☐ **Location of Pre-Arranged Emergency Supply Equipment and Supplies**: List of equipment owners, phone numbers and location of individuals and equipment that may be used in an emergency.

- ☐ **Runoff Retention Plan**: Instructions detailing the **ACTION PLAN** to be taken in an emergency involving runoff of contaminanted water that may result from fire or other emergency. *Maps of the facility and surrounding areas including drainage patterns and locations of spoil materials for forming emergency dikes, location of surface waters, waterways, wells, and any other environmentally sensitive areas should also be included.*

- ☐ **Fire Emergency Information and Response Plan**

- ☐ **Power Outage Information**

- ☐ **Personal Information and Medical Emergency Response Procedures**: *Any medical conditions you or your farm personnel may have that emergency medical personnel should be made aware (i.e., diabetes, heart or respiratory problems, medications, etc.).*

# G2: **Emergency Action Plan (Liquid Manure)**

**The following is posted, clearly by every phone on farm:**

## IF There is an EMERGENCY.......

1) **Shut off all flow into storage area or lagoon or going out to land application areas**

2) **Assess the extent of the emergency and determine how much help is needed**

3) **Contact Farm Supervisors**

| | |
|---|---|
| Name: | Phone #: |
| Name: | Phone #: |

4) **Give supervisor the following information:**
   *Your name*
   *Description of Emergency*
   *Estimates of the amounts, area covered, and distance traveled from manure storage*
   *Whether manure has reached ditches, waterways, streams or crossed property lines*
   *Any obvious damage: employee injury, fish kill, or property damage?*
   *What is being done, any assistance needed*

5) **Contact state environmental protection division, contractors, emergency officials, technical specialists and media, as needed.**
   a) Georgia Environmental Protection Division-
      i) SPILL REPORTING: 800-241-4113
      ii) LOCAL OFFICE Phone______________

| | | |
|---|---|---|
| b) Local County Health Department | | Phone______________ |
| c) Pumping- | Name____________________ | Phone______________ |
| d) NRCS- | Name____________________ | Phone______________ |
| e) Extension Office- | Name____________________ | Phone______________ |
| f) Consultants- | Name____________________ | Phone______________ |

**Provide directions that anybody can direct someone to the site by telephone.**

**Build a containment dam downstream of discharge area, then progressively build additional dams upstream**

- Add soil to the berm of the manure storage area/basin
- Remove manure from the discharge area with a trash pump if necessary

**Pump manure and wastewater from the manure storage to lower the volume in basin**

**Complete Post-Emergency Assessment and Documentation or other State reporting requirements.**

# Pre-arranged Emergency Response Agreements

List any arrangements made with other producers to share personnel and/or equipment and supplies and land access during an emergency.

Pre-arranged land access agreements

Contact #1 ______________________________________________

Contact #2 ______________________________________________

**Location of Pre-Arranged Emergency Supply Equipment and Supplies**

Available 24 hours a day. Include phone numbers and primary contacts. Put list in the order you want equipment operators contacted. Copy posted in each animal building on site, in site office and owners residence. Preferably posted by a phone or main doorway if no phone.

| **Owner** | **Phone** | **Location** |
|---|---|---|
| Irrigation Pumps | | |
| | | |
| | | |
| | | |
| Dozer/Track Loader | | |
| | | |
| | | |
| | | |
| Backhoe | | |
| | | |
| | | |
| | | |
| Vacuum Slurry Tank | | |
| | | |
| | | |
| | | |

# Post-Emergency Assessment and Documentation

1.) Assess the extent of the spill and note any obvious damages.
Did the waste reach any surface waters?
Approximately how much was released and for what duration?
Any damage noted, such as employee injury, fish kills, or property damage?

2.) Contact appropriate agencies:
Reporting a Release of Livestock Waste from a Lagoon

a) Reports of releases to surface waters, including to sinkholes, drain inlets, broken subsurface drains or other conduits to groundwater or surface waters, shall be made upon discovery of the release, except when such immediate notification will impede the owner's or operator's response to correct the cause of the release or to contain the livestock waste, in which case the report shall be made as soon as possible but no later than 24 hours after discovery.

b) The report required under subsection (a) shall be given to the State Water Quality Agency by calling: *(800) 241-4113*

Contents of Report
The report should include, as a minimum, each of the following to the extent that it is known at the time of the report:

a) name and telephone number of the person reporting the release;
b) county, distance and direction from nearest town, village or municipality of the release;
c) an estimate of the quantity in gallons that was released, and an estimate of the flow rate if the release is ongoing;
d) area into which the release occurred (field, ditch, stream, or other description) and apparent environmental impacts of the release;
e) time and duration of the release;
f) the names and telephone numbers of persons who may be contacted for further information;
g) dangers to health or the environment resulting from the release;
h) actions taken to respond to, contain and mitigate the release; and
i) name of facility and mailing address.

3.) Implement procedures to prevent similar occurrences. Seek professional assistance if problem is berm or structure related.

**DOCUMENTATION OF CLEAN-UP EFFORTS**

All responses to emergencies should be documented and kept with the manure management plan. This documentation should include all agency and local authority contacts made during the response phase. This information can be used to assess response to the emergency, prepare for future problems, and train employees.

## Review of Essential Information

An Emergency Action Plan is a basic, yet through, common sense plan that will help you make the right decisions in an emergency.

You should have an Emergency Action Plan because:

- accidents will happen,
- writing the plan requires you to plan for emergencies
- it makes you more likely to remember appropriate responses during emergencies
- they minimize environmental and human health impacts
- it is required as part of a CNMP
- it is a great pollution prevention strategy.

The format for an Emergency Action Plan consists of the following five steps:

1) Eliminate the source
   Shutting down pumps, building diversions or berms, closing valves, repairing leaks
2) Contain the spill
   Building berms, diversions, dams, or basins
3) Assess the extent of the spill and note damages
4) Contact appropriate agencies
5) Clean up and make repairs
   Modifications and plans for prevention of future accidents.

The most important part of a plan is preventing spills from occurring in the first place.

Prevention measures include regular inspection, monitoring and record keeping, automatic cut-offs, and secondary containment.

Three types of emergencies are imminent pollution (where you know its coming), pollution in progress (actively occurring), and pollution discovered after the fact.

In an emergency situation, human health and well being takes precedence. It should always be assessed first and corrective actions should not put human well being in jeopardy.

In the event of a spill or manure release that could endanger downstream users of water of the State or could damage property, Georgia law requires that you notify the Environmental Protection Division of the Georgia Department of Natural Resources.

Post Spill assessment and reporting is important because it is required by law, it helps you examine your response, determine causes and assess damages, and should lead to plans for prevention in the future.

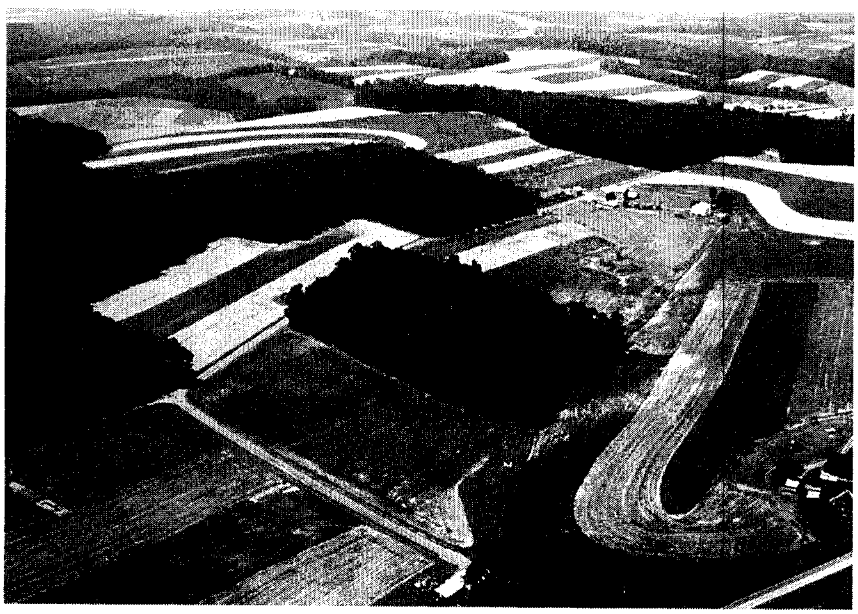
All employees of the farm should be made aware of the emergency action plan and it should be posted in a visible location, preferably near the phone.

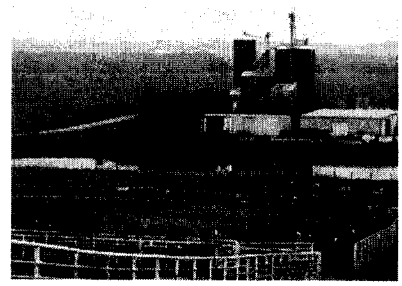
Community and neighbors should be made aware of emergency response plans. They can provide access to needed emergency equipment, provide access to property that may be needed for corrective action, help you in plan development, and make you aware of additional resources in your community.

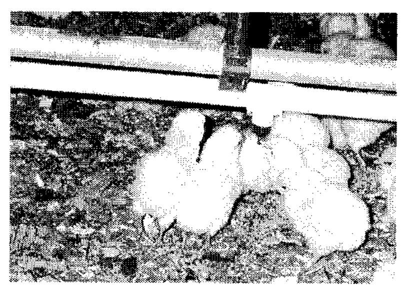
# Lesson 51

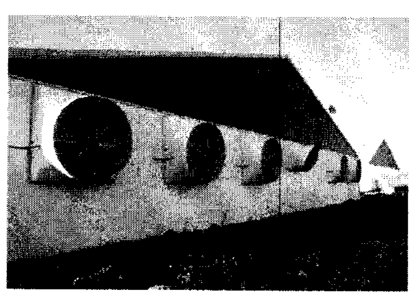
## Mortality Management

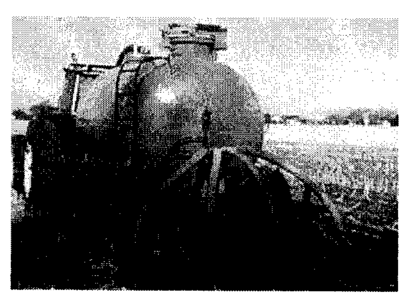
By Don Stettler, retired from the USDA Natural Resources Conservation Service, National Water and Climate Center











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## Disclaimer

This lesson reflects the best professional judgment of the contributing authors and is based on information available as of the publication date. References to particular products should not be regarded as an endorsement.

Click on road map to return to Contents.

# Lesson 51 Mortality Management

By Don Stettler, retired from the USDA Natural Resources Conservation Service, National Water and Climate Center

## Intended Outcomes

The participants will be able to
- Explain why timely management of mortality is important.
- List the different methods for managing mortality.
- List the advantages and disadvantages of different methods for managing mortality.
- Explain conceptually the sizing of mortality composting facilities.

## Contents



## Activities

Estimate
- Composter bin volume requirements.
- The size of a manure storage facility.

**PROJECT STATEMENT**

This educational program, Livestock and Poultry Environmental Stewardship, consists of lessons arranged into the following six modules:
- Introduction
- Animal Dietary Strategies
- Manure Storage and Treatment
- Land Application and Nutrient Management
- Outdoor Air Quality
- Related Issues

**Note:** Page numbers highlighted in green are linked to corresponding text.

## Introduction

Animals dying because of disease, injury, or other causes routinely happens in the day-to-day operation of any confined livestock operation. The magnitude of this mortality can be significant. The mortality rate is generally highest for newborn animals because of their vulnerability. For example, a typical rate for newborn pigs is 10%, but for older finishing hogs, it is only 2% (Table 51-1). For poultry, the mortality rate varies by type (Table 51-2).

How animals are managed has a major affect on the mortality rate. For example, the mortality rate in dairy animals is reduced by providing proper nutrition to help prevent metabolic problems, such as milk fever; by gentle handling; and by culling cows before they become infirm. The mortality rate for dairy calves is highly influenced by colostrum management. A University of California–Davis study found that calves not receiving colostrum had an increased risk of dying 74 times greater than calves receiving colostrum by the recommended method. These findings suggest that an excellent beginning to managing mortality is to care for livestock in ways that minimize it. However, regardless of how well livestock are cared for, there will be mortality and it must be managed.

**...an excellent beginning to managing mortality is to care for livestock in ways that minimize it.**

Catastrophic mortality can occur when an epidemic infects and destroys the majority of a herd or flock in a short time or when a natural disaster, such as a flood, strikes. There may also be incidences when an entire herd or flock must be destroyed to protect human health. For example, the slaughter of chickens in Hong Kong in late 1997 was deemed necessary to prevent transmission of H5N1 flu virus to humans. A prudent manager of a livestock facility will have a contingency plan for dealing with a catastrophic mortality event.

The focus of this lesson will be on managing what is considered normal, day-to-day mortality. However, several of the methods discussed may also be used for managing catastrophic mortality if scaled to accommodate it. Planning for a catastrophic mortality event should include the study of regulations because they often specify what methods may be used. Planning and preparation for catastrophic mortality may also include locating and reserving a site for disposal and having insurance to cover the cost involved.

**Table 51-1. Mortality rate for swine.**

| Animal Type | Mortality, % |
|---|---|
| Newborn pigs | 10 |
| Nursery pigs | 2–3 |
| Sows | 6 |
| Boars | 1 |
| Finishing hogs | 2 |

**Table 51-2. Mortality rate for poultry.**

| Poultry Type | Average Mortality Rate During Flock Cycle, % |
|---|---|
| Layer | |
| hen | 14 |
| pullet | 5 |
| Broiler | |
| breeder pullet | 5 |
| breeder hen | 11 |
| breeder male | 22 |
| roaster | 8 |
| Turkey | |
| hen | 6 |
| light tom | 9 |
| heavy tom | 12 |

Mortality must be managed for at least three reasons:
(1) Hygienic
(2) Environmental protection
(3) Aesthetics

Mortality must be managed for at least three reasons:

(1) Hygienic. Timely removal and appropriate handling of dead animals can prevent other animals in the operation from becoming ill and may prevent spread of the disease to other operations. This is especially true for the removal of those animals that have succumbed to contagious disease.

(2) Environmental protection. Nutrients and other contaminants that are released as the dead animal decomposes can be carried away in run off or leached to groundwater resources.

(3) Aesthetics. Perhaps those who work on the farm or ranch may be come accustomed to the sight of dead animals. However, visitors and others may find it very offensive and use it as a basis for judging the level of management being given the operation even though this may be unfair.

In the past, dead animals were frequently taken to a remote area, allowing carcasses to decompose and be eaten by scavengers. This practice is now illegal in virtually all of the United States. In addition, it is a highly irresponsible method and may encourage the spread of disease from one operation to another. It may also contribute to both surface and groundwater contamination.

Acceptable ways for managing mortality include

- Rendering.
- Composting.
- Incineration.
- Sanitary landfills.
- Burial.
- Disposal pits.

Of these methods, only the rendering and composting methods recycle the nutrients, a concept that this curriculum promotes.

Although incineration, sanitary landfills, burial, and disposal pits may be acceptable methods from an environmental protection viewpoint, they are disposal methods, and in essence, waste the nutrients. In the following paragraphs, each of the acceptable methods will be discussed, beginning with rendering.

## Rendering

Use of rendering services recycles the nutrients contained in dead animals, most often as an ingredient in animal food, especially for pets. The primary disadvantage of rendering is that the dead animals must be preserved or promptly transported to a rendering plant. This disadvantage has been intensified in recent years by a reduction in the number of facilities that provide rendering services. The outbreak of "mad cow disease" in the United Kingdom (U.K.) in 1986 has led to restrictions on how rendered products may be used in the United States. More properly described as Bovine Spongiform Encephalopathy (BSE), it is a degenerative brain disease that ultimately results in animal death. BSE is a member of the transmissible spongiform encephalopathy (TSE) group of diseases and is manifested as behavioral, gait, and postural changes, usually beginning with apprehension, anxiety, and fear. A TSE commonly known as scrapie has significantly affected the U.S. sheep industry. In the United States, cases of scrapie also have been reported in goats. Similar diseases, for example, the Creutzfeldt-Jakob disease, have surfaced in humans. These diseases have also been reported in mink, cats, deer, and elk. To date, no cases of BSE have been diagnosed in the United States. The process used by U.S. renders helps prevent a U.K.-type of epidemic. To further reduce the potential of BSE introduction into U.S. domestic herds, the Food and Drug Administration has rules that prohibits the use of ruminant byproducts in the production of feed for ruminants.

If the dead animals are not preserved, they must be transported to a rendering facility within 72 hours, minimizing decomposition. For rendering to be feasible, therefore, a rendering plant providing frequent pickup must be in close proximity. Proper bio-security measures must be utilized to minimize the spread of disease from farm to farm by rendering plant vehicles and personnel. These measures include transporting dead animals within 24 hours of their death and designating an area outside the perimeter of the facility for pickup by rendering personnel. The designated area to store dead animals must maximize sanitation and discourage scavengers.

An alternative to on-farm storage is cooperative dropoff locations where a number of producers can leave dead animals. This approach eliminates many of the problems associated with on-farm storage and the need for rendering personnel to come onto the farm. It is also advantageous to the render because the mortality for pickup will be more convenient and the mortality amount more constant because the daily variation will be smoothed when averaged over several operations.

The need for frequent pickup for transport to a rendering plant or dropoff location can be minimized by preservation of dead animals to prevent decomposition. Preservation allows the dead animals to be stored on the farm until amounts are sufficient to warrant the cost of transport for rendering. Freezing and fermentation are the two general methods that can be used for preservation.

Freezing requires the obtaining and operating of appropriate refrigeration equipment that is sealed against weather and air leakage. In some parts of the country, large custom-built or ordinary freezer boxes are used to preserve dead animals until they can be picked up and delivered to the rendering plant. Custom-built boxes or units are usually free standing with self-contained refrigeration units designed to provide temperatures between 10 and 20°F. Freezing is an expensive method of managing mortality. It does not eliminate active pathogenic microorganisms. However, the transfer of pathogen or other harmful microorganisms between farms has not been a problem. Those who use the method find it useful as a way of reducing or eliminating potential pollution and improving conditions on the farm.

Fermentation involves grinding the dead animals into 1-inch or smaller particles while adding carbohydrates such as sugar, whey, molasses, or corn. Adding bacteria may also speed fermentation. Fermentation produces volatile fatty acids and causes a decline in pH to below 4.5, which preserves the nutrients in the dead animals. The decrease in pH during fermentation inhibits further decomposition and inactivates many pathogenic microorganisms.

In summary, the rendering mortality management method has the following advantages and disadvantages (Table 51-3).

Use of rendering services recycles the nutrients contained in dead animals. ...The primary disadvantage of rendering is that the dead animals must be preserved or promptly transported to a rendering plant.

Table 51-3. Mortality management by rendering.

| Advantages | Disadvantages |
|---|---|
| 1. Conserves nutrients contained in the dead animals | 1. Increases sanitary precautions to prevent disease transmission |
| 2. Minimal capital investment unless preservation is used | 2. Storage of animals is required until pickup |
| 3. Low maintenance | 3. Fees charged for pickup |
| | 4. Rendering service may not be available |

# Composting

## Composting principles

Composting is the controlled aerobic biological decomposition of organic matter into a stable, humus-like product, called compost (Figure 51-1). It is essentially the same process as natural decomposition except that it is enhanced and accelerated by mixing organic waste with other ingredients in a manner that optimizes microbial growth.

Composting...is essentially the same process as natural decomposition except that it is enhanced and accelerated by mixing organic waste with other ingredients in a manner that optimizes microbial growth.

The compost pile will pass through a wide range of temperatures over the course of the active composting period (Figure 51-2). As the temperature varies, conditions will become unsuitable for some microorganisms while at the same time become ideal for others.

Initially, as the microbial population begins to consume the most readily degradable material in the compost pile and grow in size, the heat generated by the microbial activity will be trapped by the self-insulating compost material. As the heat within the pile accumulates, the temperature of the compost pile will begin to rise. As the pile temperatures increase, the pile will become inhabited by a diverse population of microorganisms operating at peak growth and efficiency. This intense microbial activity sustains the vigorous heating that is necessary for the destruction of pathogens, fly larvae, and weed seeds. The diversity of the microbial population also allows the decomposition of a wide range of material from simple, easily degradable material to more complex, decay resistant ones such as cellulose. The temperatures will continue to rise and peak between 130 to 160°F. Once this peak is reached, microbial activity begins to decrease in response to a depletion in readily degradable material or excessively high temperatures that are detrimental to their function. Efficient composting requires that the initial compost mix have

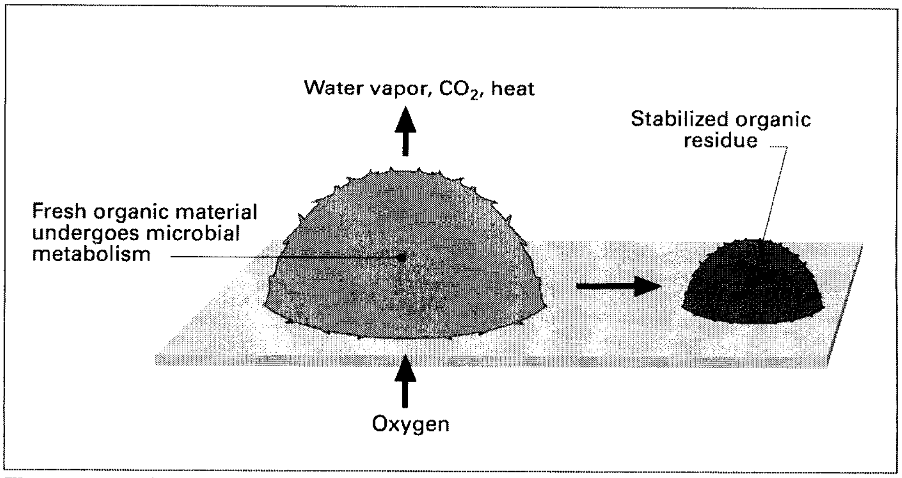


Figure 51-1. Composting process.

- A balanced source of energy (carbon) and nutrients (primarily nitrogen), typically with a carbon-to-nitrogen (C:N) ratio of 20:1 to 40:1.
- Sufficient moisture, typically 40% to 60%.
- Sufficient oxygen for an aerobic environment, typically 5% or greater.
- A pH in the range of 6 to 8.

These compost mix characteristics must be maintained throughout the composting process as well.

The proper proportion of the material to be composted combined with amendments and bulking agents is commonly called the compost mix or the "recipe" (Figure 51-3). A composting amendment is any item added to the compost mixture that alters the moisture content, C:N, or pH. Crop residue,

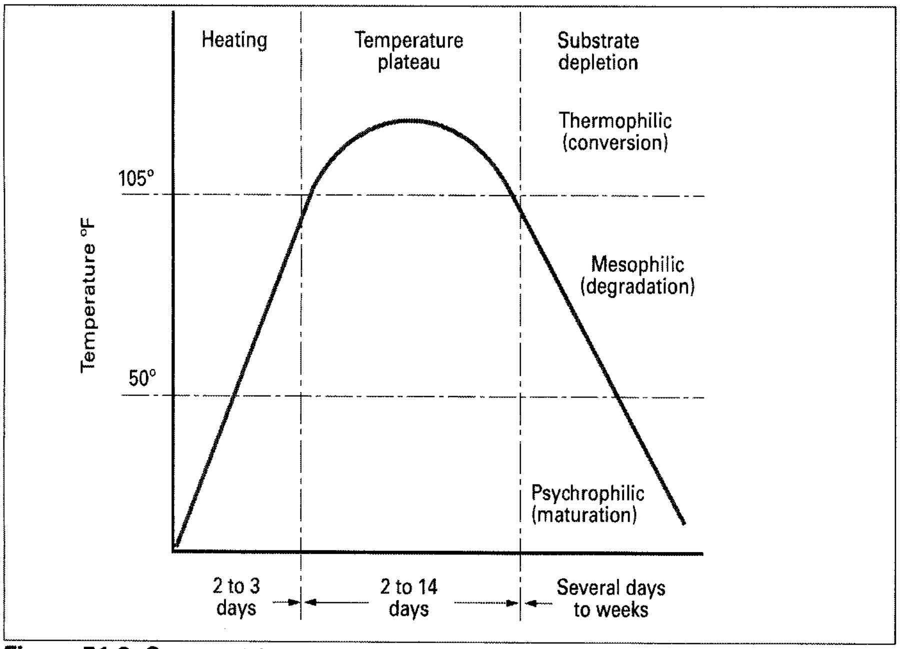


**Figure 51-2. Compost temperature ranges.**
Source: NRCS Agricultural Waste Management Field Handbook 1996, p. 10-55.

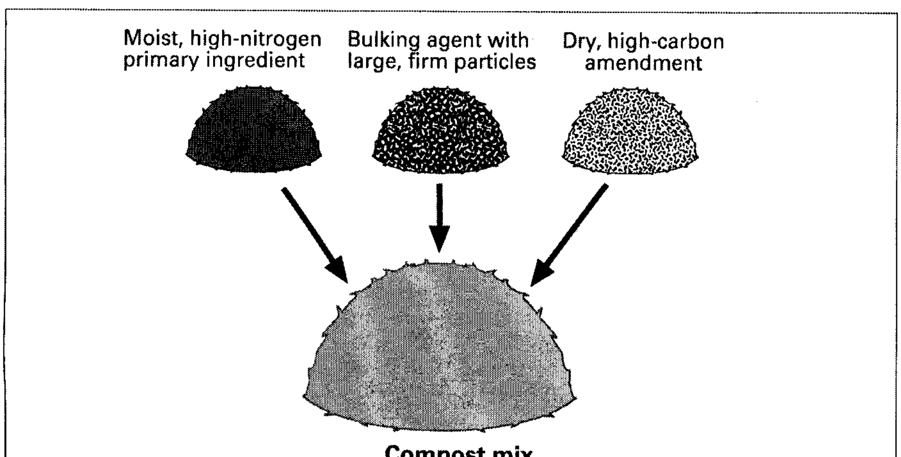


**Figure 51-3. Components of the compost mix.**

**E**fficient composting requires that the initial compost mix have

- A balanced source of energy and nutrients...
- Sufficient moisture...
- Sufficient oxygen for an aerobic environment...
- A pH in the range of 6 to 8.

**A** number of methods are used to compost organic wastes including
- Passive composting pile
- Windrow
- Passively aerated windrow
- Aerated static pile
- In-vessel

leaves, grass, straw, hay, and peanut hulls are examples of the material suitable for use as a compost amendment. A bulking agent, such as wood chips, is used primarily to improve the ability of the compost to be self-supporting or have structure and to allow internal air movement. Some bulking agents may alter the moisture content and/or C:N ratio. This type of material would serve as both an amendment and a bulking agent.

Recipe recommendations are available for composting many types of organic wastes. However, when it is necessary to determine the recipe from scratch, the characteristics of the waste, amendments, and bulking agents must be known. The characteristics that are the most important in determining the recipe are moisture content, carbon content, nitrogen content, and C:N ratio. If any two of the last three components are known, the remaining one can be calculated. The determination of the recipe is normally an iterative process of adjusting the C:N ratio and moisture content by adding amendments. If the C:N ratio is out of the acceptable range, then amendments are added to adjust it. If this results in high or low moisture content, amendments are added to adjust the moisture content. The C:N ratio is again checked, and the process may be repeated. After a couple of iterations, the mixture is normally acceptable.

A number of methods are used to compost organic wastes including
- Passive composting pile.
- Windrow.
- Passively aerated windrow.
- Aerated static pile.
- In-vessel.

## Dead animal composting

Dead animal composting generally employs the in-vessel method using composting bins (Figure 51-4). Dead animals may also be composted using the windrow or passive composting pile methods, the preferable methods for composting larger dead animals.

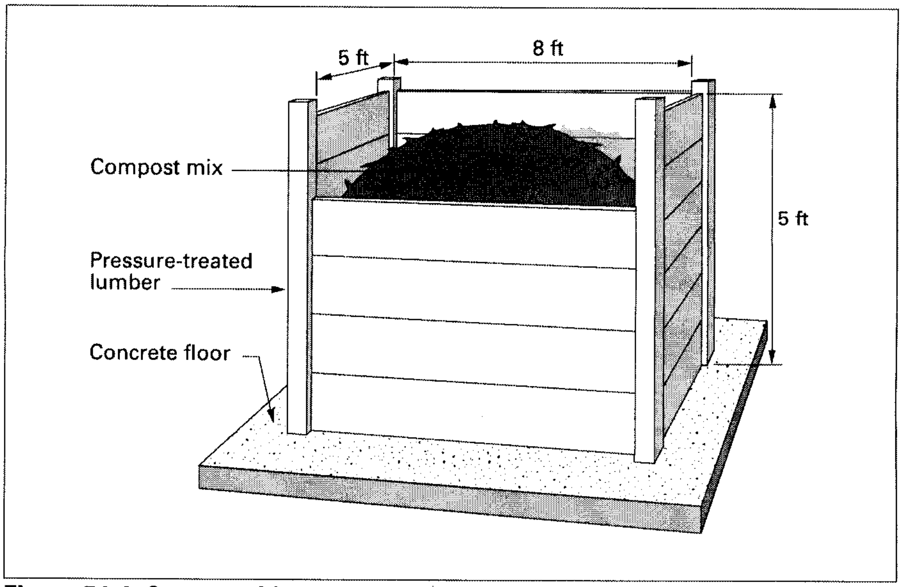


**Figure 51-4. Compost bin.**
Adapted from NRCS Agricultural Waste Management Field Handbook 1996, p. 10-59.

As already emphasized, organic wastes are generally blended into a homogenous mix having the appropriate C:N ratio, pH, oxygen, and moisture to facilitate efficient decomposition. Dead animal composting, however, requires a different approach. For dead animal composting, the carcasses and amendments are layered into the pile, and no mixing is done until after the high-rate phase of composting has occurred and the dead animals are fully decomposed. For that reason, the initial pile in which dead animals are composted is an inconsistent, nonhomogeneous mixture. Figure 51-6 illustrates how two amendments, straw and chicken litter, are layered with

**Dead animal composting... requires a different approach. ...the carcasses and amendments are layered into the pile, and no mixing is done until after the high-rate phase of composting has occurred and the dead animals are fully decomposed.**

**Figure 51-5. Windrow.**

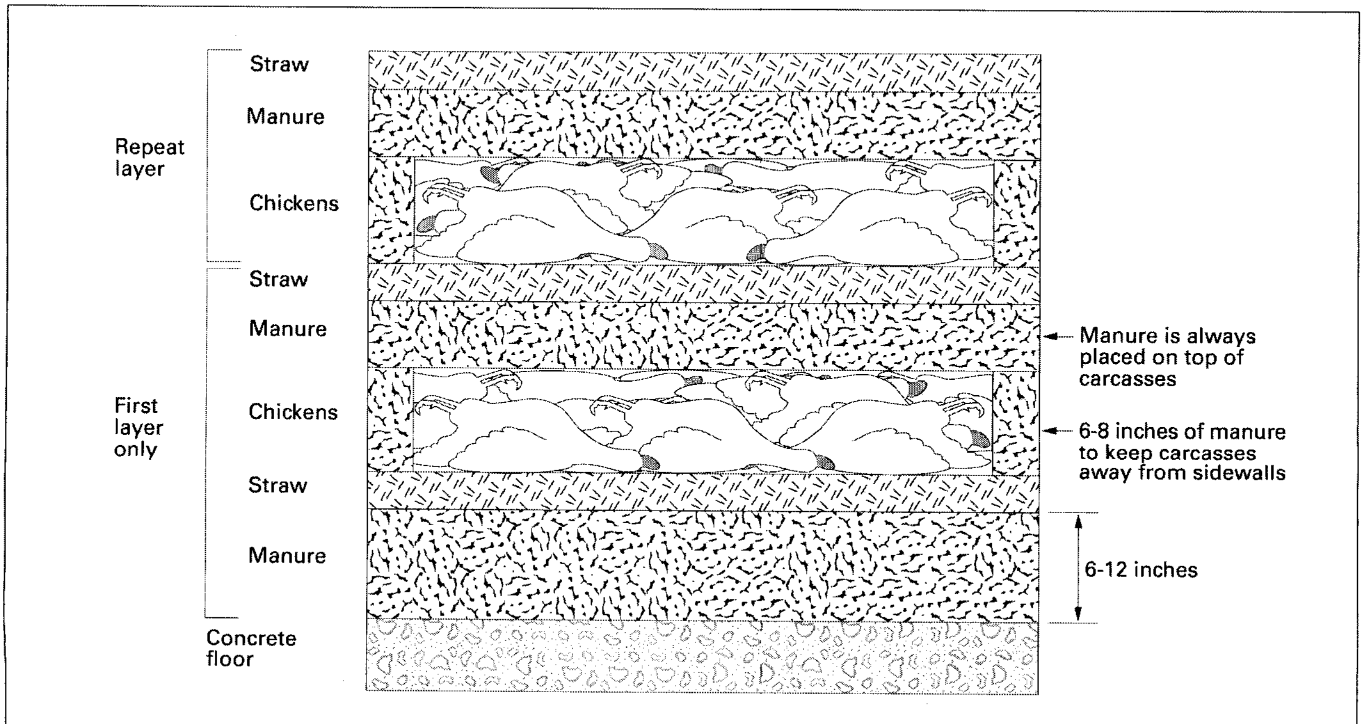


**Figure 51-6. Initial layering of the mix for composting dead broiler chickens.**
Adapted from NRCS Agricultural Waste Management Field Handbook 1996, p. 10-61.

**Composting mortality can be likened to aboveground burial in a biomass filter with the pathogens killed by high temperatures.**

dead broiler poultry in bin composting. Regulations in some states do not allow including chicken litter in the compost mix. Where chicken litter is not allowed, dead animals can be composted with sawdust as the only amendment. However, where use of chicken litter is allowed and it is conveniently available, its use will allow the compost process to be more efficient because the C:N ratio is adjusted.

Composting mortality can be likened to aboveground burial in a biomass filter with the pathogens killed by high temperatures (Figure 51-7). At least one foot of biofilter should be provided between the dead animals and the sides of the bin or the outside surface of the windrow. For large animals, this distance should be increased to two feet. The composting process for mortality is shown schematically in Figure 51-8.

For bin composting, a permanent structure, such as bins constructed of treated lumber or concrete within a pole-frame building with concrete floors (Figure 51-9), is the most desirable. This type of facility offers easier overall operation and management especially during inclement weather and for improved aesthetics. Some states may require that composters be roofed and/ or be located on impermeable surfaces, such as concrete or compacted clay. Consult the Natural Resources Conservation Service, Extension Service, MidWest Plan Service, or Northeast Regional Agricultural Engineering Service for composter plans that will meet your needs.

Temporary bins can also be constructed with bales of low-quality hay or straw (Figure 51-10). This type of construction is less expensive and provides the flexibility, such as the number of bins and their location, that a permanent structure would not. When the need arises, bale bins can also be used along with a permanent structure facility to provide additional composting capacity. Straw bale composters, for example, could be used for catastrophic mortality.

The correct sizing of the composting facility is critical for its successful operation and depends on the size of the animals and the amount of material to be composted on a daily basis. Proper sizing makes the management and

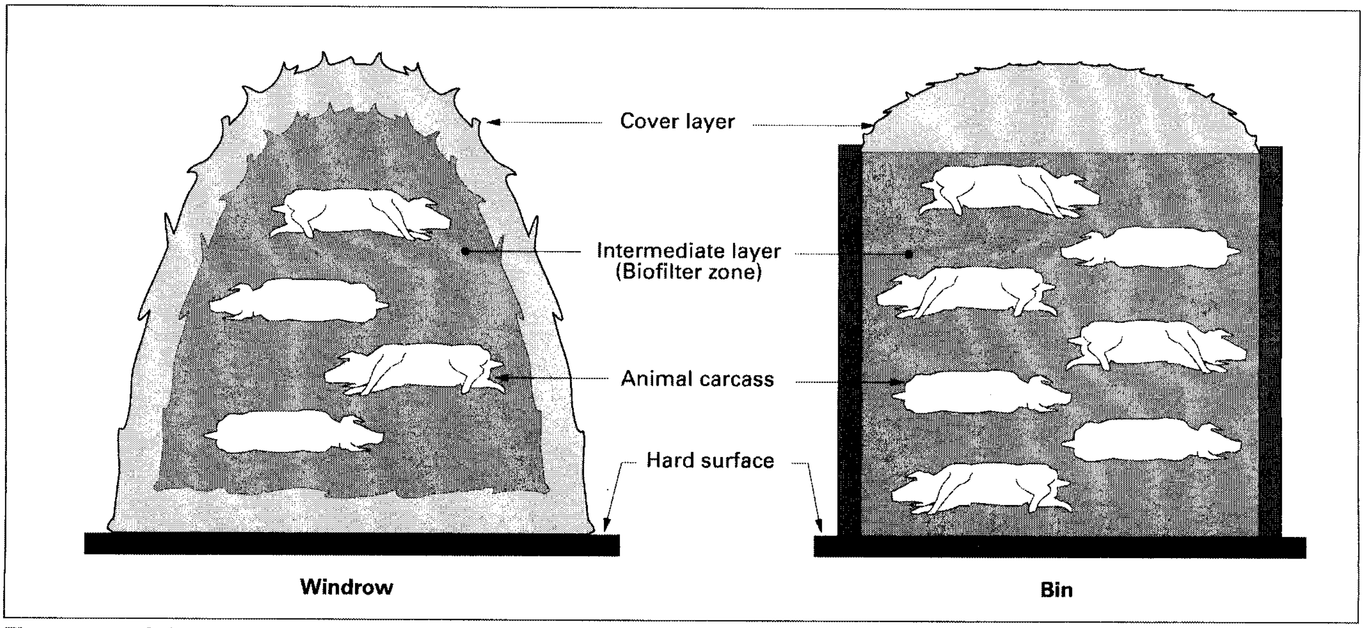


**Figure 51-7. Schematic of dead animal composting using a windrow or bin.**

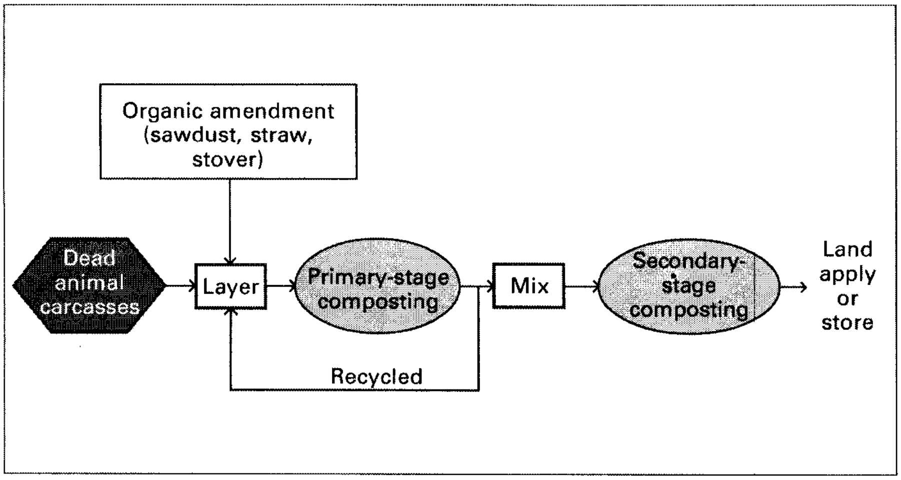


**Figure 51-8. Composting process schematic.**

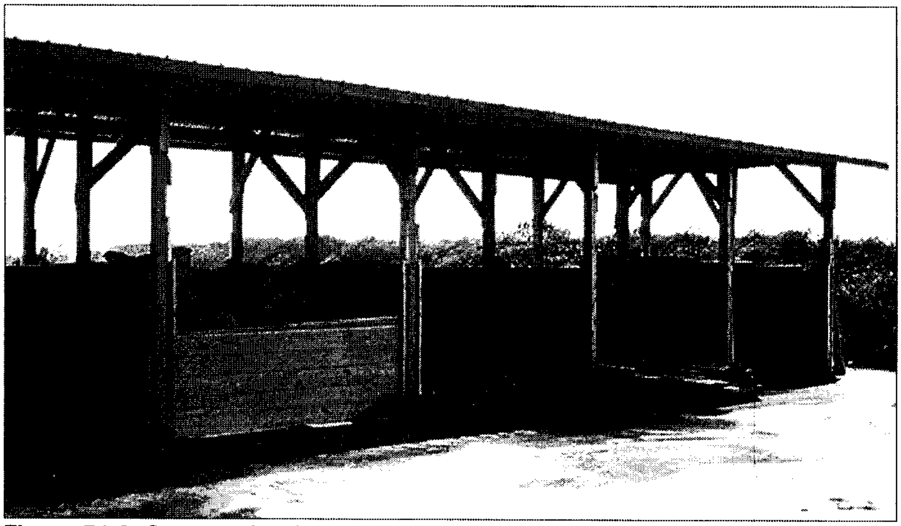

**Figure 51-9. Composting building.**

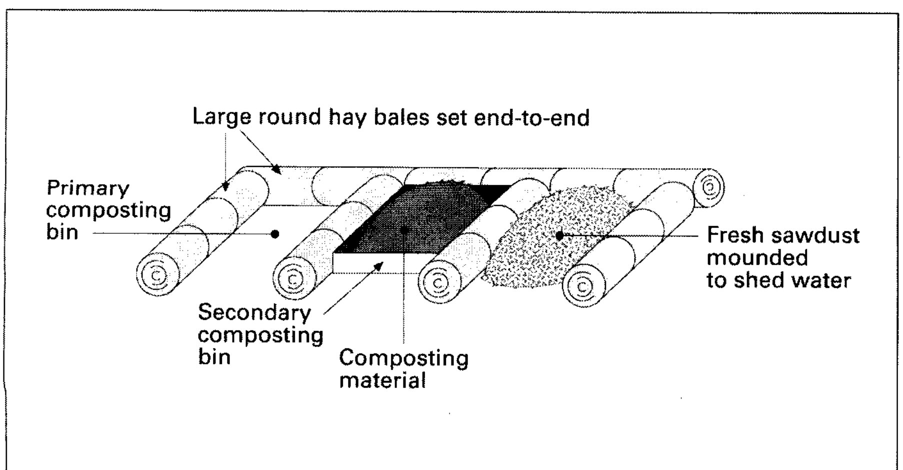


**Figure 51-10. Straw bale composter.**

Consult the Natural Resources Conservation Service, Extension Service, MidWest Plan Service, or Northeast Regional Agricultural Engineering Service for composter plans that will meet your needs.

Step A—Determine the weight of the animal carcasses to be composted.

Step B—Determine the composting cycle times for the "design weight" to be composted in each windrow or bin.

Proper sizing makes the management and operation of the composting process easier.

operation of the composting process easier. For example, composting facilities that are undersized can lead to problems with odor and flies. Sizing is fairly easy, using the universal sizing procedure. The steps of this procedure are given in Table 51-4. It is applicable to the sizing of either bins or windrows and for any type of dead animal.

**Step A**—Determine the weight of the animal carcasses to be composted. Use farm records for building capacity, animal sizes, and livestock production values and loss records when possible or use the mortality table developed for the various livestock species. Table 51-5 is an example of a mortality table for poultry. Determine the average daily death loss for each growth stage on the farm. Then estimate both the pounds of mortality produced by the operations in one year using "average weight" and the average daily loss in pounds per day to be composted. For species such as cattle or sheep where the majority of mortality occurs during a short period such as during lambing and calving, the average daily loss needs to be determined on the shorter period rather than the entire year.

**Step B**—Determine the composting cycle times for the "design weight" to be composted in each windrow or bin. The time for primary composting as well as the needed composting volume increases as the animal weight increases. An operation with different growth stages should evaluate the feasibility of using segregated bins or windrows. For mature cattle or horses, the preferred approach is to place each individual mortality in a pile on a composting pad. Separate facilities are recommended for animals in the following weight ranges:

- Less than 50 lbs
- 50 to 250 lbs
- Greater than 250 lbs

**Table 51-4. Universal sizing procedure.**

| Step | Description |
|---|---|
| A | Determine the average daily weight of animal carcasses to be composted. |
| B | Determine the composting cycle times for the "design weight" to be composted in each windrow or bin.<br>1. Primary cycle time (days)<br>= 5.00 x (design animal weight, lbs)$^{0.5}$, minimum time ≥10 days<br>2. Secondary cycle time (days)<br>= 1/3 Primary cycle time, minimum time ≥ 10 days<br>3. Storage time (days) = Year's maximum period of time between land application events. Must be in keeping with the timing requirements of the nutrient management plan. |
| C | Determine the needed composter volumes.<br>1. Primary composter volume (ft$^3$)<br>= 0.2 x Average daily loss (lbs/day) x Primary cycle time (in days)<br>2. Secondary composter volume (ft$^3$)<br>= 0.2 x Average daily loss (lbs/day) x Secondary cycle time (in days)<br>3. Storage volume (ft$^3$)<br>= 0.2 x Average daily loss (lbs/day) x Storage time (days) |
| D | Determine the dimensions of the compost facility including bin dimensions and number of bins or windrow size and area requirements. |
| E | Determine the annual sawdust requirement for the composting system. Annual sawdust needs (yd$^3$/yr) = Annual loss (lbs/yr) x 0.0069. |

[1]Adapted from Ohio's Livestock and Poultry Mortality Composting Manual 1999.

The following equations may be used to determine the composting times required for bins:

1. Primary cycle time (in days) =
   5.00 x (design animal weight, lbs)$^{0.5}$, minimum time ≥ 10 days
   The "design animal weight" used in the equation for determining the primary cycle time is usually taken as the weight of the largest individual animal to be composted.
2. Secondary cycle time (in days) =
   1/3 Primary cycle time, minimum time ≥ 10 days.
3. Storage time (in days) = Years maximum period of time between land application events. Must be in keeping with the timing requirements of the nutrient management plan. For example, if the longest period of time during the year when land application cannot be made is from October 1 to March 30, the storage time required is 6 months or about 180 days.

**Step C**—Determine the composter volumes. The following equations are used to determine the needed composter volumes ($ft^3$).

1. Primary composter volume ($ft^3$) =
   0.2 x Average daily loss (lbs/day) x Primary cycle time (in days)
2. Secondary composter volume ($ft^3$) =
   0.2 x Average daily loss (lbs/day) x Secondary cycle time (in days)
3. Storage volume ($ft^3$) =
   0.2 x Average daily loss (lbs/day) x storage time (days)

**Step D**—Determine the dimensions of the compost facility, bin dimensions, and windrow size or number of bins. For a bin system, the minimum front dimension should be 2 feet greater than the loading bucket width. A minimum of two primary bins is required. An alternative to individual secondary bins is an area or areas large enough to accommodate the contents of the primary bins. Secondary bins/areas are generally directly behind the primary bins.

**Step E**—Determine the annual amount of sawdust required for the composting. The following equation estimates the total annual amount of fresh sawdust needed. In practice, it is recommended that up to 50% of the fresh sawdust needs be met with finished compost. The equation allows for a 1-foot sawdust base in the bin on which to begin placing the dead animals, 1-foot of sawdust between layers, 1 foot of sawdust clearance between the dead animals and the sides of the bin, and a 1-foot cover depth. Of course, if values different than these are used in the construction of the pile, either more or less sawdust will be required.

Annual sawdust needs ($yd^3$/yr) = Annual loss (lbs/yr) x 0.0069

**Step C**—Determine the composter volumes.

**Step D**—Determine the dimensions of the compost facility, bin dimensions, and windrow size or number of bins.

**Step E**—Determine the annual amount of sawdust required for the composting.

**Table 51-5. Poultry mortality rates.**

| Poultry Type | Avg. Weight, lbs | Loss Rate, % | Flock Life, days | Design Weight, lbs |
|---|---|---|---|---|
| Broiler | 4.2 | 4.5-5 | 42–49 | 4.5 |
| Layers | 4.5 | 14 | 440 | 4.5 |
| Breeding Hens | 7-8 | 10-12 | 440 | 8 |
| Turkey, females | 14 | 5-6 | 95 | 14 |
| Turkey, males | 24 | 9 | 112 | 24 |

## EXAMPLE

**Given:** A broiler operation. The operation's nutrient management plan does not allow land application between September 1 and March 30 or 210 days. Flock cycles occupy the facility 365 days per year.

**Required:** Compost bin volume requirements using the universal sizing method.

**Solution:**

**Step A—Determine the weight of animal carcasses to be composted.**
From farm records, it can be determined that the average daily loss (ADL) is 30 lbs/day. A design mortality weight (W1) of 3 lbs will be assumed.
Annual loss = ADL x 365
= 30 x 365
= 10,950 lbs/yr

**Step B—Determine the composting cycle times for the "design weight" to be composted in each windrow or bin.**
Primary cycle time (days) = 5.00 x (design animal weight, lbs)$^{0.5}$, Minimum time ≥ 10 days
= 5.00 x (3)$^{0.5}$
= 8.7 days < 10 days Use 10 days.
Secondary cycle time (days) = 1/3 Primary cycle time, Minimum time ≥ 10 days
= 1/3 x 10
= 3 days < 10 days. Use 10 days.
Storage time (days) = Year's maximum period of time between land application events.
= 210 days (from nutrient management plan)

**Step C—Determine the needed composter volumes.**
Primary composter volume (ft$^3$) = 0.2 x Average daily loss (lbs/day) x Primary cycle time
= 0.2 x 30 x 10
= 60 ft$^3$
Secondary composter volume (ft$^3$) = 0.2 x Average daily loss (lbs/day) x Secondary cycle time
= 0.2 x 30 x 10
= 60 ft$^3$
Storage volume (ft$^3$) = 0.2 x Average daily loss (lbs/day) x Storage time (days)
= 0.2 x 30 x 210
= 1,260 ft$^3$

**Step D—Determine the dimensions of the compost facility, bin dimensions, and windrow size or number of bins.**
Any dimension that is acceptable to the producer and will provide the volume requirement for primary and secondary composter volumes and the storage volume is acceptable. A building to store the finished compost and fresh sawdust should be considered.

**Step E—Determine the annual sawdust required for the composting.**
Annual sawdust needs (yd$^3$/yr) = Annual loss (lbs/yr) x 0.0069
= 10,950 x 0.0069
= 76 yd$^3$/yr
Assuming that 50% of the sawdust needs will be met by using finished compost, the annual sawdust need is 76 x 50% = 38 yd$^3$/yr.

The universal sizing procedure sizes the facilities. It does not prescribe the materials or recipe. The recipe used to compost mortality depends on the raw material that is available and especially on the material that is available on-farm. The recipe may also depend on what state and county regulations allow. For example, some states do not permit the use of chicken litter as an amendment in the recipe for composting dead animals. In these states, it is necessary to compost without chicken litter even though it is an effective amendment and may be readily available at low cost. Composting is a combination of art and science. Therefore, it is necessary to adjust the recipe using trial and error until the desired results are achieved.

Straw can be used instead of or to replace a portion of the volume of sawdust computed in the universal sizing equations. Sawdust generally provides superior structure to the compost pile. However, if sawdust is not available or is very expensive, it may be advantageous to use straw. The straw used must yield the same compressed volume as the sawdust to provide clearance and cover equal to that of sawdust. Straw will generally compress to over one-half its loose volume. For this reason, straw must be chopped and initially layered to twice its desired final depth.

Chicken litter can be used to replace a portion of the sawdust, if regulations permit, to improve the C:N ratio of the pile and enhance the compost process. Up to two-thirds of the required sawdust can be replaced with chicken litter. Studies have shown that dead broiler chickens can be successfully composted with only chicken litter (McCaskey 1994).

## Composter operation

The compost pile must be monitored and the appropriate adjustments made throughout the composting period to sustain a high rate of aerobic microbial activity for complete decomposition with a minimum of odors as well as maximum destruction of pathogens. A convenient and meaningful compost parameter to monitor is temperature; it is an indicator of microbial activity. By recording temperatures daily, a normal pattern of temperature development can be established. Deviation from the normal pattern of temperature increase indicates a slowing of or unexpected change in microbial activity. Temperatures should begin to rise fairly steadily as the microbial population begins to develop. If the temperatures do not begin to rise within the first several days, adjustments must be made in the compost mix. A lack of heating indicates that aerobic decomposition has not been established. This state can be caused by any number of factors such as a lack of aeration, inadequate carbon or nitrogen source, low moisture, or low pH. Poor aeration is caused by inadequate porosity that, in turn, can result from material characteristics or excessive moisture.

**A convenient and meaningful compost parameter to monitor is temperature; it is an indicator of microbial activity.**

Specific guidelines for the operation of a compost facility include

- Use only approved plans to construct compost facilities.
- Remove mortalities daily from housing facilities.
- Shape piles and windrows so that precipitation will run off.
- Add fresh carbon amendment to outside of the pile for biofilter and to absorb leachate and odors.
- Monitor the compost pile temperature. To eliminate pathogens, an average temperature greater than 122°F must be achieved throughout the compost for at least 5 days during either the primary or secondary composting stages or as the cumulative time with temperatures greater than 122°F in both stages.

- Leave primary compost in the bin until the temperature reaches its maximum and then shows a steady decline for one week. Use care to avoid short circuiting the primary cycle time.
- Mix and aerate the compost by moving the compost to the secondary bin.
- Store stabilized compost until it can be applied in accordance with the timing prescribed by the nutrient management plan or prepared for sale to others.

### Compost end use

The primary final use of finished compost is for land application. While the main value of applying compost to land is to improve the soil's structure and water-holding capacity, compost does contain many nutrients. These nutrients are generally not present in the same quantities per unit of volume as inorganic fertilizer. For this reason, a high-rate application of compost will be needed to meet crop nutrient needs. Regardless, the application rate must be based on soil testing and compost nutrient content testing and be applied in keeping with a nutrient management plan.

The advantage of using compost as a fertilizer is that it releases nutrients slowly, usually under the same warm, moist soil conditions required for plant growth. Thus, nutrient release is matched with plant uptake, resulting in a more efficient utilization of nitrogen and a decreased potential for nitrogen leaching. While the potential for leaching still exists when conditions are suitable for nutrient release from the compost, there is no plant growth to use the nitrogen. This can occur, for example, in early fall after crops have been harvested, but there is still adequate soil moisture and temperature for nutrient release.

In summary, the composting method for managing mortality has the following advantages and disadvantages (Table 51-6).

**Table 51-6. Mortality management by composting.**

| Advantages | Disadvantages |
|---|---|
| 1. Conserves nutrients contained in the dead animals | 1. High initial cost |
| 2. Low odor | 2. Labor intensive |
| 3. Environmentally safe | 3. Regular monitoring and maintenance is required |
| 4. No need to store dead animals | 4. Cropland required for utilization of finished compost |

## Incineration

Incinerating dead poultry and small animals is biologically the safest disposal method. The residue from properly incinerated mortality is largely harmless and does not attract rodents or insects. On the other hand, it may be slow, require fuel and expensive equipment, and generate nuisance complaints from particulate air pollution and odors even when highly efficient incinerators are used. Incineration generally requires an air pollution permit, and as such, requires that the unit meet state agency regulations. Local regulations may also require an installation permit. Therefore, incineration is not a casual or inexpensive undertaking. Barrels or other homemade vessels are unsatisfactory burners and may have serious consequences if they result in air pollution or unpleasant odors.

Commercial incineration units fired with gas or oil burners are available (Figure 51-11). When selecting an incinerator, consider its sturdiness and the type of controls. The unit selected should be able to operate under heavy loading conditions and withstand high operating temperatures. Consider purchasing a unit with automatic timer controls that shut off the fuel supply after predetermined time because of the convenience they provide in operating the unit.

The incinerator's capacity should be based on animal size and the expected daily mortality rate. The incinerator should be sited in a convenient location that will avoid potential problems and be downwind of livestock housing, farm residences, and neighbors. In most situations, the incinerator should be housed and placed on a concrete slab to extend its life. Maintenance costs include the replacement of expendable parts and grates every few years. The incinerator unit may need to be replaced or completely overhauled every 5 to 7 years.

To summarize, the incineration method for managing mortality has the following advantages and disadvantages (Table 51-7).

Incinerating dead poultry and small animals is biologically the safest disposal method.

**Table 51-7. Mortality management by incineration.**

| Advantages | Disadvantages |
|---|---|
| 1. Sanitary | 1. Nutrients contained in the dead animals is |
| 2. Final except for ashes wasted | 2. Initial cost |
| | 3. Fuel costs |
| | 4. Equipment operation and maintenance costs |
| | 5. Potential air quality impairment |

The incinerator should be sited in a convenient location that will avoid potential problems and be downwind of livestock housing, farm residences, and neighbors.

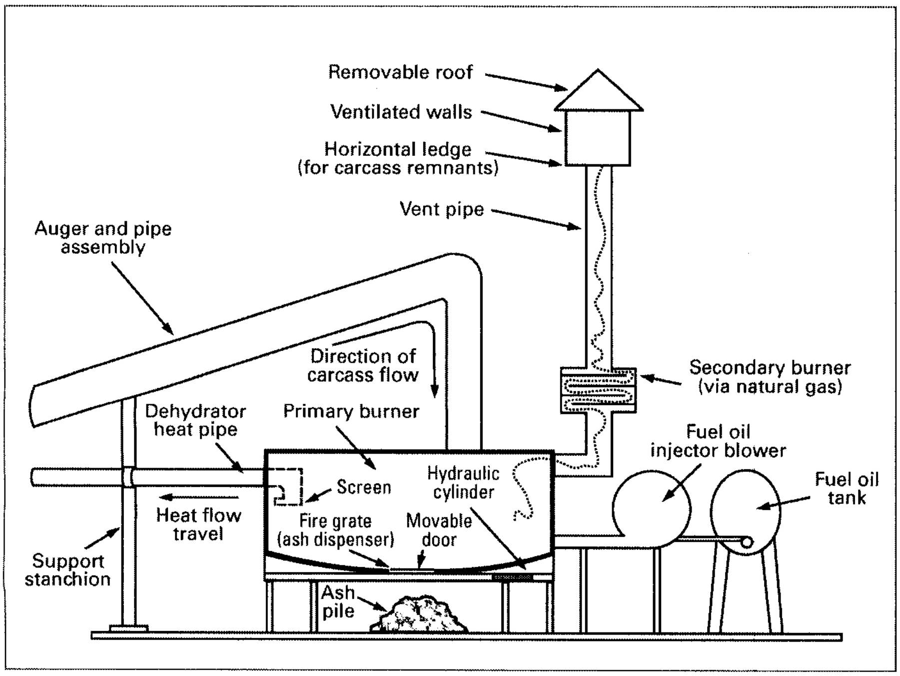


**Figure 51-11. Incineration system.**
Source: Severincinerator, GlobalWasteTransformation, Inc., Adairsville, GA.

Because not all landfills will accept dead animals... arrangements with the landfill operator should be made in advance.

## Sanitary Landfills

Sanitary landfills are engineered burial facilities for disposal of solid waste (Figure 51-12). They are located, designed, constructed, and operated in a manner that will contain the solid waste so it will not cause a present or potential hazard to public health or to the environment. Generally, most landfills are operated under the authority of a local government that controls what can or cannot be disposed of in the landfill. To minimize the environmental hazard, hazardous material is not allowed to be disposed of in a landfill. Because of the difficulty of siting and constructing new landfills, material that can be managed with alternative methods are oftentimes excluded to preserve space. Solid waste often banned for this reason includes large home or industrial appliances and tires.

In some areas, disposal of dead poultry and/or animals in a sanitary landfill is permitted. This may be one of the simpler methods of disposal if a landfill is near the livestock facility. Because not all landfills will accept dead animals, however, arrangements with the landfill operator should be made in advance. In addition, some states require special licenses to transport dead animals. Regardless, carcasses should be hauled in a leakproof, covered container and/or vehicle.

In summary, the sanitary landfill method of managing mortality has the following advantages and disadvantages (Table 51-8).

**Table 51-8. Mortality management using sanitary landfills.**

| Advantages | Disadvantages |
|---|---|
| 1. Simplicity | 1. Nutrients contained in the dead animals are wasted. |
| 2. No capital investment | 2. Few landfills accept dead animals. |
| 3. No maintenance | 3. Transportation costs |
| | 4. Not permitted in many areas |

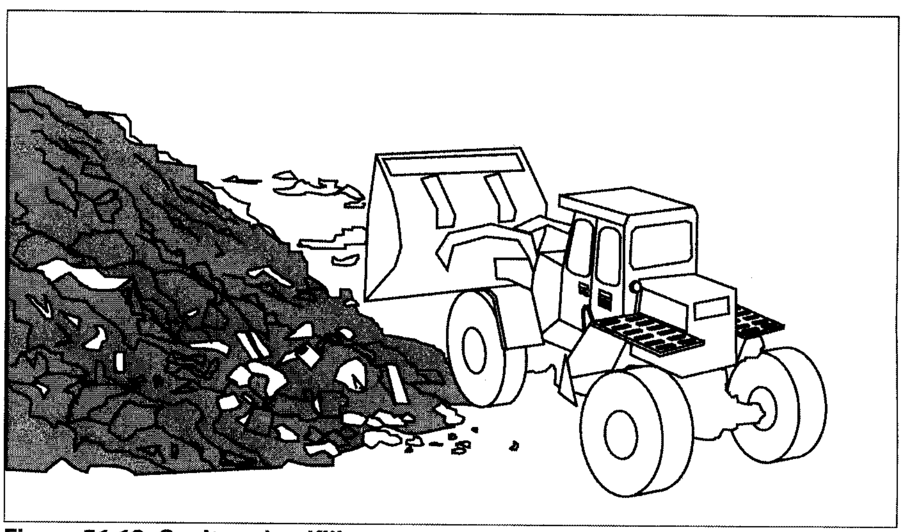

**Figure 51-12. Sanitary landfill.**

## Burial

Burial is a common method of handling dead animals. This method involves excavating a grave or pit, filling the bulk of the excavation with dead animals, and then covering them with soil until the grave or pit is filled. The fill over the dead animals should be heaped to allow for settling. In time, the carcasses will decompose. In cold climates, burial is difficult when the ground is frozen.

At some locations, regulations may allow disposal by burial only for a massive die-off. For this reason, it is important to contact the appropriate regulatory agency for assistance and/or guidelines if this method is under consideration for day-to-day mortality. Where regulations allow burial, there are generally strict siting requirements. Common siting requirements include locating the burial

- Where it will not create an actual or potential public health hazard.
- In soils having a moderate to slow permeability.
- Where there is a specified minimum separation distance from wells and surface water bodies.
- Where there is no evidence of a seasonal high-water table above the bottom of the grave/pit.
- Outside the 100-year floodplain.

Where regulations allow burial, there are generally strict siting requirements.

Sites that have permeable soils, fractured or cavernous bedrock, and a seasonal high-water table must be avoided.

Construction requirements for burial graves or pits limit the depth to less than 8 feet and demand that the sides of the excavation be sloped to a stable angle. If burial is used, it is important to protect the site from scavengers and rodents before and after burial. For poultry, a 12-inch compacted soil cover is considered minimum with 24 inches being the recommended depth. For larger animals, the cover depth should be at least 36 inches of compacted soil. The completed burial should be seeded with grass to prevent erosion. Check with local officials for specific regulations.

In summary, the burial method of managing mortality has the following advantages and disadvantages (Table 51-9).

**Table 51-9. Mortality management using burial.**

| Advantages | Disadvantages |
|---|---|
| 1. Capital limited to land and excavating equipment | 1. Nutrients contained in the dead animals are wasted. |
| | 2. Increases sanitary precautions to pre vent disease transmission. |
| | 3. Storage of carcasses until burial may be necessary. Difficult if ground is frozen |
| | 4. Land area becomes significant for large operations |
| | 5. Impossible when ground is frozen |

## Disposal Pits

Of the methods discussed, disposal pits are the least desirable method for managing mortality from an environmental protection perspective. This method differs from burial because the dead animals are placed in a lined pit (Figure 51-13) rather than an unlined grave. Dead animals may take a long time to decompose in a disposal pit because of limited aeration. For this reason, there may be a high potential for groundwater contamination. Where permitted by regulations, disposal pits should be considered only if soil conditions will protect the groundwater and there is adequate separation distance from drinking water supplies. The requirements for siting disposal pits are very similar to burial. In addition, disposal pit sites should be located on sites with 5% or greater slopes to ensure good surface drainage, minimizing infiltration.

Disposal pits are constructed of concrete blocks, treated lumber, or poured-in-place concrete. The bottom of the pit should be soil covered with several inches of crushed-rock gravel. The pit requires a cover made of reinforced concrete with an opening (filling port) large enough for the mortality. This opening must have a lid that can be secured to seal the pit when it is not in use.

In summary, the disposal pit method of managing mortality has the following advantages and disadvantages (Table 51-10).

Where permitted by regulations, disposal pits should be considered only if soil conditions will protect the groundwater and there is adequate separation distance from drinking water supplies.

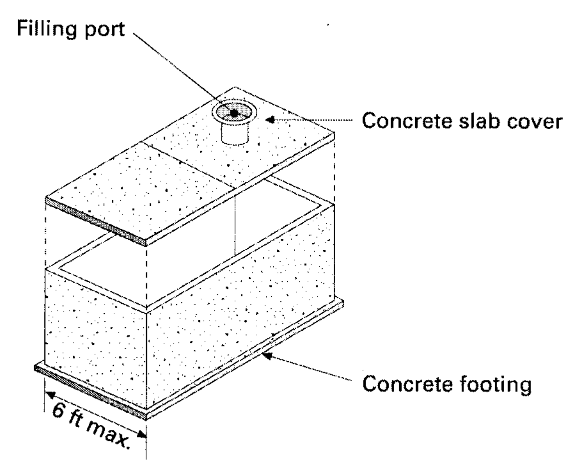


**Figure 51-13. Disposal pit.**
Source: NRCS Agricultural Waste Management Field Handbook 1996, p. 10-78.

**Table 51-10. Mortality management using disposal pits.**

| Advantages | Disadvantages |
|---|---|
| 1. Simplicity | 1. Nutrients contained in the dead animals are wasted.<br>2. Exacting soil and drainage conditions are required.<br>3. Satisfactory location may not be convenient to facilities.<br>4. Possibility of environmental hazards<br>5. Not permitted in many areas |

## Regulatory Compliance Issues

Regulations relating to livestock and poultry mortality vary from state to state. Most, if not all, states require timely management. It is essential that you research the regulations for your state and locality. You may use the table in Appendix B as a checklist for conducting research on the different aspects of mortality management.

# APPENDIX A
## Environmental Stewardship Assessment: Mortality management

| Issue | High Risk Risk 4 | High to Moderate Risk Risk 3 | Moderate to Low Risk Risk 2 | Low Risk Risk 1 |
|---|---|---|---|---|
| **Hygienic and biosecurity** | | | | |
| How soon is mortality removed from housing? | Not until several days after their death | | | Promptly after death, usually within one day |
| How is mortality temporarily stored to await final handling? | Piled or left randomly in the open | | | Stored in an area secured from scavengers with appropriate runoff/ leaching controls |
| How long is mortality temporarily stored after removal from housing and before final handling is initiated? | More than 3 days | | | 3 days or less |
| **Aesthetics** | | | | |
| Are mortality and mortality management facilities screened from view? | No | | | Yes |
| **Method of final management** | | | | |
| Has an acceptable routine method of mortality management been established? | No | | | Yes |
| **Rendering method** | | | | |
| If not refrigerated, how soon is mortality transported to renderer? | In excess of 3 days | | | Within 3 days |
| If refrigerated, how soon is mortality transported to renderer? | More than 3 days after refrigeration units are filled to overflowing | | | Before refrigeration units are filled |
| **Composting method** | | | | |
| Is facility either outside the 100-year flood plain or protected from flooding? | No | | | Yes |
| What type of composting facility is used? | Piled on ground | | | Permanent construction of durable material |
| Is facility located on a concrete slab to protect groundwater? | No | | | Yes |
| If a bin facility, is the facility roofed except in arid regions? | No | | | Yes |
| Is runoff from facility transferred to a liquid waste storage facility? | No | | | Yes |
| Are windrows or bins monitored for internal temperature and aerated when appropriate? | No | | | Yes |
| Except in arid regions, is a roofed storage available for completed compost awaiting land application? | No | | | Yes |

# APPENDIX A
## Environmental Stewardship Assessment: Mortality management (continued)

| Issue | High to High Risk Risk 4 | Moderate to Moderate Risk Risk 3 | Low Risk Risk 2 | Low Risk Risk 1 |
|---|---|---|---|---|
| | | **Composting method (continued)** | | |
| Is fresh carbon amendment added to the outside of the pile or windrow as a biofilter to absorb leachate and odors? | No | | | Yes |
| | | **Incineration method** | | |
| What type of incinerator is used? | Barrels, other homemade vessels, or open burning | | | A unit that meets state agency regulations |
| What is the capacity of the incineration unit? | Less than maximum expected daily mortality | | | Greater than maximum expected daily mortality |
| Where is the incinerator located? | Upwind of livestock housing, farm residence, and neighbors | | | Downwind of livestock housing, farm residence, and neighbors |
| | | **Sanitary landfill method** | | |
| What type of arrangement has been made with sanitary landfill authorities? | None | | | Long term |
| What type of transport is used? | Open bed truck or trailer | | | Leakproof covered truck or trailer |

# APPENDIX B
## Regulatory Compliance Assessment: Mortality management

| Regulatory Issue | Is this issue addressed by regulations? If "Yes," summarize those regulations. | Is my livestock/ poultry operation in compliance? |
|---|---|---|
| What agencies are involved in administrating regulations related to livestock/poultry mortality? | ___ U.S. EPA ___ State ___ Local List Name, Address, Phone Number | |
| Do regulation require that an agency be notified if death is caused by certain infectious diseases? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Do regulations vary based upon size of the livestock/ poultry operation? | ___ Yes, facilities for managing mortality are required for having more than ________ (number) for ________________ (type of livestock/poultry)<br>___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Are methods (burial, incineration, composting, etc.) of attending to livestock/ poultry mortality specified by regulation? | ___ Yes, the approved methods are<br>___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Is there a time limit for attending to livestock/poultry mortality? | ___ Yes, the time limit is<br>___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Are plans and specification for mortality facilities required to be approved prior to construction? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Are there restrictions or licenses required to transport dead livestock/poultry away from property? | ___ Yes, a license is required ________ The restrictions are<br>___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Is certification required to operate a composter? | ___ Yes, a certification is required ___________<br>___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Do regulations require mortality composters to be constructed with floors, roofs, and of rot-/rust-resistant building materials? | Roofs ___ Yes ___ No<br>Floors ___ Yes ___ No<br>Rot-/rust-resistant building material ___ Yes ___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Do regulations limit the location of burials of mortality to locations with certain characteristics such as separation distance to wells and streams, depth to water table, property lines, and occupied buildings? | ___ Yes, what are the requirements?<br>___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Do regulations specify cover depth for burial? | ___ Yes, the depth of cover required is ___________<br>___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Do regulations require that an approved incinerator be used? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Does incineration require a air quality permit? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |
| Are there special requirements should catastrophic die-off occur? | ___ Yes ___ No | ___ Yes ___ No<br>___ Not Applicable<br>___ Don't Know |

# APPENDIX C
## Poultry and Livestock Mortality Rates

### Poultry

| Poultry Type | Average Weight, lbs | Mortality Rate, % | Flock Life, days | Design Weight, lbs |
|---|---|---|---|---|
| Broiler | 4.2 | 4.5-5 | 42-49 | 4.5 |
| Layers | 4.5 | 14 | 440 | 4.5 |
| Breeding Hens | 7-8 | 10-12 | 440 | 8 |
| Turkey, females | 14 | 5-6 | 95 | 14 |
| Turkey, males | 24 | 9 | 112 | 24 |

### Swine

| Growth | Average Weight, lbs | Mortality Rate,% | | | Design Weight, lbs |
|---|---|---|---|---|---|
| | | Low | Average | High | |
| Birth to Weaning | 6 | < 10 | 10-12 | > 12 | 10 |
| Nursery | 24 | < 2 | 2-4 | > 4 | 35 |
| Growing-Finishing | 140 | < 2 | 2-4 | > 4 | 210 |
| Breeding Herd | 350 | < 2 | 2-5 | > 5 | 350 |

### Cattle/Horses

| Growth Stage | Average Weight, lbs | Mortality Rate,% | | | Design Weight, lbs |
|---|---|---|---|---|---|
| | | Low | Average | High | |
| Birth | 70-130 | < 8 | 8-10 | > 10 | 130 |
| Weanling | 600 | < 2 | 2-3 | > 3 | 600 |
| Yearling | 900 | < 1 | 1 | > 1 | 900 |
| Mature | 1,400 | < 0.5 | 0.5-1 | > 1 | 1,400 |

### Sheep/Goats

| Growth Stage | Average Weight, lbs | Mortality Rate,% | | | Design Weight, lbs |
|---|---|---|---|---|---|
| | | Low | Average | High | |
| Birth | 8 | < 8 | 8-10 | > 10 | 10 |
| Lambs | 50-80 | < 4 | 4-6 | > 6 | 80 |
| Mature | 170 | < 2 | 3-5 | > 8 | 170 |

Source: Ohio's Livestock and Poultry Mortality Composting Manual, 1999.

# APPENDIX D
## Worksheet for Determining Compost Bin or Windrow Volume Requirements

**Name:** ____________________ **Location** ____________________

**Step A—Determine the weight of animal carcasses to be composted.**

Average daily loss (ADL) __________ lbs.
Design mortality weight (W1) __________ lbs.
Annual loss = ADL x 365 = (__________) x 365 = __________ lbs.

**Step B—Determine the composting cycle times for the "design weight" to be composted in each windrow or bin.**

Primary cycle time (days) = 5.00 x $(W1)^{0.5}$ = 5.00 x $(\_\_\_\_\_\_\_\_\_\_)^{0.5}$
= __________ days (If less than 10 days, use 10.)

Secondary cycle time (days) = 1/3 primary cycle time, minimum time ≥ 10 days
= 1/3 x (__________)
= __________days (If less than 10 days, use 10.)

Storage time (days) =Year's maximum period of time between land application events.
= __________ days (from nutrient management plan)

**Step C—Determine the needed composter volumes.**

Primary composter volume ($ft^3$) = 0.2 x ADL x primary cycle time
= 0.2 x __________ x __________ = __________ $ft^3$

Secondary composter volume ($ft^3$) = 0.2 x ADL x secondary cycle time
= 0.2 x __________ x __________ = __________ $ft^3$

Storage volume ($ft^3$) = 0.2 x ADL x storage time (days)
= 0.2 x __________ x __________ = __________ $ft^3$

**Step D—Determine the dimensions of the compost facility, bin dimensions, and windrow size or number of bins.**

**Step E—Determine the annual sawdust required for the composting.**

Annual sawdust needs ($yd^3/yr$) = annual loss (lbs/yr) x 0.0069
= __________ x __________
= __________ $yd^3/yr$

### Equations for universal sizing of composting bins and windrows

$T_1 = 5 \times W_1^{0.5}$ — days
$\geq 10$ days

$V_1 \geq 0.2 \times ADL \times T_1$ — $ft^3$

$T_2 = 1/3 \times T_1$ — days
$\geq 10$ days

$V_2 \geq 0.2 \times ADL \times T_2$ — $ft^3$

$T_3$ = storage — days
=Year's maximum period of time between land application events in keeping with the timing requirements of the nutrient management plan

$V_3 \geq 0.2 \times ADL \times T_3$ — $ft^3$
Annual sawdust needs = ADL x 0.0069 — $yd^3/yr$

Where
ADL = average daily mortality (lbs/day)
$W_1$ = design mortality weight (lbs)
$T_1$ = Primary cycle time (days)
$V_1$ = Primary compost bin or windrow volume ($ft^3$)
$T_2$ = Secondary cycle time (days)
$V_2$ = Secondary compost bin or windrow volume ($ft^3$)
$T_3$ = Storage period (days)
$V_3$ = Storage volume requirement ($ft^3$)

## About the Author

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## Glossary

**Aeration.** The process by which the oxygen-deficient air in compost is replaced by air from the atmosphere. Aeration can be enhanced by turning.

**Aerobic.** An adjective describing an organism or process that requires oxygen (for example, an aerobic organism).

**Amendment.** *See* Composting amendment.

**Anaerobic.** An adjective describing an organism or process that does not require air or free oxygen.

**Bacteria.** A group of microorganisms having single-celled or noncellular bodies. Bacteria usually appear as spheroid, rod-like, or curved entities but occasionally appear as sheets, chains, or branched filaments.

**Bin composting.** A composting technique in which mixtures of material is composted in simple structures (bins) rather than freestanding piles. Bins are considered a form of in-vessel composting, but they are usually not totally enclosed. Many composting bins include a means of forced aeration.

**Bulking agent.** An ingredient in a mixture of composting raw material included to improve the structure and porosity of the mix. Bulking agents are usually rigid and dry and often have large particles (for example, straw). The terms "bulking agent" and "amendment" are commonly used interchangeably.

**C.** Chemical symbol for carbon.

**Carbon-to-nitrogen (C:N) ratio.** The ratio of the weight of organic carbon (C) to that of total nitrogen (N) in an organic material.

**Cellulose.** A long chain of tightly bound sugar molecules that constitutes the chief part of the cell walls of plants.

**Compost.** A group of organic residues or a mixture of organic residues and soil that have been piled, moistened, and allowed to undergo aerobic biological decomposition.

**Composting.** Biological degradation of organic matter under aerobic conditions to a relatively stable humus-like material called compost.

**Composting amendment.** An ingredient in a mixture of composting raw material included to improve the overall characteristics of the mix. Amendments often add carbon, dryness, or porosity to the mix.

**Degradable material.** Material that breaks down quickly and/or completely during composting is highly degradable. Material that resists biological decomposition is poorly or even nondegradable.

**Disposal pit.** A method for managing mortality that involves placing dead animals in an excavated hole or pit that is lined equipped with a cover. It is considered the least desirable method for managing mortality.

**Grinding.** Operation that reduces the particle size of material. Grinding implies that particles are broken apart largely by smashing and crushing rather than tearing or slicing.

**Humus.** The dark or black carbon-rich relatively stable residue resulting from the decomposition of organic matter.

**Incineration.** A method for managing mortality that involves burning dead animals with a very hot flame, reducing them to ashes. It is considered the most environmentally benign method for managing mortality.

**In-vessel composting.** A diverse group of composting methods in which composting material is contained in a building, reactor, or vessel.

**Land application.** Application of compost, manure, sewage sludge, municipal wastewater, and industrial wastes to land either for ultimate disposal or for reuse of the nutrients and organic matter for their fertilizer value.

**Leaching.** The removal of soluble material from one zone in soil to another via water movement in the profile.

**Litter, poultry.** Dry absorbent bedding material such as straw, sawdust, and wood shavings that is spread on the floor of poultry barns to absorb and condition manure. Sometimes the manure-litter combination from the barn is also referred to as litter.

**Microorganism.** An organism requiring magnification for observation.

**Moisture content.** The fraction or percentage of a substance comprised of water. Moisture content equals the weight of the water portion divided by the total weight (water plus dry matter portion). Moisture content is sometimes reported on a dry basis. Dry-basis moisture content equals the weight of the water divided by the weight of the dry matter.

**Mortality.** Animals that die prematurely because of disease, injury, or other causes.

**N.** Chemical symbol for nitrogen.

**Organic matter.** Chemical substances of animal or vegetable origin, consisting of hydrocarbons and their derivatives.

**Pathogen.** Any organism capable of producing disease or infection. Often found in waste material, most pathogens are killed by the high temperatures of the composting process.

**pH.** A measure of the concentration of hydrogen ions in a solution. pH is expressed as a negative exponent. Thus, something that has a pH of 8 has ten times fewer hydrogen ions than something with a pH of 7. The lower the pH, the more hydrogen ions present, and the more acidic the material is. The higher the pH, the fewer hydrogen ions present, and the more basic it is. A pH of 7 is considered neutral.

**Porosity.** A measure of the pore space of a material or pile of material. Porosity is equal to the volume of the pores divided by the total volume. In composting, the term porosity is sometimes used loosely, referring to the volume of the pores occupied by air only (without including the pore space occupied by water).

**Recipe.** The ingredients and proportions used in blending together several raw materials for composting.

**Rendering.** A method for managing mortality that converts the dead animals into useful products, such as pet food and fertilizer.

**Sanitary landfill.** An engineered burial facility for disposal of solid waste that is located, designed, constructed, and operated in a manner that will contain the waste so it will not cause a present or potential hazard to public health or to the environment.

**Shredding.** An operation that reduces the particle size of material. Shredding implies that the particles are broken apart by tearing and slicing. *See also* Grinding.

**Structure, of composting mix or raw material.** The ability to resist settling and compaction. Structure is improved by large rigid particles.

**Universal sizing procedure.** A method for determining the size of compost bins and windrows that is based on the average daily mortality.

**Windrow.** A long, relatively narrow, and low pile. Windrows have a large exposed surface area that encourages passive aeration and drying.

## Index (Page numbers highlighted in green are linked to corresponding text.)



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Click on road map to return to Contents.

## Reviewers

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# Livestock and Poultry Environmental Stewardship Curriculum: Lesson Organization

This curriculum consists of 27 lessons arranged into six modules. Please note that the current lesson is highlighted.

### Module A. Introduction

1. Principles of Environmental Stewardship
2. Whole Farm Nutrient Planning

### Module B. Animal Dietary Strategies

10. Reducing the Nutrient Excretion and Odor of Pigs Through Nutritional Means
11. Using Dietary and Management Strategies to Reduce the Nutrient Excretion of Poultry
12. Feeding Dairy Cows to Reduce Nutrient Excretion
13. Using Dietary Strategies to Reduce the Nutrient Excretion of Feedlot Cattle

### Module C. Manure Storage and Treatment

20. Planning and Evaluation of Manure Storage
21. Sizing Manure Storage, Typical Nutrient Characteristics
22. Open Lot Runoff Management Options
23. Manure Storage Construction and Safety, New Facility Considerations
24. Operation and Maintenance of Manure Storage Facilities
25. Manure Treatment Options

### Module D. Land Application and Nutrient Management

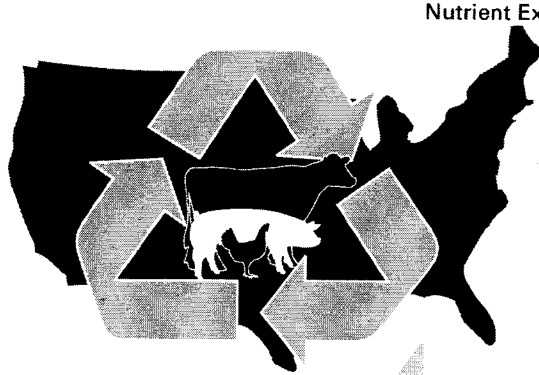
30. Soil Utilization of Manure
31. Manure Utilization Plans
32. Land Application Best Management Practices
33. Selecting Land Application Sites
34. Phosphorus Management for Agriculture and the Environment
35. Land Application Records and Sampling
36. Land Application Equipment

### Module E. Outdoor Air Quality

40. Emission from Animal Production Systems
41. Emission Control Strategies for Building Sources
42. Controlling Dust and Odor from Open Lot Livestock Facilities
43. Emission Control Strategies for Manure Storage Facilities
44. Emission Control Strategies for Land Application

### Module F. Related Issues

50. Emergency Action Plans
51. **Mortality Management**
52. Environmental Risk and Regulatory Assessment Workbook



## Emissions from Animal Production Systems

John W. Worley

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## Chapter 1: The Science of Odors and Emissions

In the past, airborne emissions were considered only a minor drawback for livestock and poultry production operations. However, with the trend toward larger, more concentrated production sites, odors and other airborne emissions are rapidly becoming an important issue for all animal producers. Shifting population distributions; the unwillingness of many to tolerate odors, gases, and dust emitted from animal production; and the economic importance of animal agriculture in the United States all contribute to the urgent need for stakeholders to find adequate solutions to this problem. A prerequisite to good solutions is a thorough understanding of the problem.

### Emissions and Health

Very little information is available on the direct impact of airborne emissions on human health. However, some human health complaints are being made based on certain emissions like odor. A North Carolina study (Schiffman 1995) reported that people living near hog facilities who were exposed to odors experienced more tension, depression, anger, fatigue, and confusion than a group of residents not exposed to hog odors. Another study in Iowa (Thu, et al. 1997) found a higher frequency of mainly respiratory health symptoms in people living within 2 miles of a 4,000-head swine operation compared to a control group in an area with no intensive livestock operations. A different North Carolina study (Wing and Wolf, 1999) found similar results when surveying residents of three rural communities: one a non-livestock area, another with cattle (about 300 dairy cows) operations, and a final area that contained a 6,000-head pig unit. Certain respiratory and gastrointestinal health symptoms (runny nose, sore throat, excessive coughing, and diarrhea) were reported more often in the livestock (mostly hog) communities. Also quality-of-life factors like not wanting to open windows or going outside during pleasant weather were similar in the control (non-livestock) and cattle areas but much lower for residents living in the hog community. Finally, many individuals and/or grass- roots organizations claim negative effects have occurred due to odor and other airborne emissions from livestock operations (Hudson 1998).

### Airborne Emissions from Animal Production Systems

***Type of emissions*:** Odor emissions from animal production systems originate from three primary sources: manure storage units, animal housing, and land application of manure. Table 1 summarizes identified odor sources and animal species for justifiable complaints in a 1982 study in a United Kingdom (U.K.) country (Hardwick, 1985). Almost 50% of all odor complaints were traced back to land application of manure, about 20% were from manure storage units, and another 25% were from animal buildings. Other sources included feed production, processing centers, and silage storage. Between the three animal species, pigs were identified as the source of slightly more than half of the complaints (54%), with cattle and poultry being the source of 20% and 24% of the complaints, respectively. Even though these findings are from the U.K. and are nearly 20 years old, general observations in this country seem to agree with this distribution of odor sources. However, with the increased use of manure injection for land application in certain parts of the country and longer manure storage (and larger manure storage structures), there may be a higher percentage of complaints in the future associated with manure storage units and animal buildings.

**Table 1. Number and source of odor complaints received during a one-year period in a United Kingdom country**

| Odor Source | Pigs | | Cattle | | Poultry | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| Buildings | 224 | 22 | 65 | 18 | 163 | 36 | 452 | 25 |
| Slurry storage | 169 | 17 | 98 | 28 | 78 | 17 | 345 | 19 |
| Slurry spreading | 526 | 52 | 122 | 34 | 190 | 42 | 838 | 46 |
| Animal feed production | 84 | 8 | 4 | 1 | 11 | 3 | 99 | 5 |
| Silage storage | 10 | 1 | 68 | 19 | 8 | 2 | 86 | 5 |
| Total | 1,013 | 56 | 357 | 20 | 450 | 24 | 1,820 | 100 |

Source: Hardwick, 1985

Most of the odorous compounds that are emitted from animal production operations are by-products of anaerobic decomposition/transformation of livestock wastes by microorganisms. Livestock wastes include manure (feces and urine), spilled feed and water, bedding materials (i.e., straw, sunflower hulls, wood shaving), wash water, and other wastes. This highly organic mixture includes carbohydrates, fats, proteins, and other nutrients that are readily degradable by microorganisms under a wide variety of suitable environments. The by-products of microbial transformations depends, in a major part, on whether it is done aerobically (i.e., with oxygen) or anaerobically (i.e., without oxygen). Microbial transformations done under aerobic conditions generally produce fewer odorous by-products than those done under anaerobic conditions. Moisture content and temperature affect the rate of microbial decomposition.

A large number of volatile compounds have been identified as by-products of animal waste decomposition. Kreis (1978) developed one of the earliest lists of volatile compounds associated with decomposition of cattle, poultry, and swine wastes. He listed 32 compounds reported to have come from cattle wastes, 17 from poultry wastes, and more than 50 compounds from swine wastes (Kreis, 1978). O'Neill and Phillips (1992) compiled a list of 168 different compounds identified in swine and poultry wastes. The compounds are often listed in groups based on their chemical structure. Some of the principal odorous compounds, individual and as groups, are ammonia, amines, hydrogen sulfide, volatile fatty acids, indoles, skatole, phenols, mercaptans, alcohols, and carbonyls (Curtis, 1983). Carbon dioxide and methane are odorless.

Some of the gases that are emitted have implications for global warming and acid rain issues. Among these gases are ammonia and non-odorous gases such as methane and carbon dioxide. European countries have instituted strict ammonia emission limits in recent years. It has been estimated that one third of the methane produced each year comes from industrial sources, one third from natural sources, and one third from agriculture (primarily animals and manure storage units). Although animals produce more carbon dioxide than methane, methane contribution to the greenhouse effect is estimated at 15 times that of an equal amount of $CO_2$

Dust is another airborne emission concern that is difficult to eliminate from animal production units. It is a combination of manure solids, dander, feathers, hair, and feed. It is typically more of a problem in buildings that have solid floors and use bedding as opposed to slatted floors and liquid manure. Dust concentrations inside animal buildings and near outdoor feedlots have been measured and range from 1 up to 10 $mg/m^3$ (Curtis, 1983). However, dust emission rates are mostly unknown from animal production sites.

Pathogens are yet another airborne emission concern for animal production operations. Although pathogens are present in buildings and manure storage units, they typically do not survive aerosolization well, but some have been transported by dust particles.

Flies are an additional concern from certain types of poultry and livestock operations. The housefly completes a cycle from egg to adult in 6 to 7 days when temperatures are 80 to 90ºF. Females can produce 600 to 800 eggs, and larvae can survive burial at depths up to 4 feet. Adults can fly up to 20 miles. These facts verify that large populations of flies can be produced relatively quickly if the correct environment (moisture and nutrients as when manure is stored) are provided. Studies have shown that flies proliferate in areas not trod by animals. To prevent flies, special care should be taken to keep spoiled feed and manure from under feeders and waterers, under fences, and other areas that the animals do not reach. Compost piles make excellent fly habitat if not managed correctly.

**Airborne Emission Movement or Dispersion**

The movement or dispersion of airborne emissions from an animal production site is difficult to predict and is affected by such factors as topography, prevailing winds, and building orientation. Odor plumes decrease exponentially with distance (Brembery 1994), but long distances are needed if no odors, gases, or dust are to be detected downwind from a source. A number of models are being developed to more accurately predict setback distances from livestock operations based on animal units (Schauberger and Piringer 1997) or actual emission values (Jacobson, et al. 1999).

Prevailing winds should be considered so facilities are sited to minimize odor transport to close or sensitive neighbors. For many existing facilities, this is impossible. For those situations, odor reduction techniques may be needed to reduce the odor emission rate or disperse odors faster and more effectively before they reach a sensitive neighbor or individual.

There is ample evidence that rural air quality issues have become a major concern in the siting of animal production units. A variety of livestock and poultry producers, from various areas of the United States, have reported difficulty in obtaining permits to construct new or expand existing livestock operations due to RAQ complaints from neighbors. Odors typically lowered property values of residential homes although one study in Minnesota actually reported a slight appreciation of real-estate values near livestock production units. Another often mentioned concern is the reduced value of land near livestock and poultry units for outdoor recreational activities.

In a 1999 survey of states by the North Dakota Attorney General's office, a total of 31 states reported various types of airborne emission regulations. Many of these states either exempt or chose not to enforce the regulations for agricultural operations. Most states and local units of government deal with this issue through zoning or land use ordinances. Typically, certain setback distances are required for a given size operation or for land application of manure. Also, setbacks from lakes and public waterways are common. A few states (for example, Minnesota) may have an ambient gas concentration ($H_2S$ in the case of Minnesota) standard at a property line that may impact animal agriculture. Another possibility is an odor standard that only a few states have adopted (North Dakota, Colorado, Wyoming, and Missouri) that is again measured at the property line. Gas and odor standards are difficult to enforce since gases and especially odor are hard to measure on-site with a high degree of accuracy.

**Measuring Outdoor Air Quality Components**

***Olfaction: the sense of smell:*** The sense of smell is complex. The basic anatomy of the human nose and olfactory system is well understood. Odorous compounds are detected in a small region known as the olfactory epithelium located high in the rear of the nasal cavity.

Odors evoke a wide range of physiological and emotional reactions. Odors can be either energizing or calming. They can stimulate very strong positive or negative reactions and memories. The development of aromatherapy illustrates how important smells can be to people.

The power, complexity, and our limited understanding of the sense of smell make olfaction a challenging field. Even though humans can detect over ten thousand different odors, they are sometimes simply categorized as being either pleasant or unpleasant. They are often described using terms like floral, minty, musky, foul, or acrid. The large number of recognizable odors and the general terms used to describe them make it difficult to measure and describe odors consistently and objectively.

Most odors consist of a mixture of many different gases at extremely low concentrations. The composition and concentration of the gas mixture affects the perceived odor. To completely measure an odor, each gas would need to be measured. Some odorous gases can be detected (smelled) by humans at very low concentrations (Table 2). The fact that most odors are made up of many different gases at extremely low concentrations makes it very difficult and expensive to determine the exact composition of an odor.

***Odor vs. Gas Measurement:*** Two general approaches are used to measure odor: either measure individual gas concentrations or use olfactometry. Both approaches have strengths and weaknesses. Future developments will hopefully close the gap between the two approaches.

The specific individual gaseous compounds in an air sample can be identified and measured using a variety of sensors and techniques. The results can be used to compare different air samples. With good sensors and proper techniques, valuable information about the gases that emanate from a source can be collected and evaluated. Gas emission rates and control techniques can be compared rigorously. Regulations can be established to limit individual gas concentrations.

The gas measurement approach has some weaknesses when used to measure and control odors. The greatest weakness of the gas measurement approach is that there is no known relationship between the specific gas concentrations in a mixture and its perceived odor (Ostojic and O'Brien, 1996). As a result, controls based on gas concentrations may reduce specific gas emissions but not adequately address the odors sensed by people downwind of a source.

The key advantage of olfactometry is the direct correlation with odor and its use of the human's highly sensitive sense of smell. Olfactometry also has the advantage that it analyzes the complete gas mixture so that the contribution of each compound in the sample is included in the analysis. There are different olfactometry techniques. Data collected by different techniques can be neither combined nor directly compared.

**Table 2. Odor threshold for select chemicals often found in livestock odors.**

| Chemical | Odor Threshold, ppm |
|---|---|
| Aldehydes | |
| Acetaldehyde | 0.21 |
| Propionaldehyde | 0.0095 |
| Volatile Fatty Acids | |
| Acetic acid | 1.0 |
| Propionic acid | 20.0 |
| Butyric acid | 0.001 |
| Nitrogen containing | |
| Methylamine | 0.021 |
| Dimethylamine | 0.047 |
| Trimethylamine | 0.00021 |
| Skatole | 0.019 |
| Ammonia | 46.8 |
| Sulfur containing | |
| Methanethiol | 0.0021 |
| Ethanethiol | 0.001 |
| Propanethiol | 0.00074 |
| t-Butythiol | 0.00009 |
| Dimethy sulfide | 0.001 |
| Hydrogen sulfide | 0.0072 |

Source: Kreis 1978.

McFarland (1995) reviewed many of the current olfactometry techniques being used for odor measurement and concluded that dynamic forced-choice olfactometry appears to be the most accepted method. Olfactometry suffers from a lack of precision compared to some of the sophisticated chemical sensors available. The lack of precision in olfactometry is due in part to the variability in each person's sense of smell and their reaction to an odor. Also, olfactometry does not identify the individual compounds that make up the odor. Even though olfactometry has limitations, it still is the best technique available for directly measuring odors at this time.

***Gas Measurement Methods:*** Many analytical methods measure individual gas concentrations in the air. The following section briefly describes some of the more common methods used to measure select gases in the air around livestock facilities. Some measuring techniques give a single instantaneous reading at a specific place and point in time. Another measurement using the same method some time later will probably give a different value. A series of instantaneous readings can be used to indicate how a gas concentration fluctuates. Some people combine individual readings and report average concentrations. Other measuring techniques sample air for several minutes or more and give an average concentration over the sampling period. When comparing results, it is important to recognize that instantaneous readings will vary more and have higher and lower individual readings than average readings over a sampling period.

Technique precision or detection limit is an important measurement characteristic. Some devices or methods have an accuracy of • •1 part per million (ppm). Others may only be accurate to • •20 ppm. Devices with greater precision can be used to detect small differences in concentrations that less precise devices cannot detect. However, devices with greater precision usually cost more.

*Patches*: Patches are single-use pieces of cardboard or plastic coated with a chemical that changes color when exposed to the gas being measured. Both the amount of time exposed and the amount of color change are important. Patches give an integrated or average value but are not very precise. They can be hung in a space, worn by workers, or combined with small fans for different applications. Hydrogen sulfide patches are the most commonly used patches in livestock odor work.

*Tubes-Indicator and Diffusion:* Indicator tubes are available to measure a wide range of gases. To take a reading with an indicator tube (a sealed glass tube), the tips on both ends of the tube are broken off, and the tube is attached to a hand-held pump. The pump pulls a known amount of air through the tube. The media in the tube reacts and changes color with select gases in the air sample. A scale on the tube is used to measure the amount of media that reacted with the gas and indicates the concentration. Indicator tubes give nearly instantaneous readings, but they come with limited scales, and precision is around 10% of the full-scale reading on the tube. They cost around $5 each, and the hand-held pump costs from $100 to $250.

Diffusion tubes that provide an average concentration are also available for some gases. To take a reading, one end of the tube is opened and the tube is hung in the space to be monitored. Some known time later, usually six to eight hours, a reading is taken by noting the amount of media that changed color. The amount of color change in the tube and the time exposed are used to calculate an average concentration over the sampling time. Tubes cost around $8 each.

*Jerome® Meter:* The Jerome® meter is a portable electronic device for measuring hydrogen sulfide concentrations. It samples the air for several seconds to give a nearly instantaneous reading. The meter can measure hydrogen sulfide concentrations down to 3 parts per billion (ppb). It detects hydrogen sulfide concentrations by measuring the difference in the electric resistance of a gold leaf cover metal strip, which is exposed to the air sample. Jerome® meters cost around $10,000.

*MDA-Single-Point Monitor*: The MDA s-p m is used to monitor ambient air concentrations of individual compounds over extended periods of time. The units use the Chemcassette® Detection System. The cassette tape reacts, causing a color change, with the chemical being monitored. The color change is measured and used to indicate the gas concentration in the ambient air. MDA monitors can be used to measure ambient hydrogen sulfide concentrations between 2 and 90 ppb over 15-minute periods. Units with different electronics and cassettes can be purchased to monitor other gases. Units cost around $7,000.

*Electronic Sensors:* A number of different electronic sensors are available for measuring gas concentrations. Their method of action and precision vary. Some units have multiple gas sensors. Some units are used in the safety field to monitor gas concentrations and sound alarms if safe concentrations are exceeded in confined spaces. Many of these units cannot measure gas concentrations at levels needed for odor monitoring.

*Gas chromatograph/Mass spectrometer:* A gas chromatograph-/-mass spectrometer (GC/MS) is generally considered a research laboratory device. It can be used to both identify and measure gas concentrations. Very small air samples are injected into a carrier (nitrogen or helium) gas stream passing through a GC/MS column. The column adsorbs and desorbs the chemicals in the air at different rates to separate them. After separation, the carrier gas stream with the separated chemicals passes through a detector. The detector output signal identifies the chemical and the amount in the sample. Portable units to do field research are now available.

***Odor Measurement and Description: An Introduction to Olfactometry:***

Various techniques measure and describe odors,. which can be characterized by the following five different characteristics or dimensions that add to the complete description of an odor:

(1) Concentration
(2) Intensity
(3) Persistence
(4) Hedonic tone
(5) Character descriptor

Odor concentration and intensity are the two most common odor characteristics measured. The other three–persistence, hedonic tone and character descriptors–are commonly viewed as more subjective characteristics. As subjective characteristics they do not lend themselves to objective measurement for scientific or regulatory purposes.

*Concentration:* Two odor concentrations (thresholds) can be measured: detection threshold and recognition threshold. They are usually reported in odor units (ou). Odor units are dimensionless numbers and are defined as the volume of dilution (non-odorous) air divided by the volume of odorous sample air at either detection or recognition.

The detection threshold concentration is the volume of non-odorous air needed to dilute a unit volume of odorous sample air to the point where trained panelists can correctly detect a difference compared to non-odorous air. At the detection threshold, a trained panelist just begins to detect the difference between odorous and non-odorous air. This is the most common concentration determined and reported.

The recognition threshold concentration is the volume of non-odorous air needed to dilute a unit volume of odorous sample air to the point where trained panelists can barely recognize the odorous air. The difference between detection and recognition thresholds can be illustrated with an analogy using sound and a person in a quiet room with a radio. If the radio is turned down so low that the person cannot hear the radio, the radio is at a level below detection. If the volume is increased in very small steps, it will increase to a point where the person will detect a noise. This volume corresponds to the detection threshold. The person will not be able to recognize the noise, whether it is music or people talking. If the volume is again increased in small steps , it will increase to a point where the person will be able to recognize that the noise is either music or people talking. This volume corresponds to the recognition threshold.

*Intensity:* Intensity describes the strength of an odor sample and is measured at concentrations above the detection threshold. It changes with gas or odor concentration.

Intensity can be measured at full-strength (i.e., no dilution with non-odorous air) or diluted with non-odorous air. In either case, it can be measured against a five-step scale using n-butanol, a standard reference chemical (ASTM, 1988). To learn the scale, trained panelists sniff containers of n-butanol at different concentrations in water (Table 3). They then are presented diluted or full-strength (diluted is always presented first) odorous air samples that they rate against the n-butanol scale.

**Table 3. Odor intensity reference scale based on n-butanol.**

| Intensity Category | | Equivalent Head Space Concentration of N-Butanol in Air, (ppm)* | Mixture of N-Butanol in Water, (ppm) |
|---|---|---|---|
| 0 | No odor | 0 | 0 |
| 1 | Very light | 25 | 250 |
| 2 | Light | 75 | 750 |
| 3 | Moderate | 225 | 2250 |
| 4 | Strong | 675 | 6750 |
| 5 | Very strong | 2025 | 20250 |

* Based on air temperature of 20.3•C.

***Odor Measurement Devices and Techniques***

*Electronic nose:* The term "electronic nose" describes a family of devices, some commercially available, that measure a select number of individual chemical compounds to measure the odor". The devices use a variety of methods for measuring the gas concentrations. Researchers have and continue to evaluate these devices. To date, they have not successfully correlated livestock odors with the output of commercial or current research electronic noses.

*Scentometer:* The scentometer, developed in the late 1950s (Barnebey-Cheney 1973), is a hand-held device that can be used to measure odor levels in the field.. It is a rectangular, clear plastic box with two nasal ports, two chambers of activated carbon with air inlets, and several different sized odorous air inlets. A trained individual breathes through the scentometer. All of the odorous air inlets are initially closed so that the inhaled air must pass through the activated carbon and is deodorized. The individual begins sampling by opening the odorous air inlets one at a time until an odor is detected. The number and size of open holes is used to calculate the dilution-to-threshold concentration. Portability and relatively low cost are some advantages of scentometers (Barnebey-Cheney, 1992). However, the scentometer is not known for high accuracy (Jones, 1992).

*Dynamic, triangular forced-choice olfactometer:* Most laboratories measuring odors from agricultural sources use a dynamic, triangular forced-choice olfactometer to determine detection and recognition threshold concentrations. These are designed to be operated in accordance with ASTM Standard E679-91 and proposed European Standard ODC 543.271.2:628.52 (Air Quality Determination of Odour Concentration by Dynamic Olfactometry). Standardized procedures and four hours of panelist training are used to achieve repeatable olfactometer results. Panelists are required to follow strict rules which help them use their sense of smell to obtain consistent results and develop a professional attitude about their work.

A dynamic, triangular forced-choice olfactometer presents three air streams to the trained panelists. One of the air streams is a mixture of non-odorous air and an extremely small amount of odorous air from a sample bag. The other two air streams have only non-odorous air. Panelists sniff each air stream and are forced to identify which air stream is different (i.e., has some odor) than the other two non-odorous air streams. Initially, panelists must guess which air stream is different because the amount of odorous air added is below the detection threshold. In steps, the amount of odorous air added to one of the air streams is doubled until the panelist correctly recognizes which air stream is different. The air stream with the odor is randomly changed each time. The detection threshold is the non-odorous airflow rate divided by the odorous airflow rate at the time the panelist correctly recognizes which air stream is different. A panel of eight trained people is normally used to analyze each odor sample.

*Field Sniffer:* The term "field sniffer" refers to a trained panelist who determines odor intensity in the field. The panelists calibrate their noses with the n-butanol intensity scale mentioned above before going into the field to sniff. This calibration is done as a group so consistent intensity levels are established among the individual sniffers. Between readings, they use charcoal filter masks to breathe non-odorous air and thus avoid nasal fatigue. At specified times, the field sniffers remove their masks, sniff the air, and record the air's intensity. The results are used to validate odor dispersion models.

**Dust and Pathogen Measurements**

The measurement of dust concentrations in and near animal facilities is typically performed using gravimetrical methods. This is accomplished by weighing a collection filter before and after a known quantity of sample air is passed through the filter inside or near the animal unit. The results are generally given in units of mg of dust per cubic meter of air ($mg/m^3$). Certain filters are designed to collect all of the dust and are reported as total dust concentrations, while a certain device collects only particles small enough to enter the human respiratory system, which are reported as respirable dust. Another method of dust measurement is electronic particle counters. These devices report the number (not mass/weight) of particles per volume of air ($particles/m^3$). Often these instruments can categorize dust into particle diameter, which is beneficial in assessing the livestock/poultry and human health risks. Finally, pathogens can be collected in the air either directly on agar plates in a device like an "Anderson Sampler" or trapped in a liquid by an "All Glass Impinger" and then placed on petri dishes in the laboratory. After incubation, the colony-forming units are counted with the results usually reported as the number of colony-forming units per volume of air.

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## Chapter 2: Emissions Control Strategies from Buildings and Storage Structures

Odors and gases are emitted from the buildings that house animals and poultry through ventilation fans, or by buoyancy or wind forces in naturally ventilated barns. Methods to reduce these odors and gas emissions are less well documented than either manure storage units or land application control methods. Of the three sources, buildings are believed to release a relatively constant amount of the total odor and gas emissions generated. Building emissions, combined with releases from the manure storage unit, form the "baseline" emission levels from an animal production operation. Two approaches to minimizing odors from buildings and storage structures are first, minimize the odor generation, and second, treat an odor that is generated as it exits the building. Both approaches will be discussed in this text.

### General management strategies

Swine production and manure management facilities should be planned as a total system that reduces environmental impacts while promoting animal performance and worker safety. Proper adjustment of feeders to minimize spillage will also reduce odors and save money on feed. An orderly system for manure collection and storage or treatment reduces potential pockets of odor production. All surfaces on which manure may collect and on which animals are maintained should be as clean and dry as possible. Manure, wet feed, and other products that could produce odors in the building should be removed regularly. This includes dust buildup both on the inside and on the outside of buildings, but especially inside animal housing facilities and on fan housings. Dirty, manure-covered animals promote accelerated bacterial growth and the production of gases that are quickly vaporized by animal body heat. Odor from floor surfaces will be reduced if the floors are kept clean and dry. Minimizing the floor surface area on which manure can accumulate reduces the gases and odors emitted from these surfaces. All components of the production/manure treatment system should be maintained and operated in good functional order. Proper disposal of dead animals and good fly and rodent control programs are also essential.

***Ventilation system:*** A properly designed and well managed ventilation system will keep animals and surfaces dry and thereby reduce odor emissions. Clean fans, shutters, and air inlets will improve the efficiency of the ventilation system and simultaneously prevent "odor episodes" that can occur when atmospheric conditions exist that encourage odor generation. Hanging a brush near exhaust fans will make cleaning more convenient and thus encourage it.

***Relationship between dust and odor:*** Dust on livestock farms affects odor measurement and control in several ways. Dust particles adsorb odorous compounds. As the dust particles are carried by the wind, so is odor. Most of the dust generated on a farm comes from feed, fecal matter, hair, and in the case of poultry, from feathers and litter. Dust also comes from animal skin, insects, and other sources. Some of the dust particles, such as those from manure and feed, omit odorous compounds as a result of bacterial decomposition. Odorous dust can increase the transport of some odor compounds. Dust concentrates odorous compounds, and as a result, odorous dust can cause an intense odor sensation. An understanding of the role dust plays in concentrating and transporting odor is important if we are to develop economical methods of controlling odor because some methods of removing dust from the air are less expensive than direct methods of treating the air to remove odorous compounds.

***Facility siting:*** Where swine facilities are located can play a significant role in whether odors become nuisance. Swine facilities should be located as far as practical from residential developments, commercial enterprises, recreational areas, or other prime areas for non-agricultural uses. A site may seem ideal with respect to transportation, feed supply, accessibility, or land ownership but may present challenges because of existing or proposed development. Where possible, production facilities should be located near the center of a tract of land large enough to allow manure to be applied to the land at agronomic rates. Pollution control and manure treatment facilities should be located as far as practical from areas of high environmental sensitivity such as drainage ditches, streams, or estuaries. Elevating buildings several feet above ground will direct surface drainage away from the building, allow good natural air circulation, and allow manure to flow by gravity to the lagoon or other treatment units.

***Dietary manipulation:*** Data in the scientific literature documents the reduction of odor and nutrients in animal excreta or alteration of the microbial population in an animal's digestive tract as a result of diet manipulation or from adding specific, odor-reducing materials to the diet. In general, this research has shown that nutrients such as nitrogen, phosphorus, copper, and zinc can be reduced through dietary manipulation without impacting the animal's growth and health. This alone is a positive impact on environmental parameters. Dietary manipulation has also been shown in some cases to reduce the odor concentration and offensiveness of freshly excreted manure. After the storage or treatment of manures under anaerobic conditions, the positive impact of dietary manipulation on odor might not persist. However, odor controls through dietary manipulation hold promise and may revolutionize animal feeding practices within the next few years.

***Management of under-floor manure pits:*** Control of odors from under-floor manure pits depends on the type and storage time. Manure stored longer than five days will generate more offensive gases. Undiluted liquid manure has a large odor production potential. Therefore, to reduce odors from shallow gutters with pull plugs, the manure should be removed at least once a week. Often, weekly cleaning is not a standard practice but may become so if odor control is the main objective.

One method of shallow gutter management to enhance odor control that is still being debated is the practice of using recharge water. Some facilities use clean recharge water, some recycle recharge water, and others do not recharge their gutters. Anecdotal evidence suggests that using clean or "treated" recycled recharge water may reduce odorous emissions compared to using no recharge water. Reductions are likely to be very dependent on the quality of recharge water.

***Management of lagoons:*** One of the best ways to reduce emissions from lagoons is to properly manage the lagoon to promote healthy bacterial populations. Precharging the lagoon with dilution water before start-up, steady charging with waste rather than slug charging, and pumping or removing material from beneath the surface to avoid removal of purple sulfur bacteria are examples of good management practice. Fill pipes should empty waste below the surface to avoid stirring the surface and increasing odor emissions.

***Management of manure slurry storage structures:*** Probably the best way to reduce emissions from these structures is to cover them, either with the natural crust that sometimes forms, with a biological cover (chopped straw, etc.) or with a synthetic cover. Biological covers are relatively inexpensive, but add to the amount of organic matter that must be removed each year and sometimes do not hold together in windy conditions, especially on large structures. Synthetic covers cost more initially, but last longer. Total annual cost is similar for both systems. Ozonation of slurry as it enters the storage also reduces odors and helps retain nutrients by lowering bacterial activity, but its economic feasibility has not been proven at this time.

***Natural windbreaks:*** Rows of trees and other vegetation known as shelterbelts, which have historically been used for snow and wind protection in the Midwest, may have value as odor control devices for all species and systems. Similarly, natural forests and vegetation near animal facilities in other sections of the country may serve the same purpose. These shelterbelts also create a visual barrier. A properly designed and placed tree or vegetative shelterbelt could conceivably provide a very large filtration surface (Sweeten 1991) for both dust and odorous compound removal from building exhaust air and odor dispersion and dilution, particularly under stable nighttime conditions (Miner 1995; NPPC 1996). Currently, a few studies are addressing the total impact of vegetative barriers on odor reduction from animal farms, but many people already attest to their value. Shelterbelts are inexpensive, especially if the cost is figured over the life of the trees and shrubs, but it may take 3 to 10 years to grow an effective windbreak.

It is generally felt that windbreaks reduce odors by dispersing and mixing the odorous air with fresh air, although solid research has not confirmed these effects. Windbreaks on the downwind side of animal houses create mixing and dilution. Windbreaks on the upwind side deflect air over the houses so it picks up less odorous air. Producers should avoid placing dense windbreaks so close to naturally ventilated buildings that cooling breezes and winds exchanging the air in these buildings are eliminated or greatly reduced. A minimum distance of 50 feet, or five to ten times the tree height, from a naturally ventilated building is recommended.

**Bedded systems**

Using solid manure systems rather than liquid manure systems is generally considered to reduce odor. Although gases and dust are emitted from solid or bedded systems, most people feel that odor from bedded systems is less objectionable than the odor from liquid systems. Using bedding/dry manure systems for animals is generally considered to be more environmentally acceptable from both water quality and outdoor air quality viewpoints.

Anecdotal evidence suggests that organic bedding such as straw, corn stalks, compost, wood chips, or newspaper may reduce odor emissions. European research seems to support the use of some type of bedding (especially sawdust) to reduce odor generation/levels in buildings and subsequent odor release or emission (Nicks et al. 1997). Relatively small bedding levels may be enough to have an effect on odor generation/emission. Until liquid systems were adapted, primarily for convenience, bedding had been used for livestock production for generations. Many dairy and poultry facilities still use dry or solid manure systems.

Hoop structures have recently become popular for some swine and dairy producers, in part due to their odor control effectiveness. They feature a deep-bedded pack system using straw or other crop residues to provide animal comfort and soak up manure liquids. Bedding availability is crucial for solid manure systems except for high-rise layer or swine houses. Hoop structure bedding requirements for finishing swine are estimated to be 200 pounds of baled corn stalks per pig marketed. MWPS Publications AED 41 and 44 give details on using bedded hoop structures for swine production.

**Biofilters**

Biofiltration is an air cleaning technology that uses microorganisms to break down gaseous contaminants and produce non-odorous end products. It is used successfully around the world for treating a wide range of air emissions from industrial sources. Biofiltration works well for treating odors because most odorous emissions are made up of numerous compounds at low concentrations that are readily broken down by microorganisms.

The microorganisms in a biofilter break down (i.e., oxidize) airborne volatile organic compounds (VOCs) and oxidizable inorganic gases and vapors in the odorous exhaust air. The byproducts of the process are primarily water, carbon dioxide, mineral salts, some VOCs, and microbial biomass.

*Description:* Figure 1 illustrates a typical, open face biofilter. Odorous air is exhausted from the building with wall or pit ventilation fans that are connected by a duct to the biofilter plenum. The plenum distributes the air evenly across the biofilter media. A supported porous screen holds the media above the plenum. As the air passes through the biofilter, the odorous gases contact the media and are absorbed onto the biofilm where they are degraded by the aerobic microorganisms.

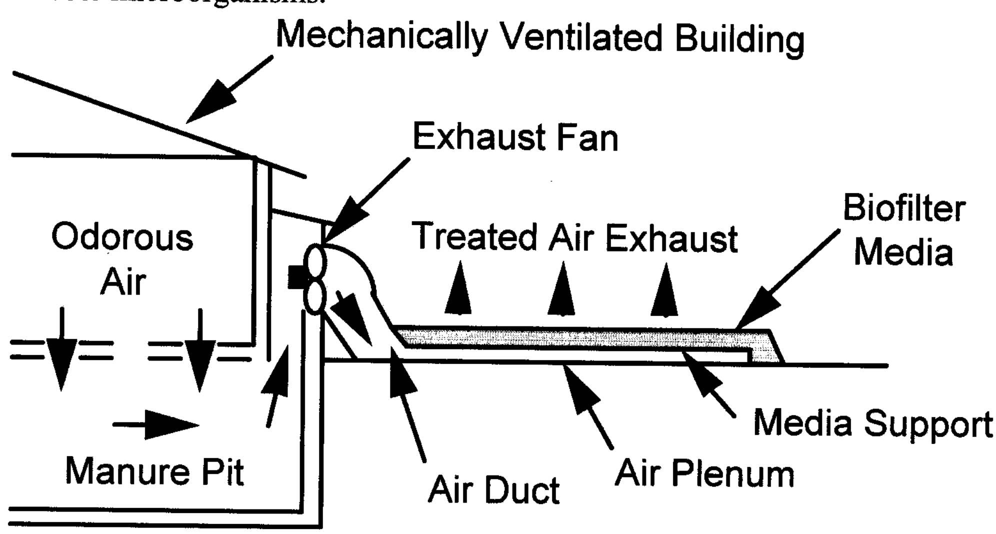


**Figure 1. Typical open face biofilter layout.**

Biofiltration use on livestock facilities began in Germany in the late 1960s and in Sweden in 1984 (Zeisig and Munchen 1987; Noren 1985). Biofilters on pig and calf sheds had average efficiencies around 70% (Scholtens et al. 1987). Nicolai and Janni (1997) reported an average odor reduction of 78% (minimum of 29% in April and maximum of 96% in August) from a pilot-scale biofilter built to treat air exhausted from a pit fan on a farrowing barn in Minnesota. Hydrogen sulfide and ammonia concentrations were reduced an average of 86% and 50%, respectively. The pressure drop across the media, which indicates how much the filter media restricts airflow, ranged between 0.10 and 0.19 in. of water (25 to 47 Pa). Data from a full-sized biofilter used to treat all of the ventilating air exhaust from a 700-sow gestation/farrowing swine facility were recently reported (Nicolai and Janni 1998b, 1998c). Average odor reduction was 82% over the first 10 months of operation. During the same period, average hydrogen sulfide reduction was 80% and ammonia reduction was 53%. Total pressure drop across the fans reached a maximum of 0.4 inches of water, 0.2 inches of that could be attributed to the building's ventilation inlet system.

The amortized construction and operating costs over three years for this full-sized biofilter were $0.22 per piglet produced per year. Rodent control costs were $275 per year. Additional operating costs of $125 per year included sprinkling costs and costs of operating the higher power ventilating fans (Nicolai and Janni 1998b, 1998c). In general, initial costs for a biofilter are approximately $0.10/cubic foot per minute (cfm) of ventilation air with annual operating costs of $0.02/cfm.

Recent research has led to the following recommendations concerning biofilters used to treat air from swine and dairy facilities:

- A residence time (amount of time the ventilation air is in contact with the media) of at least 5 seconds should be provided. This amount of time has resulted in 80% to 90% odor reductions; longer times do not increase this already high level of efficiency.
- The minimum depth of the biofilter media should be 10 inches.
- Fans need to be purchased with the capability of moving sufficient air exchange at a total static pressure (includes pressure drop of the barn air inlets as well as the biofilter's media) of 0.4 inches of water. When designing a biofilter, this pressure drop and its impact on the ventilating system must be considered.
- The Proper moisture control of the biofilter media is essential.
- A rodent control program is necessary.
- Vegetative growth on the biofilter surface must be limited.

Many common materials can be used for a biofilter, including dark red kidney bean straw and compost (Nicolai and Janni 1997), shredded wood and compost (50% by weight) (Nicolai and Janni 1998a, b, c), and even shredded wood and soil (50% by weight). Shredded wood is used to increase porosity, making it easier for the air to flow through the biofilter. Compost and soil are a source of microorganisms and nutrients.

Continual excessive moisture can lead to increased airflow resistance (pressure drop) and limited oxygen exchange that could create anaerobic zones. Insufficient moisture leads to drying, microbe deactivation, and channeling, which reduce contaminant removal efficiency. If present, mice and rats will burrow through the warm media in cold winter months, causing channeling and poor treatment. Rabbits, woodchucks, and badgers have also been suspected of burrowing through and nesting in biofilters. Finally, excessive vegetative growth on the biofilter surface can reduce its efficiency by causing channeling and limiting oxygen exchange. Root systems can cause plugging, and noxious weeds need to be removed before they produce seed. Excessive vegetative growth may also detract from the site's aesthetic appearance.

*Summary:* Biofilters effectively reduce odor, hydrogen sulfide, and ammonia emissions from mechanically ventilated livestock buildings. While simple in appearance, they are rather complex biological systems that need to be designed properly to perform well and prevent ventilation problems. Research is continuing to demonstrate their performance and to develop better design and management recommendations.

***Vegetable oil sprinkling:*** Airborne dust, a common problem inside animal housing facilities, has been linked to both human and animal health concerns. Since suspended dust particles can and often do absorb toxic and odorous gases, the reduction of the airborne dust concentrations inside buildings will lower odor and gas emissions from these animal housing units. Research studies have shown that sprinkling various types of vegetable oil inside pig buildings will reduce indoor airborne dust levels.

Detailed information on sprinkling vegetable oils in pig barns is given in the MidWest Plan Service (MWPS) publication AED-42 (Zhang et al. 1997). Oil can be applied manually with a hand-held sprayer or automatically with a permanently installed sprinkler system. Once-a-day application is recommended. It is important to operate the oil-sprinkling equipment so the droplets are properly sized, and distributed evenly. Operating the spray nozzles within pressure and temperature limits of the suggested vegetable oils can control droplet size. The MWPS publication gives the recommended levels for such oils as canola, corn, soybean, and sunflower.

*Research Data:* Oil-sprinkling research (Takai et al. 1993) indicates reductions in dust levels, and in one case (Zhang et al. 1996), reduction of odorous gases like hydrogen sulfide and ammonia. Dust levels were lowered 80%, while hydrogen sulfide and ammonia concentrations were reduced 20% or 30%, respectively, in this study.

Research conducted at the University of Minnesota (Jacobson et al. 1998) showed total dust concentrations were reduced considerably by oil sprinkling. Dust levels in the oil treatment room were about 40% of the dust levels in the control room. Respirable dust levels (the fraction that reaches the human lung), however, did not follow this trend, showing similar concentrations for both the control and treatment rooms. Reasons for the inconsistent results are difficult to determine, but may be related to the fact that once-a-day sprinkling may only reduce the large particulate (feed and fecal) materials and not smaller airborne particles. Also during this same study, an average odor reduction of 60% was seen in the oil-treated room compared to a control room for a pig nursery. Oil sprinkling in the pig nursery barn did not have the same effect on individual gas concentrations. Hydrogen sulfide levels were reduced about 60%, in the rooms sprinkled with oil, but ammonia levels were unaffected by the oil treatment.

*Challenges:* Compared to the control room, extra labor was needed to clean the oil treatment room after each group was moved out of the building. Producers may want to add a "presoak" segment to their cleaning protocol to aid the cleanup of surfaces in these facilities, which will lead to additional wash time. To be used at the farm level, an automated system is needed to deliver the oil in the building, as opposed to using hand-held sprayers. Existing presoak sprinkling systems may potentially be modified to accomplish this with the aid of timers and appropriate nozzles.

*Summary:* As outlined in MWPS-42, daily sprinkling of very small amounts of vegetable oil inside an animal facility reduced the odor, hydrogen sulfide, and total dust levels of the air inside the barn and in the exhaust ventilation air. Oil sprinkling was not effective in reducing ammonia concentrations or respirable dust levels inside the treated barn.

***Windbreak walls:*** Walls erected downwind from the fans that exhaust air from tunnel-ventilated poultry buildings are being used on more than 200 farms in Taiwan to reduce dust and odor emissions onto neighboring land. These structures, known as windbreak walls, provide some blockage of the fan airflow in the horizontal direction. They can be built with various materials covering a wood or steel frame; plywood and tarps are common. The walls are placed 10 to 20 ft downwind of the exhaust fans of tunnel ventilated barns (Figure 2).

Another variation of the windbreak wall is called a straw wall. These systems have been used in North Dakota and elsewhere. They are made with wooden structures and "chicken wire." Straw is placed inside the structures, providing a barrier to dust and other air emissions. They may also offer some filtration capability.

Windbreak walls work by reducing the forward momentum of airflow from the fans, which is beneficial during low-wind conditions, because odorous dust settles out of the airflow and remains on the farm. In addition, the walls provide a sudden, large vertical dispersion of the exhausted odor plume that acts to entrain fresh outside air into the odor plume at a faster rate than would naturally occur, providing additional dilution potential.

The data and observations taken by Bottcher et al. (1998) using scentometers at a full-scale windbreak wall site in North Carolina showed that

- Dust builds up on the wall surfaces.
- The walls redirect airflow from the building exhaust fans upward.
- When wind speeds are low and blowing from the buildings toward the lagoon, the walls move the fan airflow upward so that it blows 10 ft or more above the lagoon surface. Without the windbreak wall in place, the fan air flows directly on top of the lagoon surface.
- Dust and odor levels are greater in the airflow from the fans than they are 10 ft downwind of the windbreak wall, because the fan airflow is deflected upward.

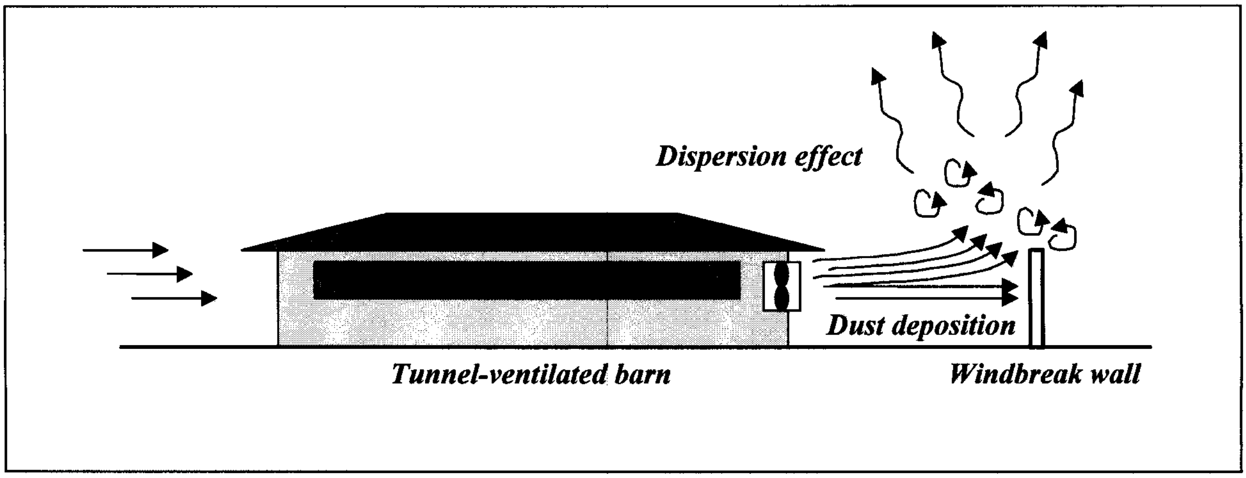


***Figure 2. A tunnel-ventilated barn with a windbreak wall.***

A model study done in Iowa predicted that tall wind barriers placed around a manure storage or lagoon would reduce odor emissions (Liu et al. 1996). Anecdotal evidence suggests a swine farm located in Minnesota benefited when a steel wall was built around an earthen storage basin. Although the operating cost of windbreak walls is relatively low, periodic cleaning of odorous dust from the walls is necessary for sustained odor control, unless rainfall is sufficient to clean the walls. Installation of windbreak walls is estimated to cost at least $1.50 per pig space (e.g., $1,500 for a building that houses 1,000 pigs).

Research to evaluate windbreak walls for dust and odor control is continuing. However, it is difficult to determine the effectiveness of windbreak walls due to several factors. As wind speed and direction shift, the airflow from building fans changes direction. As a result, it is difficult to measure odor downwind. Also, windbreak walls may not be suited for animal buildings equipped with multiple fans at non-uniform locations around the building.

***Washing walls and other wet scrubbers:*** Using water to scrub odorous dust, ammonia, hydrogen sulfide, and other gases from the airflow of swine building ventilation fans can be an effective method of controlling odor. Many industrial air pollution control systems use sprays of water to scrub dust, ammonia, $SO_x$, and $NO_x$ from various polluting air streams. In a wet scrubber, an alkali is usually added to react with acidic pollutants. A wet scrubber design that recirculates most of the water through the system has been tested in North Carolina (Bottcher et al. 1999). This design involves a wetted pad evaporative cooling system installed in a stud wall about 4 feet upwind of ventilation fans and downwind of the pigs in a tunnel ventilated building (Figure 3).

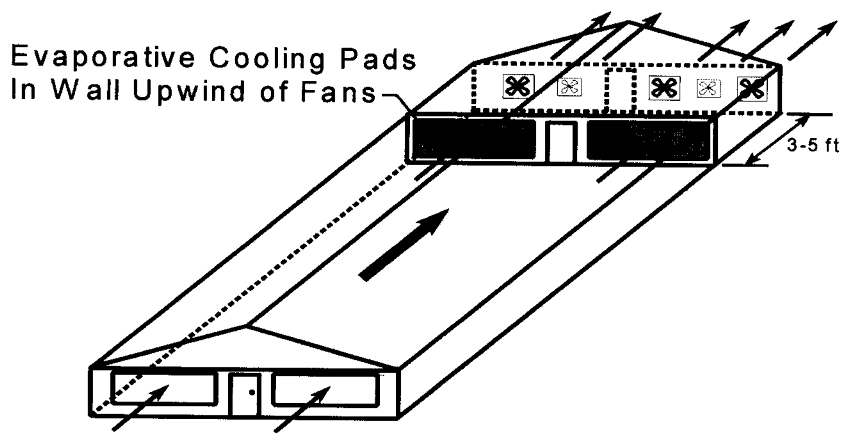


***Figure 3. Evaporative cooling pad installed as a wet scrubber in a tunnel-ventilated swine building.***

*Source: Bottcher et al. 1999.*

Recent measurements taken by Bottcher et al. (1999) show that the system can apparently reduce total dust levels as much as 65% at a relatively low ventilation rate but only by about 16% at a high airflow rate typical of maximum hot weather ventilation. Although the changes in odor levels across the wetted pad scrubber were not as great as desired at the high ventilation rate, the data does indicate a modest odor reduction, consistent with the dust reduction. These results agree with other observations that dust removal from swine building airflow is associated with odor reduction. The wetted pad wall also reduced ammonia levels in the ventilation airflow by 50% at low ventilation rates and by 33% at medium ventilation rates.

Wetted pad wall installation costs are approximately \$5.70 per pig space for an 880-head finishing building (Swine Odor Task Force 1998). The main operating cost is the 1-hp water pump, which will cost about \$600 annually. The wetted pad wall does not impose a significant airflow restriction on the building fans. Maintaining adequate airflow is important if a healthy indoor environment is to be provided for the animals in warm weather.

***Biomass filters:*** Researchers at Iowa State University have tested biomass filters as a means of removing odorous dust from swine buildings (Hoff et al. 1997a). Biomass filters use the principle that dust, if removed from the ventilation exhaust stream, will capture a large portion of the odors with it. Hoff et al. (1997b) were able to demonstrate a relationship between scrubbing dust and odors in controlled laboratory experiments and in a full-scale field trial. Using inexpensive material, a biomass filter removes odorous dust from the air stream. The biomass consists of either chopped corn stalks or corn cobs (Figure 12-6), but other materials can be used. Both odor and dust levels significantly reduced: odor by up to 90% and dust by up to 80%. These reductions occurred with low resistance to airflow at cold weather ventilation rates.

***Chemical additives:*** In some instances, chemical additives are an option for odor or gas emission control. One application where additives were shown to be effective is the addition of alum to poultry litter. Moore et al. (1995) reported on a number of products that reduced ammonia volatilization from poultry litter, including alum, which provided a 99% reduction in ammonia volatilization when 200 g/Kg (20%) was added to the litter in broiler houses. Many other additives for both liquid and solid manure are on the market. A review of products tested across the United States and Europe for ammonia reduction revealed 39 products that worked versus 18 that did not. Of the products tested for odor reduction, 22 were reported to help while 33 did not. Many products worked for only a short time. Until the mechanisms for the various products are understood so reliable performance can be predicted, the additional costs for additive products may be hard for producers to justify.

***Ozonation:*** Ozone is a powerful oxidizing agent and a very effective natural germicide. Ozone high in the atmosphere protects the earth from solar radiation. At ground level, however, the gas can be toxic at high levels. The current OSHA permissible exposure limit for ozone is 0.1 ppm for an 8-hour, time-weighted average exposure (OSHA 1998). Ozone has been used to treat drinking water on a municipal scale since 1906, when it was installed in the treatment facilities for the city of Nice, France (Singer 1990). More than 2,000 water treatment works, primarily in France and other European countries, now use ozone for disinfecting, taste, and odor control (Tate 1991). Currently, about 100 plants in the United States and Canada use ozone (Droste 1997). Ozone generators are sold to "freshen" the air in offices and industrial facilities. A number of commercial ozone generators are currently being sold as residential air cleaning devices.

The molecular arrangement of ozone is three atoms of oxygen ($O_3$). Ozone is unstable and reacts with other gases, changing their molecular structure. At low concentrations of 0.01 to 0.05 ppm, ozone has a "fresh or outdoor smell" associated with it. At higher concentrations, it begins to smell like an "electrical fire." The decomposition of ozone to oxygen is very fast. The half-life of ozone can reach 60 minutes in a cool, sterile environment and is near 20 minutes in typical conditions. In dusty animal houses, however, it may be much less. The most common products of the complete oxidation process are water vapor and carbon dioxide. Ozone reacts with and oxidizes most organic material. Thus, the relatively high level of indoor odors in livestock buildings, the ability of ozone to oxidize gas pollutants, and the potential for ozone to be rapidly depleted continue to make the ozonation of indoor air an attractive but controversial technology for reducing emissions from animal facilities.

***Application in animal facilities:*** Only a limited number of published studies have evaluated the use of ozone for odor reduction in animal production facilities. Ozonation can potentially reduce odors in livestock facilities by killing the odor-producing microorganisms and by oxidizing the odorous metabolites. When oxidized, most compounds are reduced in odor intensity. The American Society for Heating Refrigeration, and Air-Conditioning (ASHRAE, 1989) determined that ozone is **not** an effective means of eliminating odors in ventilated air inside of buildings, but several ozone systems are on the market, and some are being tested on livestock farms with encouraging results. In a 16-month experiment, Priem (1977) found that ozone (at concentrations up to 0.2 ppm) reduced ammonia levels in a swine barn by 50% under winter ventilation conditions and by 15% under summer ventilation conditions. Researchers at Michigan State University reduced odorous compounds and disease-causing bacteria by treating swine manure slurry with high concentrations of ozone (Watkins et al. 1996). In this study, ozone was bubbled directly into fresh and stored swine manure in a continuously stirred batch reactor. Ozone concentrations of 1, 2, and 3 mg/l were used. Olfactometry determinations showed a significant odor reduction in ozonated manure samples in comparison to raw and oxygenated samples. More specifically, hydrogen sulfide concentrations were reduced slightly, while sulfate concentrations concurrently increased.

Researchers are evaluating a commercial ozone air treatment system in a tunnel-ventilated swine finishing house (Keener et al. 1999). Preliminary results suggest that a significant decrease in ammonia ($P < 0.01$) and total dust ($P < 0.02$) occurred in the ozonated building. The concentration of dust particles with optical diameters less than 1 cm were lower in the ozonated house than in the control house. However, an olfactometry panel did not measure significantly different levels of odor in the air samples from the ozonated and the control buildings. The reason for the difference between field observation and laboratory evaluation is still being investigated, but may be related to the fact that dust is removed from air samples before testing in the olfactometry lab. More testing is needed before the ozonation of lagoons or of the air inside swine facilities can be recommended.

***Summary of technologies for odor control***

| ***Process/System*** | | ***Description*** | ***Advantages*** | ***Disadvantages*** | ***Cost*** |
|---|---|---|---|---|---|
| *Exhaust air treatment* | ***Biofilters*** | **Odorous gases are passed through a bed of compost and wood chips; bacterial and fungal activity help oxidize organic volatile compounds** | **Reduces odors and hydrogen sulfide emissions effectively** | **May need special fans because of pressure drop** | **$0.50 to $0.80/pig** |
| Dust reduction | Windbreak walls | A wall made of tarp or with any other porous material is placed 10-20 ft. from exhaust fans. The walls provide some blockage of the fan airflow in the horizontal direction. Dust and odor levels downwind of the windbreaks can be lower since the plume is deflected. | May reduce dust and odor emissions effectively | Periodic cleaning of dust from the walls is necessary for sustained odor control. | $1.50/pig space of bldg capacity |
| | Shelterbelts | Rows of trees and other vegetation are planted around a building, creating a barrier for both dust and odors from building exhaust air. Trees can absorb odorous compounds, and create turbulence that enhances odor dispersion | May reduce dust and odor emissions effectively | It may take several years to grow an effective vegetative wind-break | $0.20/pig space of bldg capacity or more |
| | Washing walls | A wetted pad evaporative cooling system is installed about 1.5 m upwind of ventilation fans and downwind of hogs in a tunnel-ventilated building. Exhaust air passes through the wet pad before being pulled through the fans | Reduces about 50% of dust and 33% of ammonia at medium ventilation rate | Residence time inside the pad is very small; thus odor removal may not be highly effective. | $5.70/pig space of bldg capacity installation cost |
| | Oil sprinkling | Vegetable oil is sprinkled daily at low levels in the animal pens. | Helps reduce airborne dust and odors | Creates a greasy residue on the floor and pen partitions if too much oil is used | $2.50/pig space of bldg capacity |
| Diet manipulation | Phytase | Product (enzyme) is mixed into the feed | Lower P content in the manure | Not known yet | N/A |
| | Low-phytate corn | Use low-phytate corn for feed | Lower P content in the manure | Not known yet | N/A |
| | Synthetic amino-acids and low crude protein | Products are mixed into the feed | Lower N content in the manure, may reduce odor and ammonia emissions | Not known yet | N/A |
| | Feed additives (Yucca schidigera) | Product is mixed into the feed | May reduce odor and ammonia emissions | Not known yet | $.20/pig marketed or more |
| Bedding | | Dry carbon source added to animal pens to promote comfort and soak up manure | Reduced less obnoxious odors. Works for all species | Must harvest or buy bedding, and add it throughout the year. Increased volume of manure to haul | $3.00/head capacity for swine buildings |
| Manure additives | | Chemical or biological products are added to the manure | May reduce odor and ammonia emissions | Usually questionable results. | $0.25 to $1.00/pig or more |

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## Chapter 3: Emission Control Strategies for Land Application

The land application of manure from livestock and poultry facilities is the most frequent source of odor complaints from the public (Pain 1995, Hardwick 1985). Land application of manure to cropland is an important component to the long-term sustainability of animal agriculture. Manure application returns nutrients and organic matter to the soil, keeping it healthy and productive. Unfortunately, manure application to cropland does present some environmental risk. Over application of manure can lead to nitrate leaching into groundwater, phosphorus runoff into surface water, and a variety of other pollution problems. Proper manure application requires knowledge of the nutrient content of manure, the nutrient requirements for the crops, the availability of the manure nutrients, the physical limitations of the application equipment, and some understanding of the critical environmental hazards associated with manure application.

Along with water quality problems are nuisance odor concerns. Odor from manure is, in general, offensive to most people. One of the key factors in odor control is the surface area of the emitting source. The larger the surface area, the more odors are emitted. As such, manure applied on the surface of cropland presents one of the most significant sources of odor for any livestock or poultry operation. Applying manure at low rates to avoid over applying nutrients may in fact exacerbate odor problems since the manure must be spread on larger land areas.

Odor may last for a few hours to as much as two weeks, depending on weather conditions and the manure source. Manure that is applied beneath the soil surface (injected) or covered immediately after spreading (incorporation) eliminates most of the odor because the odorous gases must then travel up through a soil layer before being emitted into the atmosphere. The soil layer acts as both a trap for odorous gases and an aerobic treatment system, changing odorous gases into less odorous gases through microbial processes. Manure injection or incorporation also reduces manure nitrogen losses to the atmosphere by reducing ammonia volatilization. Field research suggests odor and ammonia emission reductions of 90% are attainable using shallow or deep injector manure systems versus surface application (Phillips et al. 1988).

### Liquid Manure Odor Control Techniques

As indicated previously, reducing odor from the land application of liquid manure offers special challenges. Several methods of reducing odor from liquid manure land applications include incorporating the manure into the soil either during or shortly after it is spread, placing the liquid manure on the surface but in the crop canopy, or treating the manure in the storage unit before it is spread on land.

*Injection and incorporation:* Manure injection into the soil is the most effective way to reduce odor during the land application of untreated liquid manure (Figure 1). Table 1 shows odor dilution thresholds for various land application methods. One can see that the injection and the unmanured (control) methods have essentially the same odor units. The other common option is to simply spread liquid manure on the surface and immediately incorporate (plow or harrow methods in Table 1) into the soil. This method also reduces the odors considerably compared to the broadcast method. However, incorporation after spreading on the surface does not result in as great a reduction as direct injection since some manure remains on the soil surface. Another study (Berglund and Hall 1987) found the odor intensity (measure of odor's strength) from surface application at 400 meters downwind was perceived to be equal to that from injection at only 50 meters. A more recent study at Iowa State University showed odor reductions from 20% to 90% by immediate incorporation of manure into the soil. This study looked at five different types of incorporation or injection devices, with all resulting in significant odor and hydrogen sulfide reductions compared to broadcast manure left on the surface (Hanna et al. 1999).

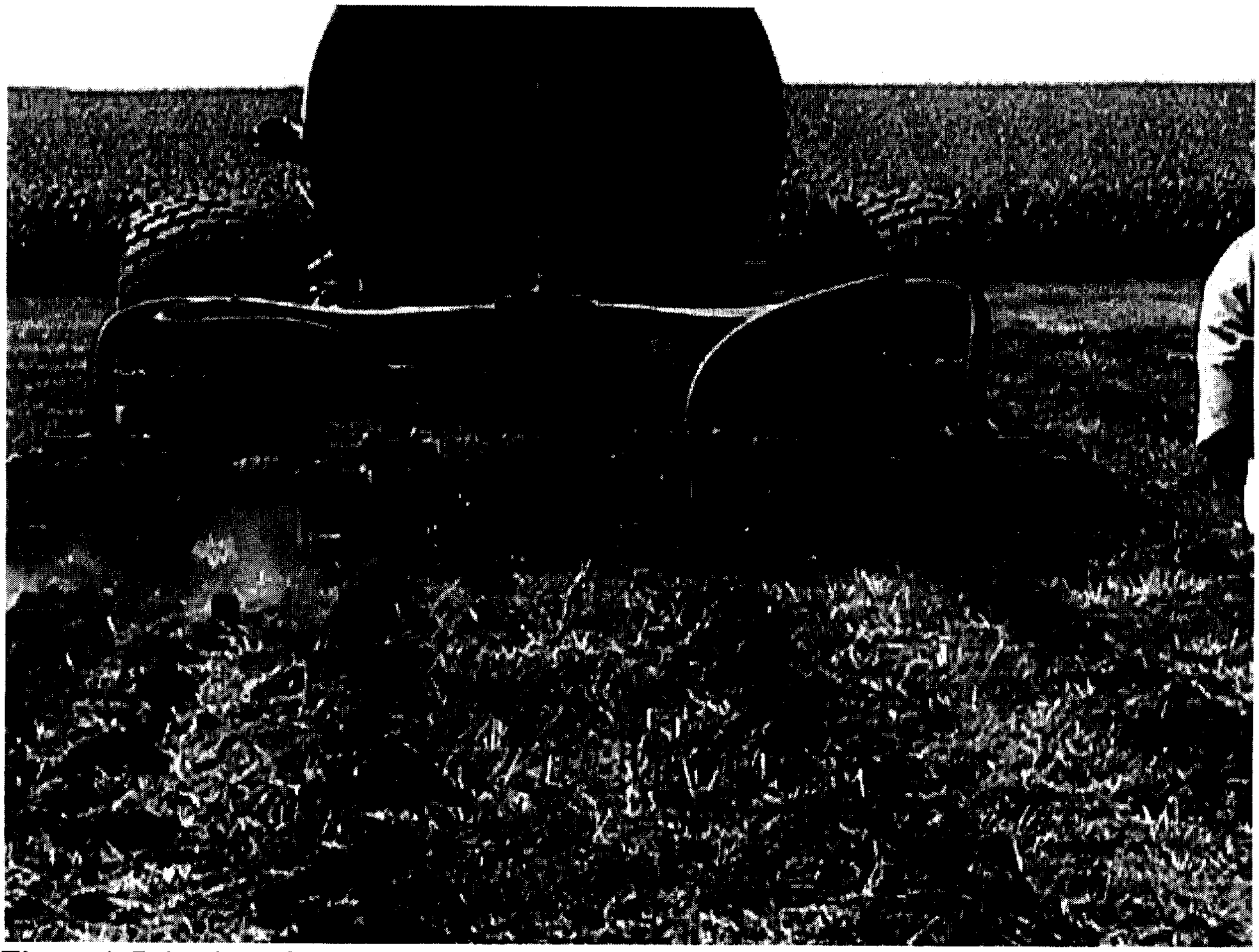

**Figure 1. Injection of liquid manure into the soil.**

Table 1. Odor thresholds for various land application methods.

| Application Method | Odor Detection Threshold[a] |
|---|---|
| Broadcast | 2818 |
| Plow | 200 |
| Harrow | 131 |
| Inject | 32 |
| Unmanured | 50 |

*[a]Ratio of fresh air to odorous air (fresh:odorous) to dilute the odor to where it is just detectable.*

The types of injectors used today include narrow tines, sweeps, disk covers, and conventional chisel plows. Besides their ability to achieve complete manure coverage for odor control, it is also important that these injector methods leave crop residue on the surface to minimize erosion and limit energy (tractor horsepower) requirements. Sweeps require more horsepower than simple tines for a given depth, but the sweeps more than compensate for this by operating at a shallower depth, permitting complete coverage. The disk covers, when set properly, require the least horsepower while still providing complete coverage, but they may also cover more crop residue. When the manure is placed on top of the soil surface and a conventional chisel plow is used for incorporation, complete coverage cannot be achieved. Thus a high level of odor control may be at the expense of higher energy requirements and the potential for greater erosion. The additional cost of manure incorporation or injection for odor control is offset somewhat by the savings in manure nitrogen. An Iowa study suggests that injecting the manure from a storage system increases costs $0.49 per year per breeding sow and $0.17 per finish hog while injecting the manure from a lagoon system increases costs $1.39 per year per breeding sow and $0.68 per finish hog (Fleming et al. 1998). However, these cost increases did not consider reduced nitrogen losses with the injection system. An Iowa survey of commercial manure applicators showed an average difference of 1/10 of a cent per gallon more for injection versus broadcast (see http://www.ae.iastate.edu/manurdir99.htm).

*Drop hoses*: Another method of application, used in northern European countries, is to simply place liquid manure on the surface through a series of drop hoses much like a sprayer hose or boom (Figure 2).

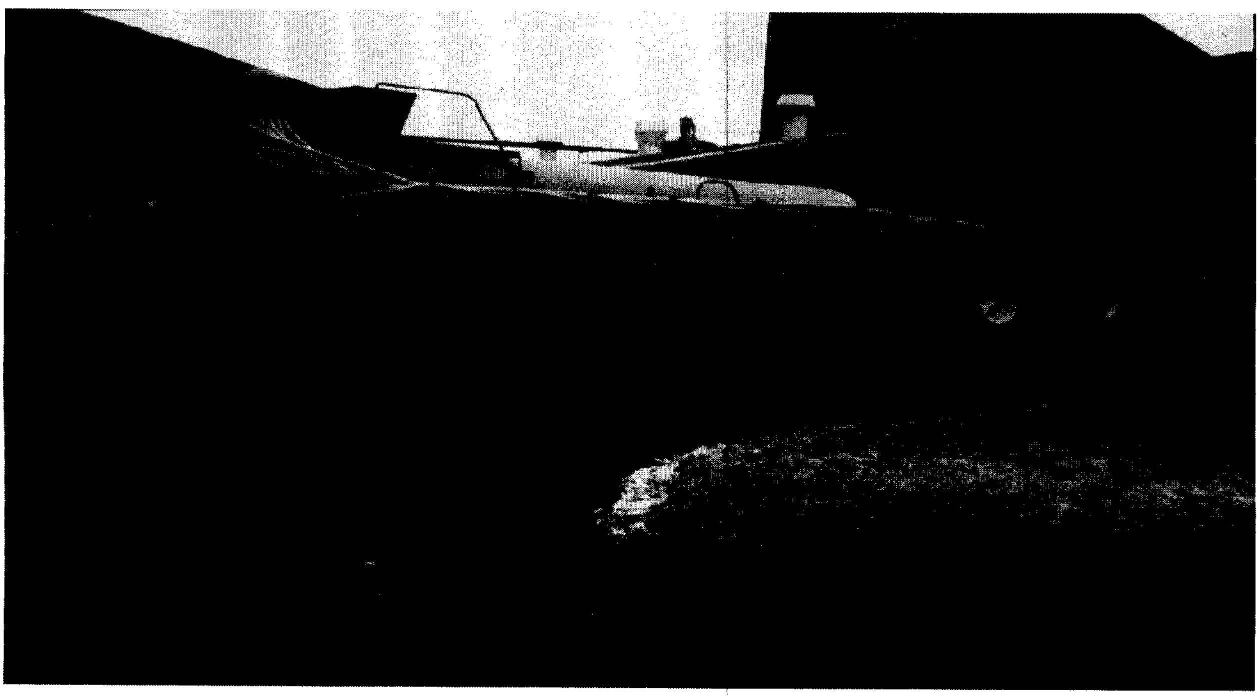

**Figure 2. Drop hose liquid manure applicator.**

This technique has been used to spread manure slurry (liquid manure from under barn pits) on tilled cropland and on growing crops (especially small grains), producing minimum odor and minimum potential runoff and/or erosion. The system has been used with manure tanks but could be adapted to drag hose technology on pastures or some crops such as forages. Adoption of this technology may be limited in the United States because of the prevalence of row crops and the difficulty of matching tanker tire size with rows and wheel spacing.

*Pretreated manure:* Treated liquid manure may be less offensive than raw or untreated manure, although this depends on the degree of treatment. Liquid manure can be treated either aerobically or anaerobically (anaerobic digestion) to significantly reduce odors. Research indicates odor reductions of 80% or more during anaerobic treatment of manure (Pain et al.1990). In such cases, manure can be surface applied or even irrigated with very little odor emissions. The same can be said for solid manure that is applied frequently (hauled daily), dried, or composted since it will generate less odor during land application.

*Surface application by irrigation:* Applying liquid manure with irrigation (both surface and spray) systems (Figure 3) remains a popular and efficient method to distribute manure nutrients onto crop land in some sections of the United States. As mentioned previously, it can produce considerable odors if not managed properly and/or the liquid manure is untreated or has a high nutrient content. Characteristics of irrigation systems that reduce odor include use of nozzles and pressures that produce large droplet sizes, installing drop nozzles on center pivot systems, and the addition of dilution water to the liquid manure before applying.

Droplet size is of importance because of the much higher surface area per unit volume associated with smaller droplets as well as the potential for greater drift of smaller droplets. In general, larger droplets are better for odor control. Droplet size is determined by a combination of nozzle size and pressure. To overcome their tendency to drift, droplets generally must be greater than 150 microns in size, depending on wind speed. Traveling guns must operate at high pressures, but the nozzle size is large, resulting in primarily large droplets. Center pivot irrigation units have wide latitude for nozzle size and pressure combinations. To minimize droplet drift and odor emissions from irrigation and other broadcast application systems, maximize nozzle size and minimize spray pressures.

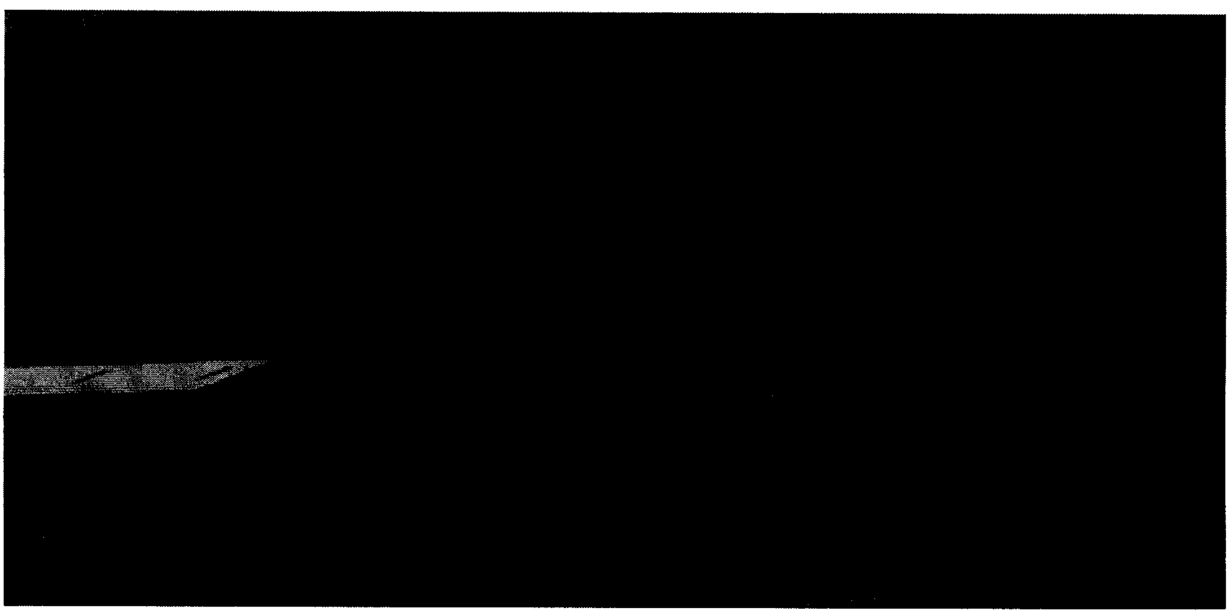

**Figure 3. Spreading liquid manure with a traveling gun irrigation system.**

Equipping center pivot irrigation systems with drop lines and downward spraying nozzles will reduce odors as well as reduce water evaporation. Drop lines can extend from 8 feet down to only 2 or 3 feet from the ground with appropriate nozzles and nozzle spacings to give good water distribution.

Fresh water dilution can also be used to reduce manure odors and nitrogen loss during irrigation applications. A Midwestern state (Iowa) requires a 15:1 dilution with fresh water if untreated slurry is to be irrigated. Burton (1997) reported that 3:1 fresh water additions to manure slurry reduced ammonia losses from 20% to 90%. Lagoon liquid is often mixed into irrigation water in states that commonly use irrigation for crop production. The lagoon effluent is then spread in a very dilute and greatly odor reduced manner.

*Treating manure in pits*: One other factor that contributes to odor and gas emission during manure application is the agitation or mixing of the manure before pumping (Figure 4). This mixing is necessary to remove the solids that have built up in the bottom of the storage and to distribute the nutrients evenly throughout the manure. Odor and gas emissions during agitation and pumping are difficult to control. The best method for reducing the impact of these odor emissions is to agitate during times when the outside air is heating (sunny clear mornings), causing the odorous air to rise and disperse.

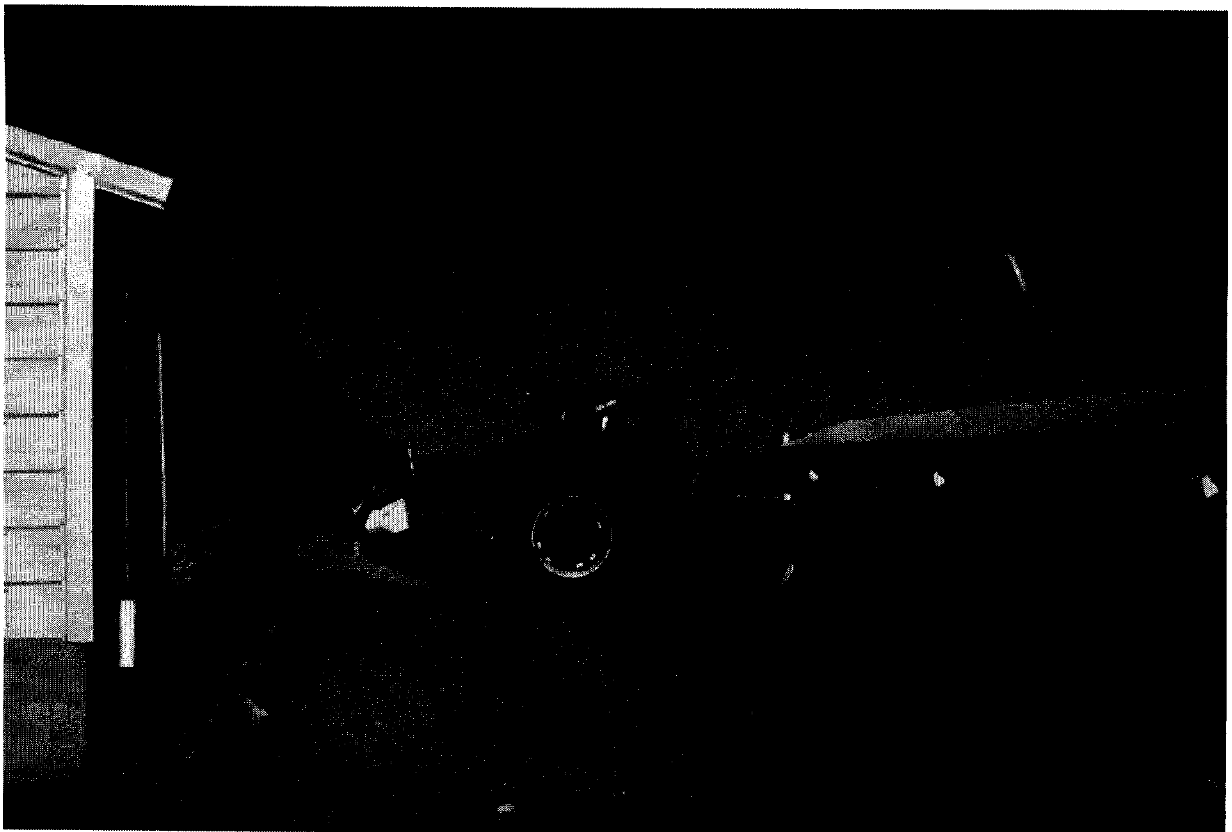

**Figure 4. Agitation and pumping equipment for a deep pit manure storage under a pig-finishing barn.**

Other techniques to reduce these emissions, such as the addition of chemical additives to the manure, are also being evaluated. Research has shown reductions in hydrogen sulfide emissions of over 90% with additions of calcium hydroxide, ferric chloride, ferrous chloride, ferrous sulfate, hydrogen peroxide, potassium permanganate, or sodium chlorite (Clanton et al. 1999). Although these reductions in emissions do not guarantee reductions in odor emissions, odor reductions are likely.

**Solid Manure Odor Control Techniques**

Technologies that reduce the odors released during land application of solid manure parallel those of liquid manure, namely, treating solid manure before it is spread and incorporating surface-applied solid manure into the soil as soon as possible after it is applied.

*Incorporation:* Solid manure is not injected, because unlike liquid manure, it will not flow through the pipes and tubes common to injectors. It therefore requires another pass with a disk or other tillage equipment before being incorporated into the soil. The simple recommendation is to use a tandem disk or field cultivator as soon as possible after the solid manure is spread. New equipment needs to be designed that will both apply and incorporate solid manure with a single piece of equipment or spread solid manure on grasslands.

The loading or transfer of solid manure from buildings, stacks, or storage areas can produce odor emissions. This can be a problem when solid manure is temporarily stored near cropland and then applied after the crop is removed in the fall or before the crop is planted in the spring. One way of minimizing odors from stacked manure, however, is by covering it with plastic. Using black plastic may also help minimize fly production due to the high temperatures that occur beneath the cover.

*Treatment:* As with liquid manure, treating solid manure (such as composting, Figure 5) can reduce odors. Some chemical treatments can reduce gas emissions. For example, alum has been shown to significantly reduce ammonia volatilization from poultry litter (Moore et al. 1995).

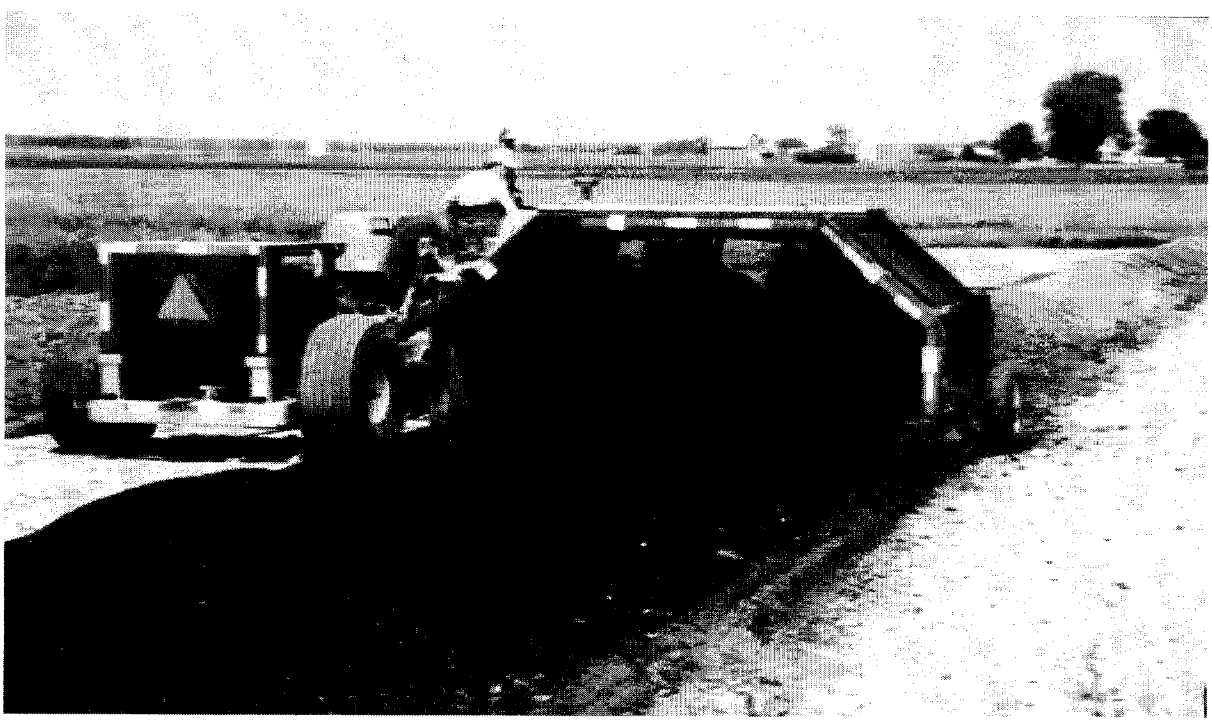

**Figure 5. Mechanical turner used in composting solid manure**

*Time and location constraints:* When applying manure, always consider wind direction especially if you are broadcasting. Select days when the wind is blowing away from neighbors and dwellings. If feasible, spread manure on weekdays when neighbors are likely to be away from their home; avoid weekends, especially Sundays and holidays. Before spreading manure, check with neighbors to be sure that they do not have a social event planned for the same day that you are planning to spread. If they do, change your plans. Finally, one of the most effective practices is simply to tell your neighbors or those who may be affected that you plan to apply manure to your farmland. Typically, people will object less if they know ahead of time and feel that they have some control or at least some input into what is happening around them.

*Summary:* Manure application can cause significant odor emissions. Several methods of reducing odor from both liquid and solid manure land applications include incorporating the manure into the soil either during or shortly after it is spread, placing manure on the surface but beneath the crop canopy, or treating the manure before it is spread on land. The agitation and/or loading of manure from long or short-term storage facilities will also create odors that need to be managed to avoid complaints during the application process.

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**About the Authors**

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Effective August 9, 2001

# RULES
# OF
# GEORGIA DEPARTMENT OF AGRICULTURE
# ANIMAL INDUSTRY DIVISION

## CHAPTER 40-16-6
## NUTRIENT MANAGEMENT PLAN SPECIALIST CERTIFICATION

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**40-16-6-.01 Definitions.**

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Authority O.C.G.A. Section 12-5-20, as amended; DNR Rule 391-3-6-.20 and 391-3-6-.21.

Effective June 25, 2001

# RULES
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## CHAPTER 40-16-5
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# Dead Animal Disposal Rule

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# ANIMAL INDUSTRY DIVISION

## CHAPTER 40-13-5
## DEAD ANIMAL DISPOSAL

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**40-13-5-.01 Definitions.**

(1) Dead animals means the carcasses, parts of carcasses, fetuses, embryos, effluent, or blood of the following:

(a) Livestock, including, without limitations, cattle, swine, sheep, goats, poultry, ratites, equine, and alternative livestock,

(b) Animals associated with animal shelters, pet dealers, kennels, stables, and bird dealers licensed by the Department,

(c) Animals processed by commercial facilities which process animals for human consumption, and

(d) Animals associated with wildlife exhibitions.
*Authority O.C.G.A. 4-5-2*

**40-13-5-.02 Disposition of Dead Animals.**

(1) No person shall abandon on any property any animals which have died or have been killed.

(2) No person shall dispose of any dead animals on another person's property without having the land owner's permission.

(3) No person shall dispose of any dead animal in a city, county or duly licensed landfill without permission of the landfill manager.

(4) Under no conditions shall dead animals be abandoned in wells, open pits, or surface waters of any kind either on private or public land.
*Authority O.C.G.A. Sec 4-5-3*

**40-13-5-.03 Facilities Requiring Written Approval or Certificate by the Department.**

(1) Livestock sales markets, livestock slaughter establishments, concentrated animal feeding operations, and Georgia Department of Agriculture licensed animals shelters, kennels, pet dealers, stables, and bird dealers shall have a written and approved method and place for disposal of dead animals and all accessory waste material involved in handling dead animals which die on or within the premises of each licensed establishment. A Certificate of Compliance may be issued from the Department.

(2) Poultry growers, poultry dealers or brokers, and poultry sales establishments may be issued a Certificate of Compliance from the Department when the methods and places of dead animal disposal are approved.

(3) Any person found to be in violation of dead animal disposal rules may be required to have written approval from the State Veterinarian for future dead animal disposal.

(4) The Commissioner shall approve the methods and places for disposal of dead animals.
*Authority O.C.G.A. Secs. 4-4-82 and 4-5-7*

**40-13-5-.04 Methods of Disposal of Dead Animals.**

Methods which may be used for the disposal of dead animals are burning to ash, incineration, burial, rendering, or any method using appropriate disposal technology which has been approved by the Commissioner, provided disposal of dead animals is carried out within 24 hours after death or discovery of the dead animal.

(1) Burial. Dead animals that are buried must be located more than 100 horizontal feet away from any existing or proposed wells and water supply lines, 15 horizontal feet away from the edge of any embankment, and 100 horizontal feet away from the seasonal high water level of any pond, lake, tributary, stream, or other body of water including wetlands. Burial sites must be in soil with moderate or slow permeability and must be at least one foot above the seasonal high groundwater elevation. Burial sites must not be located in areas with gullies, ravines, dry stream beds, natural and/or man made drainage ways,

sink holes, and/or other similar conditions, including the 100-year flood plain as determined by the United States Army Corps of Engineers.

(a) Dead animals that are buried must be at least three feet below the ground level but no more than eight feet and have not less than three feet of earth over the carcass.

(b) Dead animals may be disposed in pits which are designed, constructed, maintained and used in a manner to prevent the spread of diseases. Pits must also meet the following requirements:

1. Georgia Department of Agriculture personnel must approve the site prior to pit construction. Soils must be evaluated for suitability prior to pit construction by a certified Georgia Department of Agriculture employee or a certified soil classifier.

2. The bottom of the pit must be a soil with moderate or slow permeability or other material approved by the Georgia Department of Agriculture that prevents leaching.

3. Pits must have adequate support along the sides to prevent cave-ins and must not exceed four feet in width. For top-soils having 18 inches or more of sand, pit walls must be adequately supported and maintained by concrete, treated lumber, corrosive-resistant metal or other material approved by the Georgia Department of Agriculture.

4. Pits must not be located where the ground slope exceeds a moderate grade.

5. The pit cover must be of solid construction and must allow surface water to drain away from the pit and water supplies. The pit must be sealed to prevent the entry of rodents, insects, and the exit of odors.

6. Pits will be considered closed when covered with more than three feet of loamy or clayey textured soil with a slight dome (at least six inches higher in the middle than at the edge).

7. Any pit that deviates from the above criteria must have the approval of the State Veterinarian prior to the issuance of a permit and use.

(2) Landfill. Dead animals may be disposed in landfills approved to dispose of animal carcasses by the Georgia Department of Natural Resources Environmental Protection Division. Dead animals must be covered by three feet of dirt at the landfill on the same day as delivery.

(3) Composting. Composters and their use must be consistent with the U. S. Department of Agriculture Natural Resources Conservation Service technical guidance standards. Temperatures must be monitored using a compost thermometer at least every other day, with daily checks being preferred. Composters must reach a temperature between 130 and 160 degrees F in order to properly decompose carcasses and neutralize pathogens.

(4) Incineration. Incinerators and their use must meet all requirements of the U. S. Environmental Protection Agency and Georgia Department of Natural Resources Environmental Protection Division. The entire carcass must be reduced to ashes.

(5) Burning. Burning dead animals must comply with federal, state, and local requirements. The entire carcass must be reduced to ashes.

(6) Rendering. Carcasses disposed by rendering must be delivered to the rendering facility within twenty-four (24) hours of death unless carcasses are refrigerated or frozen.

(7) Other dead animal disposal methods must be approved by the State Veterinarian on a case by case basis.
*Authority O.C.G.A. Sec. 4-5-5*

**40-13-5-.05 Transportation of Dead Animals.**

(1) The Commissioner of Agriculture may prohibit or restrict the hauling or transportation of the body, effluent and/or parts of any dead animals.

(2) Dead animals must be transported in covered and leak-proof containers.

(3) The Commissioner of Agriculture may determine the route for transportation of dead animals so as to prevent the spread of infectious or contagious diseases.

(4) Persons engaged in the commercial transportation of dead animals must have a written permit issued by the Georgia Department of Agriculture.
*Authority O.C.G.A. Sec. 4-5-9*

**40-13-5-.06 Interstate Transportation of Dead Animals.**

(1) Dead animals, except for green salted hides, are not allowed to enter Georgia except by written permit issued by the Georgia Department of Agriculture.

(2) Written permits are not required for licensed research institutions, accredited or state colleges and Universities, and municipal governments transporting or receiving dead animals for research or investigational purposes only.
*Authority O.C.G.A. Sec 4-5-8*

**40-13-5-.07 Enforcement.**

Any person, firm, partnership or corporation violating the provisions of this act, or any rule or regulations made pursuant thereto, shall be guilty of a misdemeanor and upon conviction thereof shall be punished as provided by law.
*Authority O.C.G. A. Sec 4-5-11*

Effective August 9, 2001

# RULES
# OF
# GEORGIA DEPARTMENT OF AGRICULTURE
# ANIMAL INDUSTRY DIVISION

## CHAPTER 40-16-6
## NUTRIENT MANAGEMENT PLAN SPECIALIST CERTIFICATION

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**40-16-6-.01 Definitions.**

(1) A Certified Nutrient Management Plan (NMP) Specialist is an individual certified by the Georgia Department of Agriculture to develop and modify NMPs for animal feeding operations in accordance with the Georgia Environmental Protection Division Rules for Water Quality Control, Chapter 391-3-6.

(2) A Certified Conservation Planner is an individual identified by USDA NRCS as being trained according to criteria set forth in section 40-16-6-.03 (2) and competent to develop NMPs.

**40-16-6-.02 Application for Nutrient Management Plan Specialist Certification.** Application for NMP Specialist Certification shall be made to the Georgia Department of Agriculture (hereafter in this Chapter referred to as "Department") on a form approved by the Department.

**40-16-6-.03 Nutrient Management Plan Training**

(1) An individual may apply to the Department for certification provided one of the following training criteria has been met:

(a) Complete a minimum of two days of NMP training and testing approved by the Department and demonstrate competency by developing an acceptable plan, or

(b) Be a current employee of the USDA, Natural Resources Conservation Service (NRCS) or currently receiving technical supervision from an NRCS employee and be identified by such agency as being a "Certified Conservation Planner, " or

(c) Be certified as a Certified Conservation Planner through a NRCS recognized program and curriculum by private organization and professional groups.

(2) Training programs must include, but are not limited to the following: (a) state water quality laws and rules, (b) manure and wastewater handling and storage, (c) land application of manure and waste water, (d) site management, (e) best management

practices, (f) record keeping, (g) mortality management, (h) emergency response, (i) and closure plans for waste storage systems.

**40-16-6-.04 Nutrient Management Plan Certification**

(1) A NMP Specialist shall be considered certified when the applicant demonstrates competency in all of the above listed areas of training. The Department shall issue a certificate to the NMP Specialist upon the successful completion of training and certification.

(2) A NMP Specialist must receive a minimum of 4 hours continuing education every two years from the date of the original certification. The NMP Specialist should assure that education subject matter is pertinent to nutrient management planning and should maintain documenting records. The Department may request the NMP Specialist to provide proof of such continuing education.

(a) Failure of a NMP Specialist to receive continuing education will result in suspension of certification and may require recertification.

(b) Each Certified Nutrient Management Plan Specialist certification may be reviewed at least once every three years by the Department. The Department will review NMPs prepared by the specialist. If an individual fails to meet the criteria for the NMP Specialist, the status will be revoked and the individual must be recertified.

(3) The Department has final authority over training, certification and continuing education.

(4) The Department shall provide the Georgia Department of Natural Resources Environmental Protection Division with a current list of Certified Nutrient Management Plan Specialists upon request.

Authority O.C.G.A. Section 12-5-20, as amended; DNR Rule 391-3-6-.20 and 391-3-6-.21.

Effective June 25, 2001

# RULES
# OF
# GEORGIA DEPARTMENT OF AGRICULTURE
# ANIMAL INDUSTRY DIVISION

## CHAPTER 40-16-5
## ANIMAL FEEDING OPERATOR TRAINING AND CERTIFICATION

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### 40-16-5-.01 Definitions.

(1) A Swine Feeding Operator means a person who is designated as such by the owner of a swine feeding operation which is permitted by the Georgia Department of Natural Resources Environmental Protection Division.

(2) An Animal (Non-Swine) Feeding Operator means a person who is designated as such by the owner of a non-swine (i.e dairy, layer) feeding operation which handles liquid manure and is permitted by the Georgia Department of Natural Resources Environmental Protection Division.

(3) Animal Feeding Operators will include Swine Feeding Operators and Animal (Non-Swine) Feeding Operators as herein defined.

### 40-16-5-.02 Application for Animal Feeding Operator Training and Certification

Application for Animal Feeding Operator Training and Certification shall be made to the Department of Agriculture on a form approved by the Department.

### 40-16-5-.03 Animal Feeding Operator Training

(1) An Animal Feeding Operator shall be considered trained when the applicant successfully completes a minimum of 2 days instruction on the following:

(a) Understanding state regulations and water quality laws,
(b) Comprehensive nutrient management planning,
(c) Best management practices for manure storage, treatment and land application,
(d) Monitoring and record keeping,
(e) Pollution prevention and alternative treatment systems, and
(f) Odor and atmospheric emissions.

(2) Training will be developed and delivered by the Georgia Cooperative Extension Service or other subject matter experts as deemed appropriate by the Department. Training will be structured to address the needs of operators of differing sizes and various waste management technologies. The Department shall approve the use of all training materials and methods.

**40-16-5-.04 Animal Feeding Operator Certification**

(1) An Animal Feeding Operator shall be considered certified when the applicant demonstrates competency in all of the above listed modules including passing a written examination with a minimum score of 70%. Examinations will be structured to address the needs of operators of various production sizes and waste management technologies. The Department will administer and grade the examinations. The Department shall issue a certificate to the operator upon the successful completion of training and certification.

(a) An Animal Feeding Operator who fails to make a minimum score of 70% on the initial examination may retake an exam up to three (3) times within a twelve (12) month period, after which he or she must complete an instructional course approved by the Department before taking another exam.

(2) Animal Feeding Operators must receive a minimum of 4 hours continuing education every two years from the date of the original certification. The Department shall approve all continuing education instruction and materials and will issue certificates of completion indicating the course topic and hours of instruction.

(3) Failure of an Animal Feeding Operator to receive continued education will result in suspension of certification and require recertification.

(4) The Department has final authority over all training, certification, and continuing education.

(5) The Department shall provide the Department of Natural Resources Environmental Protection Division with a current list of Certified Animal Feeding Operators upon request.

Authority O.C.G.A. Section 12-5-20, as amended; DNR Rule 391-3-6-.20 and 391-3-6-.21.

# Dead Animal Disposal Rule

# RULES
# OF
# GEORGIA DEPARTMENT OF AGRICULTURE
# ANIMAL INDUSTRY DIVISION

## CHAPTER 40-13-5
## DEAD ANIMAL DISPOSAL

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### 40-13-5-.01 Definitions.

(1) Dead animals means the carcasses, parts of carcasses, fetuses, embryos, effluent, or blood of the following:

(a) Livestock, including, without limitations, cattle, swine, sheep, goats, poultry, ratites, equine, and alternative livestock,

(b) Animals associated with animal shelters, pet dealers, kennels, stables, and bird dealers licensed by the Department,

(c) Animals processed by commercial facilities which process animals for human consumption, and

(d) Animals associated with wildlife exhibitions.
*Authority O.C.G.A. 4-5-2*

### 40-13-5-.02 Disposition of Dead Animals.

(1) No person shall abandon on any property any animals which have died or have been killed.

(2) No person shall dispose of any dead animals on another person's property without having the land owner's permission.

(3) No person shall dispose of any dead animal in a city, county or duly licensed landfill without permission of the landfill manager.

(4) Under no conditions shall dead animals be abandoned in wells, open pits, or surface waters of any kind either on private or public land.
*Authority O.C.G.A. Sec 4-5-3*

**40-13-5-.03 Facilities Requiring Written Approval or Certificate by the Department.**

(1) Livestock sales markets, livestock slaughter establishments, concentrated animal feeding operations, and Georgia Department of Agriculture licensed animals shelters, kennels, pet dealers, stables, and bird dealers shall have a written and approved method and place for disposal of dead animals and all accessory waste material involved in handling dead animals which die on or within the premises of each licensed establishment. A Certificate of Compliance may be issued from the Department.

(2) Poultry growers, poultry dealers or brokers, and poultry sales establishments may be issued a Certificate of Compliance from the Department when the methods and places of dead animal disposal are approved.

(3) Any person found to be in violation of dead animal disposal rules may be required to have written approval from the State Veterinarian for future dead animal disposal.

(4) The Commissioner shall approve the methods and places for disposal of dead animals.
*Authority O.C.G.A. Secs. 4-4-82 and 4-5-7*

**40-13-5-.04 Methods of Disposal of Dead Animals.**

Methods which may be used for the disposal of dead animals are burning to ash, incineration, burial, rendering, or any method using appropriate disposal technology which has been approved by the Commissioner, provided disposal of dead animals is carried out within 24 hours after death or discovery of the dead animal.

(1) Burial. Dead animals that are buried must be located more than 100 horizontal feet away from any existing or proposed wells and water supply lines, 15 horizontal feet away from the edge of any embankment, and 100 horizontal feet away from the seasonal high water level of any pond, lake, tributary, stream, or other body of water including wetlands. Burial sites must be in soil with moderate or slow permeability and must be at least one foot above the seasonal high groundwater elevation. Burial sites must not be located in areas with gullies, ravines, dry stream beds, natural and/or man made drainage ways,

sink holes, and/or other similar conditions, including the 100-year flood plain as determined by the United States Army Corps of Engineers.

(a) Dead animals that are buried must be at least three feet below the ground level but no more than eight feet and have not less than three feet of earth over the carcass.

(b) Dead animals may be disposed in pits which are designed, constructed, maintained and used in a manner to prevent the spread of diseases. Pits must also meet the following requirements:

1. Georgia Department of Agriculture personnel must approve the site prior to pit construction. Soils must be evaluated for suitability prior to pit construction by a certified Georgia Department of Agriculture employee or a certified soil classifier.

2. The bottom of the pit must be a soil with moderate or slow permeability or other material approved by the Georgia Department of Agriculture that prevents leaching.

3. Pits must have adequate support along the sides to prevent cave-ins and must not exceed four feet in width. For top-soils having 18 inches or more of sand, pit walls must be adequately supported and maintained by concrete, treated lumber, corrosive-resistant metal or other material approved by the Georgia Department of Agriculture.

4. Pits must not be located where the ground slope exceeds a moderate grade.

5. The pit cover must be of solid construction and must allow surface water to drain away from the pit and water supplies. The pit must be sealed to prevent the entry of rodents, insects, and the exit of odors.

6. Pits will be considered closed when covered with more than three feet of loamy or clayey textured soil with a slight dome (at least six inches higher in the middle than at the edge).

7. Any pit that deviates from the above criteria must have the approval of the State Veterinarian prior to the issuance of a permit and use.

(2) Landfill. Dead animals may be disposed in landfills approved to dispose of animal carcasses by the Georgia Department of Natural Resources Environmental Protection Division. Dead animals must be covered by three feet of dirt at the landfill on the same day as delivery.

(3) Composting. Composters and their use must be consistent with the U. S. Department of Agriculture Natural Resources Conservation Service technical guidance standards. Temperatures must be monitored using a compost thermometer at least every other day, with daily checks being preferred. Composters must reach a temperature between 130 and 160 degrees F in order to properly decompose carcasses and neutralize pathogens.

(4) Incineration. Incinerators and their use must meet all requirements of the U. S. Environmental Protection Agency and Georgia Department of Natural Resources Environmental Protection Division. The entire carcass must be reduced to ashes.

(5) Burning. Burning dead animals must comply with federal, state, and local requirements. The entire carcass must be reduced to ashes.

(6) Rendering. Carcasses disposed by rendering must be delivered to the rendering facility within twenty-four (24) hours of death unless carcasses are refrigerated or frozen.

(7) Other dead animal disposal methods must be approved by the State Veterinarian on a case by case basis.
*Authority O.C.G.A. Sec. 4-5-5*

**40-13-5-.05 Transportation of Dead Animals.**

(1) The Commissioner of Agriculture may prohibit or restrict the hauling or transportation of the body, effluent and/or parts of any dead animals.

(2) Dead animals must be transported in covered and leak-proof containers.

(3) The Commissioner of Agriculture may determine the route for transportation of dead animals so as to prevent the spread of infectious or contagious diseases.

(4) Persons engaged in the commercial transportation of dead animals must have a written permit issued by the Georgia Department of Agriculture.
*Authority O.C.G.A. Sec. 4-5-9*

**40-13-5-.06 Interstate Transportation of Dead Animals.**

(1) Dead animals, except for green salted hides, are not allowed to enter Georgia except by written permit issued by the Georgia Department of Agriculture.

(2) Written permits are not required for licensed research institutions, accredited or state colleges and Universities, and municipal governments transporting or receiving dead animals for research or investigational purposes only.
*Authority O.C.G.A. Sec 4-5-8*

**40-13-5-.07 Enforcement.**

Any person, firm, partnership or corporation violating the provisions of this act, or any rule or regulations made pursuant thereto, shall be guilty of a misdemeanor and upon conviction thereof shall be punished as provided by law.
*Authority O.C.G. A. Sec 4-5-11*

Effective August 9, 2001

# RULES
# OF
# GEORGIA DEPARTMENT OF AGRICULTURE
# ANIMAL INDUSTRY DIVISION

## CHAPTER 40-16-6
## NUTRIENT MANAGEMENT PLAN SPECIALIST CERTIFICATION

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**40-16-6-.01 Definitions.**

(1) A Certified Nutrient Management Plan (NMP) Specialist is an individual certified by the Georgia Department of Agriculture to develop and modify NMPs for animal feeding operations in accordance with the Georgia Environmental Protection Division Rules for Water Quality Control, Chapter 391-3-6.

(2) A Certified Conservation Planner is an individual identified by USDA NRCS as being trained according to criteria set forth in section 40-16-6-.03 (2) and competent to develop NMPs.

**40-16-6-.02 Application for Nutrient Management Plan Specialist Certification.** Application for NMP Specialist Certification shall be made to the Georgia Department of Agriculture (hereafter in this Chapter referred to as "Department") on a form approved by the Department.

**40-16-6-.03 Nutrient Management Plan Training**

(1) An individual may apply to the Department for certification provided one of the following training criteria has been met:

(a) Complete a minimum of two days of NMP training and testing approved by the Department and demonstrate competency by developing an acceptable plan, or

(b) Be a current employee of the USDA, Natural Resources Conservation Service (NRCS) or currently receiving technical supervision from an NRCS employee and be identified by such agency as being a "Certified Conservation Planner, " or

(c) Be certified as a Certified Conservation Planner through a NRCS recognized program and curriculum by private organization and professional groups.

(2) Training programs must include, but are not limited to the following: (a) state water quality laws and rules, (b) manure and wastewater handling and storage, (c) land application of manure and waste water, (d) site management, (e) best management

practices, (f) record keeping, (g) mortality management, (h) emergency response, (i) and closure plans for waste storage systems.

**40-16-6-.04 Nutrient Management Plan Certification**

(1) A NMP Specialist shall be considered certified when the applicant demonstrates competency in all of the above listed areas of training. The Department shall issue a certificate to the NMP Specialist upon the successful completion of training and certification.

(2) A NMP Specialist must receive a minimum of 4 hours continuing education every two years from the date of the original certification. The NMP Specialist should assure that education subject matter is pertinent to nutrient management planning and should maintain documenting records. The Department may request the NMP Specialist to provide proof of such continuing education.

(a) Failure of a NMP Specialist to receive continuing education will result in suspension of certification and may require recertification.

(b) Each Certified Nutrient Management Plan Specialist certification may be reviewed at least once every three years by the Department. The Department will review NMPs prepared by the specialist. If an individual fails to meet the criteria for the NMP Specialist, the status will be revoked and the individual must be recertified.

(3) The Department has final authority over training, certification and continuing education.

(4) The Department shall provide the Georgia Department of Natural Resources Environmental Protection Division with a current list of Certified Nutrient Management Plan Specialists upon request.

Authority O.C.G.A. Section 12-5-20, as amended; DNR Rule 391-3-6-.20 and 391-3-6-.21.

Effective June 25, 2001

# RULES
# OF
# GEORGIA DEPARTMENT OF AGRICULTURE
# ANIMAL INDUSTRY DIVISION

## CHAPTER 40-16-5
## ANIMAL FEEDING OPERATOR TRAINING AND CERTIFICATION

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### 40-16-5-.01 Definitions.

(1) A Swine Feeding Operator means a person who is designated as such by the owner of a swine feeding operation which is permitted by the Georgia Department of Natural Resources Environmental Protection Division.

(2) An Animal (Non-Swine) Feeding Operator means a person who is designated as such by the owner of a non-swine (i.e dairy, layer) feeding operation which handles liquid manure and is permitted by the Georgia Department of Natural Resources Environmental Protection Division.

(3) Animal Feeding Operators will include Swine Feeding Operators and Animal (Non-Swine) Feeding Operators as herein defined.

### 40-16-5-.02 Application for Animal Feeding Operator Training and Certification

Application for Animal Feeding Operator Training and Certification shall be made to the Department of Agriculture on a form approved by the Department.

### 40-16-5-.03 Animal Feeding Operator Training

(1) An Animal Feeding Operator shall be considered trained when the applicant successfully completes a minimum of 2 days instruction on the following:

(a) Understanding state regulations and water quality laws,
(b) Comprehensive nutrient management planning,
(c) Best management practices for manure storage, treatment and land application,
(d) Monitoring and record keeping,
(e) Pollution prevention and alternative treatment systems, and
(f) Odor and atmospheric emissions.

(2) Training will be developed and delivered by the Georgia Cooperative Extension Service or other subject matter experts as deemed appropriate by the Department. Training will be structured to address the needs of operators of differing sizes and various waste management technologies. The Department shall approve the use of all training materials and methods.

**40-16-5-.04 Animal Feeding Operator Certification**

(1) An Animal Feeding Operator shall be considered certified when the applicant demonstrates competency in all of the above listed modules including passing a written examination with a minimum score of 70%. Examinations will be structured to address the needs of operators of various production sizes and waste management technologies. The Department will administer and grade the examinations. The Department shall issue a certificate to the operator upon the successful completion of training and certification.

(a) An Animal Feeding Operator who fails to make a minimum score of 70% on the initial examination may retake an exam up to three (3) times within a twelve (12) month period, after which he or she must complete an instructional course approved by the Department before taking another exam.

(2) Animal Feeding Operators must receive a minimum of 4 hours continuing education every two years from the date of the original certification. The Department shall approve all continuing education instruction and materials and will issue certificates of completion indicating the course topic and hours of instruction.

(3) Failure of an Animal Feeding Operator to receive continued education will result in suspension of certification and require recertification.

(4) The Department has final authority over all training, certification, and continuing education.

(5) The Department shall provide the Department of Natural Resources Environmental Protection Division with a current list of Certified Animal Feeding Operators upon request.

Authority O.C.G.A. Section 12-5-20, as amended; DNR Rule 391-3-6-.20 and 391-3-6-.21.

# Dead Animal Disposal Rule

# RULES
# OF
# GEORGIA DEPARTMENT OF AGRICULTURE
# ANIMAL INDUSTRY DIVISION

## CHAPTER 40-13-5
## DEAD ANIMAL DISPOSAL

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### 40-13-5-.01 Definitions.

(1) Dead animals means the carcasses, parts of carcasses, fetuses, embryos, effluent, or blood of the following:

(a) Livestock, including, without limitations, cattle, swine, sheep, goats, poultry, ratites, equine, and alternative livestock,

(b) Animals associated with animal shelters, pet dealers, kennels, stables, and bird dealers licensed by the Department,

(c) Animals processed by commercial facilities which process animals for human consumption, and

(d) Animals associated with wildlife exhibitions.
*Authority O.C.G.A. 4-5-2*

### 40-13-5-.02 Disposition of Dead Animals.

(1) No person shall abandon on any property any animals which have died or have been killed.

(2) No person shall dispose of any dead animals on another person's property without having the land owner's permission.

(3) No person shall dispose of any dead animal in a city, county or duly licensed landfill without permission of the landfill manager.

(4) Under no conditions shall dead animals be abandoned in wells, open pits, or surface waters of any kind either on private or public land.
*Authority O.C.G.A. Sec 4-5-3*

**40-13-5-.03 Facilities Requiring Written Approval or Certificate by the Department.**

(1) Livestock sales markets, livestock slaughter establishments, concentrated animal feeding operations, and Georgia Department of Agriculture licensed animals shelters, kennels, pet dealers, stables, and bird dealers shall have a written and approved method and place for disposal of dead animals and all accessory waste material involved in handling dead animals which die on or within the premises of each licensed establishment. A Certificate of Compliance may be issued from the Department.

(2) Poultry growers, poultry dealers or brokers, and poultry sales establishments may be issued a Certificate of Compliance from the Department when the methods and places of dead animal disposal are approved.

(3) Any person found to be in violation of dead animal disposal rules may be required to have written approval from the State Veterinarian for future dead animal disposal.

(4) The Commissioner shall approve the methods and places for disposal of dead animals.
*Authority O.C.G.A. Secs. 4-4-82 and 4-5-7*

**40-13-5-.04 Methods of Disposal of Dead Animals.**

Methods which may be used for the disposal of dead animals are burning to ash, incineration, burial, rendering, or any method using appropriate disposal technology which has been approved by the Commissioner, provided disposal of dead animals is carried out within 24 hours after death or discovery of the dead animal.

(1) Burial. Dead animals that are buried must be located more than 100 horizontal feet away from any existing or proposed wells and water supply lines, 15 horizontal feet away from the edge of any embankment, and 100 horizontal feet away from the seasonal high water level of any pond, lake, tributary, stream, or other body of water including wetlands. Burial sites must be in soil with moderate or slow permeability and must be at least one foot above the seasonal high groundwater elevation. Burial sites must not be located in areas with gullies, ravines, dry stream beds, natural and/or man made drainage ways,

sink holes, and/or other similar conditions, including the 100-year flood plain as determined by the United States Army Corps of Engineers.

(a) Dead animals that are buried must be at least three feet below the ground level but no more than eight feet and have not less than three feet of earth over the carcass.

(b) Dead animals may be disposed in pits which are designed, constructed, maintained and used in a manner to prevent the spread of diseases. Pits must also meet the following requirements:

1. Georgia Department of Agriculture personnel must approve the site prior to pit construction. Soils must be evaluated for suitability prior to pit construction by a certified Georgia Department of Agriculture employee or a certified soil classifier.

2. The bottom of the pit must be a soil with moderate or slow permeability or other material approved by the Georgia Department of Agriculture that prevents leaching.

3. Pits must have adequate support along the sides to prevent cave-ins and must not exceed four feet in width. For top-soils having 18 inches or more of sand, pit walls must be adequately supported and maintained by concrete, treated lumber, corrosive-resistant metal or other material approved by the Georgia Department of Agriculture.

4. Pits must not be located where the ground slope exceeds a moderate grade.

5. The pit cover must be of solid construction and must allow surface water to drain away from the pit and water supplies. The pit must be sealed to prevent the entry of rodents, insects, and the exit of odors.

6. Pits will be considered closed when covered with more than three feet of loamy or clayey textured soil with a slight dome (at least six inches higher in the middle than at the edge).

7. Any pit that deviates from the above criteria must have the approval of the State Veterinarian prior to the issuance of a permit and use.

(2) Landfill. Dead animals may be disposed in landfills approved to dispose of animal carcasses by the Georgia Department of Natural Resources Environmental Protection Division. Dead animals must be covered by three feet of dirt at the landfill on the same day as delivery.

(3) Composting. Composters and their use must be consistent with the U. S. Department of Agriculture Natural Resources Conservation Service technical guidance standards. Temperatures must be monitored using a compost thermometer at least every other day, with daily checks being preferred. Composters must reach a temperature between 130 and 160 degrees F in order to properly decompose carcasses and neutralize pathogens.

(4) Incineration. Incinerators and their use must meet all requirements of the U. S. Environmental Protection Agency and Georgia Department of Natural Resources Environmental Protection Division. The entire carcass must be reduced to ashes.

(5) Burning. Burning dead animals must comply with federal, state, and local requirements. The entire carcass must be reduced to ashes.

(6) Rendering. Carcasses disposed by rendering must be delivered to the rendering facility within twenty-four (24) hours of death unless carcasses are refrigerated or frozen.

(7) Other dead animal disposal methods must be approved by the State Veterinarian on a case by case basis.
*Authority O.C.G.A. Sec. 4-5-5*

**40-13-5-.05 Transportation of Dead Animals.**

(1) The Commissioner of Agriculture may prohibit or restrict the hauling or transportation of the body, effluent and/or parts of any dead animals.

(2) Dead animals must be transported in covered and leak-proof containers.

(3) The Commissioner of Agriculture may determine the route for transportation of dead animals so as to prevent the spread of infectious or contagious diseases.

(4) Persons engaged in the commercial transportation of dead animals must have a written permit issued by the Georgia Department of Agriculture.
*Authority O.C.G.A. Sec. 4-5-9*

**40-13-5-.06 Interstate Transportation of Dead Animals.**

(1) Dead animals, except for green salted hides, are not allowed to enter Georgia except by written permit issued by the Georgia Department of Agriculture.

(2) Written permits are not required for licensed research institutions, accredited or state colleges and Universities, and municipal governments transporting or receiving dead animals for research or investigational purposes only.
*Authority O.C.G.A. Sec 4-5-8*

**40-13-5-.07 Enforcement.**

Any person, firm, partnership or corporation violating the provisions of this act, or any rule or regulations made pursuant thereto, shall be guilty of a misdemeanor and upon conviction thereof shall be punished as provided by law.
*Authority O.C.G. A. Sec 4-5-11*

# Animal Feeding Operation Rule

For operation greater than 300 animal units

Other than swine greater than 3000 animal units

**391-3-6-.21 Animal Feeding Operation Permit Requirements.* Amended.**

(1) **Purpose.**

The purpose of this paragraph 391-3-6-.21 is to provide for the uniform procedures and practices to be followed relating to the application for and the issuance or revocation of permits for animal feeding operations with more than 300 Animal Units (AU). This paragraph only includes swine feeding operations with more than 300 AU but equal to or less than 3000 AU. The requirements for swine feeding operations with more than 3000 AU are at paragraph 391-3-6-.20. Nothing in this paragraph shall be construed to preclude the modification of any requirement of this paragraph when the Division determines that the requirement is not protective of the environment.

(2) **Definitions.**

All terms used in this paragraph shall be interpreted in accordance with the definitions as set forth in the Act unless otherwise defined in this paragraph or in any other paragraph of these Rules:

(a) "Act" means the Georgia Water Quality Control Act, as amended.

(b) "Animal feeding operation," "operation," or "AFO" means a lot or facility (other than an aquatic animal production facility or swine feeding operation with more than 3000 AU) where animals have been, are, or will be stabled or confined and fed or maintained for a total of at least 45 days in any 12-month period, and the confinement areas do not sustain crops, vegetation, forage growth, or post-harvest residues in the normal growing season.

(c) "Animal Unit" (AU) is a unit of measurement for any AFO calculated by adding the following numbers: the number of slaughter and feeder cattle multiplied by 1.0, plus the number of mature dairy cattle multiplied by 1.4, plus the number of swine weighing over 25 kilograms (approximately 55 pounds) multiplied by 0.4, plus the number of sheep multiplied by 0.1, plus the number of horses multiplied by 2.0.

(d) "Barn" means a structure where confinement feeding (feeding in limited quarters under a roof) occurs. Structures where confinement feeding does not occur are not considered "barns" for the purposes of this rule.

(e) "Certified operator" means any person who has been trained and certified by the Georgia Department of Agriculture and has direct general charge of the day-to-day field operation of an AFO waste storage and disposal system, and who is responsible for the quality of the treated waste.

(f) "Closure plan" means the plan approved by the Division for clean up and closure of the AFO and associated waste storage and disposal facilities.

(g) "Concentrated Animal Feeding Operation," or "CAFO," means an AFO which is defined as a Large CAFO or Medium CAFO by 40 CFR 122.23 (4) and (6), or that is designated as a CAFO.

(h) "Existing" applies to that which existed prior to September 15, 2003. "Existing operation" means an AFO that was in operation prior to September 15, 2003.

(i) "Freeboard" is the extra depth added to a waste storage lagoon or structure as a safety factor between the designed full depth and the overflow depth. This is the vertical distance below the lowest point of the lagoon or structure berm above which the liquid level must never rise except in the case of a storm event exceeding the design maximum precipitation event.

(j) "Natural Resources Conservation Service" (NRCS) is an agency within the United States Department of Agriculture.

(k) "New" applies to that which existed on or after September 15, 2003. "New or expanding operation" or "new AFO" means an AFO the construction or expansion of which is commenced on or after September 15, 2003.

(l) "NRCS guidance" means the latest editions of the Natural Resources Conservation Service (NRCS) Agricultural Waste Management Field Handbook, Part 651, FOTG Section IV Georgia, and other applicable publications of the NRCS. A certified specialist or trained person may use NRCS guidance to develop or modify an NMP.

(m) "Nutrient Management Plan" (NMP) is a plan which identifies actions or priorities that will be followed to meet clearly defined nutrient management goals at an agricultural operation. Defining nutrient management goals and identifying measures and schedules for attaining the goals are critical to reducing threats to water quality and public health. The NMP should address activities related to compliance with effluent limitations and other permit requirements, including manure handling and storage, land application of manure and wastewater, site management, record keeping, and management of other utilization options. For an AFO with a liquid manure handling system, the NMP must be developed or modified by a "certified specialist" as defined by the Division. The Division will specify the requirements for certification. For an AFO that handles dry manure, the NMP must be developed by a person trained in the subject by an academic or trade organization. It should include emergency response planning and a closure plan for abandonment of any facility used for the treatment or storage of animal waste. The requirements for submittal and approval of the NMP are specified in the following paragraphs.

(n) "Owner" means any person owning any system for waste treatment and disposal at an AFO.

(o) "Permit" means a permit applied for and issued in accordance with the terms and conditions for paragraphs 391-3-6-.06, Waste Treatment and Permit Requirements (individual NPDES permits), or 391-3-6-.11, Land Disposal and Permit Requirements (non-NPDES individual land application system or "LAS" permit), or 391-3-6-.15, Non-Storm Water General Permit Requirements (general NPDES permit), or 391-3-6-.19, General Permit - Land Application System Requirements (non-NPDES general LAS permit), of this Chapter.

(p) "Wetted area" or "disposal area" is the land area where AFO waste is sprayed, spread, incorporated, or injected so that the waste can either condition the soil or fertilize crops or vegetation grown in the soil.

(q) "25-year, 24-hour storm event" is the maximum 24-hour precipitation event expressed in inches with a probable recurrence interval of once in 25 years, as defined by the National Weather Service of the United States Department of Commerce in Technical Paper Number 40, "Rainfall Frequency Atlas of the United States," May 1961, and subsequent amendments.

(r) "100-year flood plain" is the land inundated from a flood whose peak magnitude would be experienced on an average of once every 100 years. The 100-year flood has a 1% probability of occurring in one given year.

(s) "300 AU" means three hundred animal units. Paragraph 391-3-6-.21(2) (c) notwithstanding, the numbers of animals in any of the following categories are equivalent to 300 AU:

1. 200 mature dairy cows, whether milked or dry,
2. 300 veal calves,
3. 750 swine each weighing 55 pounds or more.
4. 300 cattle other than mature dairy cows or veal calves. Cattle includes but is not limited to heifers, steers, bulls, and cow/calf pairs,
5. 150 horses,
6. 3,000 sheep or lambs,
7. 16,500 turkeys,
8. 9,000 laying hens or broilers, if the AFO uses a liquid manure handling system,
9. 1,500 ducks, if the AFO uses a liquid manure handling system.

(t) "1000 AU" means one thousand animal units. Paragraph 391-3-6-.21(2) (c) notwithstanding, the numbers of animals in any of the following categories are equivalent to 1000 AU:

1. 700 mature dairy cows, whether milked or dry,
2. 1,000 veal calves,
3. 2,500 swine each weighing 55 pounds or more,
4. 10,000 swine each weighing less than 55 pounds (immature swine or nursery pigs),
5. 1,000 cattle other than mature dairy cows or veal calves. Cattle includes but is not limited to heifers, steers, bulls, and cow/calf pairs,
6. 500 horses,
7. 10,000 sheep or lambs,
8. 55,000 turkeys,
9. 30,000 laying hens or broilers, if the AFO uses a liquid manure handling system,
10. 125,000 chickens or broilers (other than laying hens), if the AFO handles dry manure only,
11. 82,000 laying hens, if the AFO handles dry manure only,
12. 30,000 ducks, if the AFO handles dry manure only,
13. 5,000 ducks, if the AFO uses a liquid manure handling system.

(u) "3000 AU" means three thousand animal units. Paragraph 391-3-6-.21(2) (c) notwithstanding, the numbers of swine in any of the following categories are equivalent to 3000 AU:

1. 7,500 swine each weighing 55 pounds or more,
2. 30,000 swine each weighing less than 55 pounds (immature swine or nursery pigs).

(3) **Basic Permit Requirement.**

(a) Any person who is the owner of an AFO with more than 300 AU shall obtain a permit from the Division in accordance with this paragraph corresponding to the age and size of the AFO.

(b) Any person who is the owner of an AFO is not required to obtain an NPDES permit unless the AFO is defined as a CAFO per 40 CFR 122 and discharges to a water of the State excluding subsurface water (groundwater), or the Division has made a case-by-case designation as a CAFO and NPDES permitting is required for discharges to a water of the State excluding subsurface water (groundwater) by 40 CFR 122.23. The owner of any AFO with 300 AU or less remains subject to applicable sections of the Act, including civil liability, civil penalty, and criminal penalty, §O.C.G.A. 12-5-51, et seq.

(c) Discharges from a CAFO include discharges of manure, litter, or process wastewater from land application areas under the control of the CAFO that are not exempt as agricultural storm water discharges. Precipitation-related discharges qualifying as agricultural storm water discharges are not subject to these permit requirements. For discharges from the land application area to qualify as agricultural storm water, manure and wastewater must be applied in accordance with site-specific practices that ensure appropriate agricultural utilization of nutrients [under 40 CFR 122.23(e)].

(d) The Division will notify the public of a proposal to grant coverage under a general NPDES permit or a proposed individual NPDES permit and make available for public review and comment the permit application, the notice of intent, the NMP, and the draft terms of the NMP to be incorporated into the permit.

(e) Two or more AFOs under common ownership are considered to be a single operation subject to this paragraph if they adjoin each other (are contiguous) or if they use a common area or system for the disposal of wastes.

(f) Exclusions from all permit requirements of this paragraph are made for the following facilities unless they are defined as a CAFO per 40 CFR 122 or the Division has made a case-by-case designation as a CAFO and they discharge, in which cases NPDES permitting is required by 40 CFR 122.23:

1. A livestock market, sale barn, stockyard, or auction house where animals are assembled from at least two sources to be publicly auctioned or privately sold on a commission basis and that is under state or federal supervision. However, these facilities are defined as AFOs if they meet the definition of an AFO in 391-3-6-.21(2)(b).

(g) Any person who removes and transports animal waste from its point of origin shall conform to the animal manure handler rules of the Georgia Department of Agriculture.

(4) **Permit for Operations with Liquid Manure Handling Systems.**

(a) Any person who is the owner of an AFO with more than 300 AU and uses liquid manure handling must apply for an LAS permit from the Division. The Division may issue an individual or general permit. Permit applications for new or expanding AFOs should be submitted 180 days prior to beginning the AFO. Any person who owns an AFO must have waste storage and disposal systems pursuant to this rule and meet the conditions in subparagraphs (b) through (o) below.

(b) Prior to beginning operation of the AFO, all new operations must have waste storage and disposal systems in operation that have been designed and constructed in accordance with NRCS guidance.

(c) The owner of an existing AFO shall submit to the Division an NMP for the AFO. The NMP shall be of sufficient substance and quality as to be approvable by the Division. The owner of a new operation shall submit to the Division an NMP and obtain approval prior to beginning operation of the AFO.

(d) All operations shall have a certified operator. New operations shall have a certified operator prior to beginning operation of the AFO. The certified operator shall be trained and certified in accordance with 391-3-6-.21(5).

(e) Any new waste storage lagoon or structure must be constructed to ensure that seepage is limited to a maximum of 1/8 inch per day ($3.67 \times 10^{-6}$ cm/sec). However, new waste storage lagoons or structures located within significant ground water recharge areas which fall within the categories defined in the Georgia Department of Natural Resources Rules for Environmental Planning Criteria, Chapter 391-3-16-.02(3)(e) must be provided with either a compacted clay or synthetic liner such that the vertical hydraulic conductivity does not exceed $5 \times 10^{-7}$ cm/sec or other criteria as determined by the Division. If it is determined that an existing waste storage lagoon or structure is creating a ground water contamination problem, the Division may require the lagoon or structure to be repaired.

(f) New barns and new waste storage lagoons or structures for all new AFOs shall not be located within a 100-year flood plain.

(g) For new operations with more than 1000 AU, it is required that a minimum of 1 foot of freeboard plus storage for the 25 year 24 hour storm event be maintained in the waste storage lagoons or structures. The liquid level must not rise into this design storage level for lesser storms.

(h) For new operations with more than 1000 AU, the following buffers and setbacks shall be maintained:

1. 100 feet between wetted areas and water wells that supply water for human consumption;

2. 100 feet between waste storage lagoons, waste storage structures, or barns and waters of the State excluding subsurface water;

3. 500 feet between waste storage lagoons, waste storage structures, or barns and any existing wells that supply water to a public water system, or any other existing well off the owner's property that supplies water for human consumption.

(i) For all operations with more than 1000 AU, the waste disposal system shall be designed and operated such that it does not cause Nitrate Nitrogen ($NO_3$-N) in the ground water at the operation's property line to exceed 10 mg/l. The Division will require the owner to implement corrective actions if the permitted waste disposal system has caused the Nitrate Nitrogen ($NO_3$-N) to exceed 10 mg/l as described.

(j) For all operations with more than 1000 AU, a setback shall be maintained of 100 feet between wetted areas or waste disposal areas and waters of the State excluding subsurface water (ground water). As a compliance alternative, the owner may substitute the 100 feet setback with a 35 feet wide vegetated buffer where waste disposal is prohibited.

(k) For all operations with more than 1000 AU, representative samples shall be collected from each major soil series present within the waste disposal field areas in a manner to be specified in the permit. One down gradient ground water monitoring well shall be installed for each waste storage lagoon or structure or series of lagoons or structures. The number, location, design, and construction specifications of the monitoring wells shall be included in the NMP. Existing wells that are approved by the Division can be used for testing. Monitoring wells shall be properly installed within 24 months of permit issuance.

(l) For all operations with more than 1000 AU, the permit will contain specific requirements for monitoring the waste storage effluent to be land applied and for the ground water monitoring wells. This will usually consist, at a minimum, of semiannual monitoring of the effluent for Total Kjeldahl Nitrogen (TKN), Nitrate Nitrogen ($NO_3$-N) and Total Phosphorus (TP) as well as semiannual monitoring of the wells for TKN and $NO_3$- N.

(m) For all operations with more than 1000 AU, the permittee must submit an annual report to the Division. The annual report must include the items specified in the permit.

(n) For all operations with more than 1000 AU, when the owner ceases operation of the AFO, he must notify the Division of that fact within three months, and he must properly close all waste storage lagoons or structures within twenty-four months. Proper closure of a lagoon or structure entails removing all waste from the lagoon or structure and land applying it at agronomic rates, and in a manner so as not to discharge to any surface water.

(o) Any failure to comply with any condition of (a) through (n) above or any condition of any individual permit issued for the operation shall be deemed a violation of the Act and may be punishable in accordance with the penalties provided in the Act.

**(5) Certified Operator - Training and Certification Requirements for Operations With Liquid Manure Handling Systems.**

(a) AFOs shall have certified operators prior to beginning the AFO.

(b) AFO certified operators shall be trained and certified by the Georgia Department of Agriculture. Proof of such training, certification, and continuing education may be maintained by the Department of Agriculture and records provided to the Georgia Environmental Protection Division.

(c) Certification training, agenda, and topics will be determined by the Georgia Department of Agriculture; but will include, at a minimum, best management practices, nutrient management planning, understanding regulations and water quality laws, standards and practices, siting, pollution prevention, monitoring, and record keeping. Training programs will be structured to address the needs of the certified operators of differing sizes and various waste management technologies. Continuing education will be required to maintain this certification.

Authority: §O.C.G.A. Section 12-5-20, et. Seq. **History.** Original Rule entitled "Animal (Non-Swine) Feeding Operation Permit Requirements" adopted. F. Feb. 8, 2001; eff. Feb. 28, 2001. **Amended:** Aug 26, 2003; eff. Sept.

15, 2003. **Amended:** Rule entitled "Animal Feeding Operation Permit Requirements. Amended." F. Jul. 18, 2012; eff. Aug. 7, 2012.

STATE OF GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

# GENERAL LAND APPLICATION SYSTEM PERMIT FOR ANIMAL FEEDING OPERATIONS – 301 TO 1000 ANIMAL UNITS

GENERAL PERMIT NO. GAG920000

In accordance with the provisions of the Georgia Water Quality Control Act (O.C.G.A. §12-5-20), and the Rules and Regulations (Chapters 391-3-6-.21, as amended) promulgated pursuant thereto, this permit is issued for animal feeding operation waste storage and disposal within the State of Georgia.

Owners of existing, new, and expanding animal feeding operations (301 to 1000 animal units category) that are required to have a land application system permit shall, on submittal of a Notice of Intent and after acknowledgement by the Environmental Protection Division of coverage under this permit, carry out the land application of animal feeding operation waste in accordance with the limitations, monitoring requirements, and other conditions set forth in this permit.

This permit is conditioned upon the permittee complying with the limitations, monitoring requirements and other conditions set forth in the permit, with the statements, plans, and supporting data submitted with the Notice of Intent and filed with the Environmental Protection Division of the Department of Natural Resources and with any requirements specified in the Notice of Intent acceptance letter.

This permit shall become effective on April 1, 2014.

This permit shall expire at midnight, March 31, 2019.

Issued this 1st day of April 2014.

STATE OF GEORGIA CONSTITUTION 1776

Director,
Environmental Protection Division

## PART I

### A. CONDITIONS

1. **DEFINITIONS**: All terms used in this permit shall be interpreted in accordance with the definitions contained in the Rules and Regulations for Water Quality Control, unless otherwise defined in this permit.

   a. Director: The Director of the Division.

   b. Division: The Environmental Protection Division of the Department of Natural Resources.

   c. Notice of Intent (NOI): A form used by a potential permittee to notify the Division that they intend to seek coverage under a general permit.

   d. Notice of Termination (NOT): A form used by a permittee to notify the Division that they wish to cease coverage under a general permit.

   e. State Act: The Georgia Water Quality Control Act (Official Code of Georgia Annotated; Title 12, Chapter 5, Article 20).

   f. State Rules: The Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6, including but not limited to Chapter 391-3-6-.21, Animal Feeding Operation Permit Requirements, latest edition.

2. **MONITORING**

   a. The Division may require the monitoring of pollutants by written notification.

   b. Analytical procedures, sample containers, sample preservation techniques, and sample holding times must be consistent with the techniques and procedures listed in 40 CFR Part 136 for monitoring or as otherwise approved by the Division. The analytical methods used must be sufficiently sensitive. Parameters will be reported as "not detected" when they are below the detection limit and will then be considered in compliance with the effluent limit. The detection limit will also be reported.

   c. Records of monitoring information shall include the following:

      i. The date, exact place, and time of sampling or measurements.

      ii. The individual(s) who performed the sampling or measurements.

iii. The date(s) analyses were performed.

iv. The individual(s) who performed the analyses.

v. The analytical techniques or methods used.

vi. The results of such analyses.

**3. <u>ELIGIBILITY AND PERMIT COVERAGE AREA</u>**

a. This permit regulates animal feeding operation manure and process wastewater land application systems within the State of Georgia.

b. Limitations on coverage: This permit does not authorize coverage to the following land application systems:

i. Systems associated with or containing biosolids;

ii. Systems that are covered by an individual land application system permit;

iii. Systems associated with or containing grease trap waste;

iv. Systems associated with or containing industrial, commercial, hazardous, or non-biodegradable wastes or municipal solid wastes; or

v. Systems associated with or containing domestic septage.

**4. <u>AUTHORIZATION</u>**

a. The permittee applying or proposing to apply animal feeding operation manure and process wastewater to land application systems must submit a Notice of Intent (NOI) and an initial or updated nutrient management plan in accordance with this permit to be authorized coverage under this general permit. Such Notice of Intent shall be on forms as may be prescribed and furnished by the Division.

b. Coverage under this general permit shall be effective upon receipt of notification of inclusion by the Division.

c. The Division may deny coverage under this permit and require submittal of an application for an individual system permit based on a review of the NOI or other information.

d. Notice of Intent Forms, nutrient management plans, and other required reports and forms shall be submitted to the Georgia Department of Agriculture on behalf of the Division. The address for submittal of forms (and for obtaining forms) is:

Animal Feeding Operation Permitting Program
Livestock/Poultry Field Forces
Georgia Department of Agriculture
P.O. Box 7847
Gainesville, Georgia 30504

## 5. GENERAL REQUIREMENTS

a. The land application system will be operated in accordance with the design criteria as presented in the approved nutrient management plan (NMP), the permit application and/or other written agreements between the Division and the permittee.

b. Manure and process wastewater shall not be applied to a site that is frozen, flooded, or snow-covered. If it is raining or if the soil is saturated, then manure and process wastewater application shall not take place.

c. The sites and location of the land application system shall consist of the number of acres identified in the NMP. Application shall take place within the boundaries identified in the NMP. Manure and process wastewater may be transferred from the permitted facility in accordance with off-site transfer procedures specified in the NOI and NMP.

d. The land application system must be operated as a no discharge to surface water system. Corrective actions, which could include curtailing or ceasing production, shall be undertaken if the application rate cannot satisfactorily be handled by the currently approved disposal field(s). Manure and process wastewater shall be sprayed as specified in the approved NMP to insure operation as a no discharge to surface water system. Precipitation-related discharges qualifying as agricultural storm water discharges are not subject to these permit requirements.

## 6. REPORTING AND RECORDS

a. The Division may require the collection and analysis of samples and reporting of monitoring results by written notification.

b. All reports or information generated in compliance with this permit must be signed in accordance with the Georgia Rules and Regulations For Water Quality Control, Chapter 391-3-6-.19(5)(e).

c. The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the NOI for this permit, for a period of at least 3 years from the date of the sample, measurement, report, or application. That period may be extended by request of the Division at any time.

## 7. TERMINATION OF PERMIT COVERAGE

Coverage under this permit may be terminated if the Division determines in writing that the permittee has submitted a complete and adequate NOT, the facility has ceased all operation, the facility is no longer an animal feeding operation that land applies manure and process wastewater, and the facility has properly closed the animal feeding operation in accordance with the approved NMP.

## 8. CLOSURE

a. Closure of the animal feeding operation manure and process wastewater land application system shall be done as directed by the Division.

b. Operation of the system will cease and the land disposal of manure and process wastewater will be eliminated consistent with the closure plan in the approved NMP.

## 9. EXPANSION OF SYSTEM

The permittee shall not allow any unauthorized sites or fields under his control to receive manure and process wastewater beyond that capacity identified in the approved NMP without written approval from the Division.

## B. LIMITATIONS AND MONITORING REQUIREMENTS

### 1. WASTE STORAGE LAGOON OR STRUCTURE

If it is determined that a waste storage lagoon or structure is creating a groundwater contamination problem, the Division may require the lagoon or structure to be repaired, or may require additional corrective action.

### 2. SOIL MONITORING REQUIREMENTS

Representative samples shall be collected and analyzed in accordance with the approved NMP.

### 3. GROUNDWATER LIMITATIONS AND MONITORING

The waste storage and disposal system shall be designed and operated such that it does not cause Nitrate Nitrogen (NO3-N) in the groundwater at the operation's property line to exceed primary maximum contaminant levels for drinking water in accordance with the Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6-.21(4)(h)(3)(i).

a. The permittee may be required to install groundwater monitoring wells if they were not included in the original design, or if existing wells are inadequate.

b. If information obtained by the permittee indicates contamination of groundwater or surface water, problems with meeting operational criteria, or changes from design criteria due to increased production or other factors, the permittee shall propose to the Director additional reports or modifications to the system to address said contamination, problems, or changes.

**PART II**

**A. MANAGEMENT REQUIREMENTS**

**1. FACILITY OPERATION**

a. The permittee shall, at all times, properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) that are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes the operation of backup or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of the permit.

b. Proper operation of the land application system also includes the best management practice of establishing and maintaining crops, vegetation, forage growth or post-harvest residues in the normal growing season on the land application site.

**2. NONCOMPLIANCE NOTIFICATION**

a. If, for any reason the permittee does not comply with, or will be unable to comply with any terms and limits specified in the permit, the permittee shall provide the Division with an oral report within twenty-four (24) hours from the time the permittee becomes aware of the circumstances followed by a written report within five (5) days of becoming aware of such condition. The written submission shall contain the following information:

   i. A description of the noncompliance and its cause;

   ii. The period of noncompliance, including the exact date and times; or, if not corrected, the anticipated time the noncompliance is expected to continue; and

   iii. The steps taken to reduce, eliminate, and prevent recurrence of the non-compliance.

b. If, for any reason the permittee anticipates a noncompliance event, the permittee shall give written notice to the Division at least ten (10) days before:

   i. Any planned changes in the permitted facility; or

   ii. Any activity that may result in noncompliance with the permit.

c. The permittee must report all instances of noncompliance not reported under other specific reporting requirements, at the time monitoring reports are submitted. The reports shall contain the information required under conditions of twenty-four (24) hour reporting.

3. **OPERATOR CERTIFICATION REQUIREMENTS**

a. The permittee shall ensure that the operator in charge of the daily operation of the land application system is a certified animal feeding operator in accordance with the Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6-.21(5) and the Rules of the Georgia Department of Agriculture Animal Industry Division, Chapter 40-16-5.

b. The operator in charge of the land application system shall be certified prior to beginning the animal feeding operation.

4. **LABORATORY ANALYST CERTIFICATION REQUIREMENTS**

The permittee shall ensure that all persons performing the laboratory analyses for this animal feeding operation are Certified Wastewater Laboratory Analysts unless such analyses is performed in a commercial environmental laboratory that is approved by the Division under the Rules for Commercial Environmental Laboratories, Chapter 391-3-26.

5. **DUTY TO MITIGATE**

The permittee shall take all reasonable steps to minimize or prevent any discharge or disposal in violation of this permit, which has a reasonable likelihood of adversely affecting human health or the environment.

B. **RESPONSIBILITIES**

1. **COMPLIANCE**

a. The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the State Act, and the Georgia Rules and Regulations for Water Quality Control and is grounds for:

i. Enforcement action; or

ii. Permit termination, revocation and reissuance, or

iii. Denial of a permit renewal application; and/or

iv. Requiring a permittee to apply for and obtain an individual permit.

b. It shall not be a defense of the permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity to maintain compliance with the conditions of this permit.

2. **RIGHT OF ENTRY**

The permittee shall allow the Director of the Division and authorized representatives, agents, or employees after they present credentials:

a. To enter the permittee's premises where a regulated activity or facility is located, or where any records required by this permit are kept; and

b. At reasonable times, to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and to sample any substance or parameters at any location.

3. **SUBMITTAL OF INFORMATION**

The permittee shall furnish to the Division any information which the Division may request to determine whether cause exists for modifying, revoking and reissuing, or terminating coverage under this permit or to determine compli ance with this permit. The permittee shall also furnish to the Division upon request, copies of records required to be kept by this permit. Where the permittee becomes aware that it failed to submit any relevant facts in a NOI or NMP, or submitted incorrect information in a NOI or NMP or in any report to the Division, the permittee shall promptly submit such facts or information.

4. **TRANSFER OF OWNERSHIP OR CONTROL**

Coverage under this permit may be transferred to another person by a per mittee if:

a. The permittee notifies the Georgia Department of Agriculture on behalf of the Director in writing of the proposed transfer at least thirty (30) days in advance of the proposed transfer;

b. A written agreement containing a specific date for transfer of permit responsibility and coverage between the current and proposed permittee (including acknowledgment that the existing permittee is liable for violations up to that date, and that the proposed permittee is liable for violations from that date on) is submitted to the Georgia Department of Agriculture on behalf of the Director at least thirty (30) days in advance of the proposed transfer with respective NOT and NOI forms; and

c. The Director, within thirty (30) days, does not notify the current permittee and the proposed permittee of the Division's intent to modify, revoke and reissue, or terminate the permit.

## 5. PERMIT MODIFICATION

Coverage under this permit may be modified, terminated, or revoked and reissued in whole or in part during its term for causes including, but not limited to:

a. Permit violations;

b. Obtaining permit coverage by misrepresentation or by failure to disclose all relevant facts;

c. Changing any condition that requires either a temporary or permanent reduction or elimination of the permitted land application; and

d. Significant changes in animal feeding operation manure and process wastewater characteristics not addressed in the NOI or approved NMP.

The filing of a request by the permittee for permit modification, termination, revocation and reissuance, or notification of planned changes or anticipated noncompliance does not negate any permit condition.

## 6. PENALTIES

a. The State Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit, makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance shall, upon conviction, be punished by a fine or by imprisonment, or by both. The State Act also provides procedures for imposing civil penalties which may be levied for violations of the Act, any permit condition or limitation established pursuant to the Act, or negligently or intentionally failing or refusing to comply with any final or emergency order of the Director of the Division.

b. Nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

7. **CIVIL AND CRIMINAL LIABILITIES**

The permittee is liable for civil or criminal penalties for noncompliance with this permit and must comply with applicable State laws including promulgated water quality standards. The permit cannot be interpreted to relieve the permittee of this liability even if it has not been modified to incorporate additional requirements.

8. **STATE LAWS**

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or pen alties established pursuant to any applicable State law or regulation.

9. **EXPIRATION OF PERMIT**

The permittee shall not operate the system after the expiration date. In order to receive permit renewal consideration to operate beyond the expiration date, the permittee shall submit such information, and NOI forms as are required by the Division no later than one-hundred-and-eighty (180) days prior to the expiration date.

10. **SEVERABILITY**

The provisions of this permit are severable. If any permit provision or the application of any permit provision to any circumstance is held invalid, the pro vision does not affect other circumstances or the remainder of this permit.

11. **NMP CERTIFICATION AND COMPLIANCE SCHEDULE**

a. Prior to coverage under the general permit, if the permittee was covered under LAS Permit No. GAU700000 or NPDES Permit No. GAG930000, the permittee must certify on forms as may be prescribed and furnished by the Division that the NMP was submitted and approved on or after March 15, 2011 and is valid for operation in accordance with the permit; or

b. If the permittee was covered under LAS Permit No. GAU700000 or NPDES Permit No. GAG930000 and the NMP was not submitted and approved on or after March 15, 2011, the permittee must submit an updated NMP no later than one-hundred-and-eighty (180) days after obtaining coverage under the general permit.

c. If the permittee was not covered under LAS Permit No. GAU700000 or NPDES Permit No. GAG930000, the NMP must be submitted and approved prior to obtaining coverage under this permit.

d. Failure to obtain an approved NMP will result in coverage under this permit being modified, terminated, or revoked and reissued in whole or in part during its term.

STATE OF GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

# GENERAL LAND APPLICATION SYSTEM PERMIT
# FOR
# ANIMAL FEEDING OPERATIONS – MORE THAN 1000 ANIMAL UNITS

GENERAL PERMIT NO. GAG940000

In accordance with the provisions of the Georgia Water Quality Control Act (O.C.G.A. §12-5-20), and the Rules and Regulations (Chapters 391-3-6-.21, as amended) promulgated pursuant thereto, this permit is issued for animal feeding operation waste storage and disposal within the State of Georgia.

Owners of existing, new, and expanding animal feeding operations (more than 1000 animal units category) that are required to have a land application system permit shall, on submittal of a Notice of Intent and after acknowledgement by the Environmental Protection Division of coverage under this permit, carry out the land application of animal feeding operation waste in accordance with the limitations, monitoring requirements, and other conditions set forth in this permit.

This permit is conditioned upon the permittee complying with the limitations, monitoring requirements and other conditions set forth in the permit, with the statements, plans, and supporting data submitted with the Notice of Intent and filed with the Environmental Protection Division of the Department of Natural Resources and with any requirements specified in the Notice of Intent acceptance letter.

This permit shall become effective on April 1, 2014.

This permit shall expire at midnight, March 31, 2019.

Issued this 1st day of April 2014.

Director
Environmental Protection Division

**PART I**

**A. CONDITIONS**

1. **DEFINITIONS**: All terms used in this permit shall be interpreted in accordance with the definitions contained in the Rules and Regulations for Water Quality Control, unless otherwise defined in this permit.

   a. Director: The Director of the Division.

   b. Division: The Environmental Protection Division of the Department of Natural Resources.

   c. Notice of Intent (NOI): A form used by a potential permittee to notify the Division that they intend to seek coverage under a general permit.

   d. Notice of Termination (NOT): A form used by a permittee to notify the Division that they wish to cease coverage under a general permit.

   e. State Act: The Georgia Water Quality Control Act (Official Code of Georgia Annotated; Title 12, Chapter 5, Article 20).

   f. State Rules: The Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6, including but not limited to Chapter 391-3-6-.21, Animal Feeding Operation Permit Requirements, latest edition.

2. **MONITORING**

   a. Analyses required semiannually (twice per year) will be performed on or before the last day of June and December. Analyses required annually will be performed on or before the last day of December. The Division may require additional monitoring.

   b. Analytical procedures, sample containers, sample preservation techniques, and sample holding times must be consistent with the techniques and procedures listed in 40 CFR Part 136 for monitoring or as otherwise approved by the Division. The analytical methods used must be sufficiently sensitive. Parameters will be reported as "not detected" when they are below the detection limit and will then be considered in compliance with the effluent limit. The detection limit will also be reported.

c. Records of monitoring information shall include the following:

   i. The date, exact place, and time of sampling or measurements.

   ii. The individual(s) who performed the sampling or measurements.

   iii. The date(s) analyses were performed.

   iv. The individual(s) who performed the analyses.

   v. The analytical techniques or methods used.

   vi. The results of such analyses.

d. If the permittee monitors any pollutant more frequently than required by the permit using test procedures approved under 40 CFR Part 136, or as specified in the permit, the results of this monitoring shall be included in the calculation and reporting of the data.

3. **<u>ELIGIBILITY AND PERMIT COVERAGE AREA</u>**

a. This permit regulates animal feeding operation manure and process wastewater land application systems within the State of Georgia.

b. Limitations on coverage: This permit does not authorize coverage to the following land application systems:

   i. Systems associated with or containing biosolids;

   ii. Systems that are covered by an individual land application system permit;

   iii. Systems associated with or containing grease trap waste;

   iv. Systems associated with or containing industrial, commercial, hazardous, or non-biodegradable wastes or municipal solid wastes; or

   v. Systems associated with or containing domestic septage.

## 4. AUTHORIZATION

a. The permittee applying or proposing to apply animal feeding operation manure and process wastewater to land application systems must submit a Notice of Intent (NOI) and an initial or updated nutrient management plan in accordance with this permit to be authorized coverage under this general permit. Such Notice of Intent shall be on forms as may be prescribed and furnished by the Division.

b. Coverage under this general permit shall be effective upon receipt of notification of inclusion by the Division.

c. The Division may deny coverage under this permit and require submittal of an application for an individual system permit based on a review of the NOI or other information.

d. Notice of Intent Forms, nutrient management plans, annual reports, and other required reports and forms shall be submitted to the Georgia Department of Agriculture on behalf of the Division. The address for submittal of forms (and for obtaining forms) is:

Animal Feeding Operation Permitting Program
Livestock/Poultry Field Forces
Georgia Department of Agriculture
P.O. Box 7847
Gainesville, Georgia 30504

## 5. GENERAL REQUIREMENTS

a. The land application system will be operated in accordance with the design criteria as presented in the approved nutrient management plan (NMP), the permit application and/or other written agreements between the Division and the permittee.

b. Manure and process wastewater shall not be applied to a site that is frozen, flooded, or snow-covered. If it is raining or if the soil is saturated, then manure and process wastewater application shall not take place.

c. The sites and location of the land application system shall consist of the number of acres identified in the NMP. Application shall take place within the boundaries identified in the NMP. Manure and process wastewater may be transferred from the permitted facility in accordance with off-site transfer procedures specified in the NOI and NMP.

d. The land application system must be operated as a no discharge to surface water system. Corrective actions, which could include curtailing or ceasing production, shall be undertaken if the application rate cannot satisfactorily be handled by the currently approved disposal field(s). Manure and process wastewater shall be sprayed as specified in the approved NMP to insure operation as a no discharge to surface water system. Precipitation-related discharges qualifying as agricultural storm water discharges are not subject to these permit requirements.

## 6. REPORTING AND RECORDS

a. Analytical results required by this permit shall be summarized on an Operation Monitoring Report (OMR) form (Form WQ 1.45). Forms other than Form WQ 1.45 may be used upon approval by the Division. The OMR forms shall be completed twice per year with the summarized monitoring results, signed in accordance with the Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6-.19(5)(e), and shall be maintained on file at the operation, unless otherwise notified in writing by the Division. The Division may require the reporting of additional monitoring results or more frequent reporting.

b. Annual reports for the previous calendar year (January through December) shall be summarized and reported on the "GEORGIA LAS AFO PERMIT ANNUAL REPORT" form. These forms and any other required reports and information shall be completed, signed in accordance with the Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6-.19(5)(e) and submitted to the address specified above, postmarked no later than the 15th day of February each year.

c. All reports or information generated in compliance with this permit must be signed in accordance with the Georgia Rules and Regulations For Water Quality Control, Chapter 391-3-6-.19(5)(e).

d. The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the NOI for this permit, for a period of at least 3 years from the date of the sample, measurement, report, or application. That period may be extended by request of the Division at any time.

## 7. TERMINATION OF PERMIT COVERAGE

Coverage under this permit may be terminated if the Division determines in writing that the permittee has submitted a complete and adequate NOT, the facility has ceased all operation, the facility is no longer an animal feeding operation that land applies manure and process wastewater, and the facility has properly closed the animal feeding operation in accordance with the approved NMP.

## 8. CLOSURE

a. Closure of the animal feeding operation manure and process wastewater land application system shall be done in accordance with the Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6-.21(4)(n), where applicable.

b. Operation of the system will cease and the land disposal of manure and process wastewater will be eliminated consistent with the closure plan in the approved NMP.

## 9. EXPANSION OF SYSTEM

The permittee shall not allow any unauthorized sites or fields under the permittee's control to receive manure and process wastewater beyond that capacity identified in the approved NMP without written approval from the Division.

## B. LIMITATIONS AND MONITORING REQUIREMENTS

### 1. WASTE STORAGE LAGOON OR STRUCTURE

| Parameter (Units) | Monitoring Requirements | | |
|---|---|---|---|
| | Measurement Frequency | Sample Type | Sample Location |
| Total Flow (MG)* | Daily | Total | Effluent to spray field |
| TKN (mg/L as N) | Semiannually | Grab | Effluent to spray field |
| $NO_3$-N (mg/L as N) | Semiannually | Grab | Effluent to spray field |
| Total Phosphorus (mg/L) | Semiannually | Grab | Effluent to spray field |

The permittee may be required to sample for additional parameters. If it is determined that a waste storage lagoon or structure is creating a groundwater contamination problem, the Division may require the lagoon or structure to be repaired, or may require additional corrective action.

*MG equals Million Gallons.

## 2. SOIL MONITORING REQUIREMENTS

Representative samples shall be collected from each major soil series present within the land application area. The samples shall be analyzed in accordance with the latest edition of Methods of Soil Analysis (published by the American Society of Agronomy, Madison, Wisconsin) or other methods approved by the Division. The soil samples shall be analyzed for the parameters and at the frequency listed below:

| Parameter | Measurement Frequency |
|---|---|
| Soil Fertility Test* | Annually |

*This test is to be done on or before the last day of December each year. The soil fertility test is to include soil pH, phosphorus, potassium, calcium, magnesium, zinc, and manganese using the Mehlich I extraction procedure. The permittee may be required to sample for additional parameters.

## 3. GROUNDWATER LIMITATIONS AND MONITORING

The waste storage and disposal system shall be designed and operated such that it does not cause Nitrate Nitrogen ($NO_3$-N) in the groundwater at the operation's property line to exceed primary maximum contaminant levels for drinking water in accordance with the Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6-.21(4)(h)(3)(i). The groundwater shall be monitored from each groundwater monitoring well by the permittee for the parameters and at the frequency listed below:

| Parameter | Measurement Frequency |
|---|---|
| TKN (mg/L as N) | Semiannually |
| $NO_3$-N (mg/L as N) | Semiannually |
| Depth to Groundwater | Semiannually |

The permittee may be required to sample for additional parameters. See Part II.A.6. for additional groundwater and monitoring well requirements.

4. **ANNUAL REPORTING REQUIREMENTS**

a. The permittee must submit an annual report by February 15th of each year.

b. The annual report must include the following information:

i. The number and type of animals, whether in open confinement or housed under roof;

ii. Estimated amount of total manure and process wastewater generated in the previous 12 months (tons and gallons, respectively);

iii. Estimated amount of total manure and process wastewater transferred to other persons in the previous 12 months (tons and gallons respectively);

iv. Total number of acres for land application covered by the nutrient management plan;

v. Total number of acres under control of the permittee that were used for land application of manure and process wastewater in the previous 12 months;

vi. Summary of all manure and process wastewater discharges from the production area that have occurred in the previous 12 months, including date, time, and approximate volume; and

vii. A statement indicating whether the current version of the permittee's NMP was developed or approved by a certified nutrient management planner.

**PART II**

## A. MANAGEMENT REQUIREMENTS

### 1. FACILITY OPERATION

a. The permittee shall, at all times, properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) that are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes the operation of backup or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of the permit.

b. Proper operation of the land application system also includes the best management practice of establishing and maintaining crops, vegetation, forage growth or post-harvest residues in the normal growing season on the land application site.

### 2. NONCOMPLIANCE NOTIFICATION

a. If, for any reason the permittee does not comply with, or will be unable to comply with any terms and limits specified in the permit, the permittee shall provide the Division with an oral report within twenty-four (24) hours from the time the permittee becomes aware of the circumstances followed by a written report within five (5) days of becoming aware of such condition. The written submission shall contain the following information:

   i. A description of the noncompliance and its cause;

   ii. The period of noncompliance, including the exact date and times; or, if not corrected, the anticipated time the noncompliance is expected to continue; and

   iii. The steps taken to reduce, eliminate, and prevent recurrence of the non-compliance.

b. If, for any reason the permittee anticipates a noncompliance event, the permittee shall give written notice to the Division at least ten (10) days before:

   i. Any planned changes in the permitted facility; or

   ii. Any activity that may result in noncompliance with the permit.

c. The permittee must report all instances of noncompliance not reported under other specific reporting requirements, at the time monitoring reports are submitted. The reports shall contain the information required under conditions of twenty-four (24) hour reporting.

3. **OPERATOR CERTIFICATION REQUIREMENTS**

a. The permittee shall ensure that the operator in charge of the daily operation of the land application system is a certified animal feeding operator in accordance with the Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6-.21(5) and the Rules of the Georgia Department of Agriculture Animal Industry Division, Chapter 40-16-5.

b. The operator in charge of the land application system shall be certified prior to beginning the animal feeding operation.

4. **LABORATORY ANALYST CERTIFICATION REQUIREMENTS**

The permittee shall ensure that all persons performing the laboratory analyses for this animal feeding operation are Certified Wastewater Laboratory Analysts unless such analyses are performed in a commercial environmental laboratory that is approved by the Division under the Rules for Commercial Environmental Laboratories, Chapter 391-3-26.

5. **DUTY TO MITIGATE**

The permittee shall take all reasonable steps to minimize or prevent any discharge or disposal in violation of this permit, which has a reasonable likelihood of adversely affecting human health or the environment.

6. **GROUNDWATER AND MONITORING WELL REQUIREMENTS**

a. The waste storage and disposal system shall be designed and operated such that it does not cause Nitrate Nitrogen ($NO_3$-N) in the groundwater at the operation's property line to exceed 10 mg/l in accordance with the State Rules, Chapter 391-3-6-.21(4)(h)(3)(i).

b. The permittee must implement corrective actions if the permitted waste disposal system has caused the Nitrate Nitrogen ($NO_3$-N) to exceed 10 mg/l as described. The permittee must submit a corrective action plan to the Director within thirty (30) days of becoming aware of such condition.

c. The plan will be implemented by the permittee immediately upon Division approval.

d. For operations commencing construction on or after the effective date of this permit, a monitoring well system that is sufficient to monitor groundwater down and/or cross gradient from the waste storage lagoons or structures shall be installed and monitored. The plan for installing monitoring wells shall be submitted with the NMP and reviewed and approved by the Division. All newly constructed wells shall be installed in accordance with the Georgia Department of Natural Resources Manual for Groundwater Monitoring (September 1991, and revisions). The wells must be installed prior to beginning the animal feeding operation.

## B. RESPONSIBILITIES

### 1. COMPLIANCE

a. The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the State Act, and the Georgia Rules and Regulations for Water Quality Control and is grounds for:

i. Enforcement action; or

ii. Permit termination, revocation and reissuance, or

iii. Denial of a permit renewal application; and/or

iv. Requiring a permittee to apply for and obtain an individual permit.

b. It shall not be a defense of the permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity to maintain compliance with the conditions of this permit.

2. **RIGHT OF ENTRY**

The permittee shall allow the Director of the Division and authorized representatives, agents, or employees after they present credentials:

a. To enter the permittee's premises where a regulated activity or facility is located, or where any records required by this permit are kept; and

b. At reasonable times, to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and to sample any substance or parameters at any location.

3. **SUBMITTAL OF INFORMATION**

The permittee shall furnish to the Division, any information which the Division may request to determine whether cause exists for modifying, revoking and reissuing, or terminating coverage under this permit or to determine compliance with this permit. The permittee shall also furnish to the Division upon request, copies of records required to be kept by this permit. Where the permittee becomes aware that it failed to submit any relevant facts in a NOI or NMP, or submitted incorrect information in a NOI or NMP or in any report to the Division, the permittee shall promptly submit such facts or information.

4. **TRANSFER OF OWNERSHIP OR CONTROL**

Coverage under this permit may be transferred to another person by a per mittee if:

a. The permittee notifies the Georgia Department of Agriculture on behalf of the Director in writing of the proposed transfer at least thirty (30) days in advance of the proposed transfer;

b. A written agreement containing a specific date for transfer of permit responsibility and coverage between the current and proposed permittee (including acknowledgment that the existing permittee is liable for violations up to that date, and that the proposed permittee is liable for violations from that date on) is submitted to the Georgia Department of Agriculture on behalf of the Director at least thirty (30) days in advance of the proposed transfer with respective NOT and NOI forms; and

c. The Director, within thirty (30) days, does not notify the current permittee and the proposed permittee of the Division's intent to modify, revoke and reissue, or terminate the permit.

5. **PERMIT MODIFICATION**

Coverage under this permit may be modified, terminated, or revoked and re-issued in whole or in part during its term for causes including, but not limited to:

a. Permit violations;

b. Obtaining permit coverage by misrepresentation or by failure to disclose all relevant facts;

c. Changing any condition that requires either a temporary or permanent reduction or elimination of the permitted land application; and

d. Significant changes in animal feeding operation manure and process wastewater characteristics not addressed in the NOI or approved NMP.

The filing of a request by the permittee for permit modification, termination, revocation and reissuance, or notification of planned changes or anticipated noncompliance does not negate any permit condition.

6. **PENALTIES**

a. The State Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit, makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance shall, upon conviction, be punished by a fine or by imprisonment, or by both. The State Act also provides procedures for imposing civil penalties which may be levied for violations of the Act, any permit condition or limitation established pursuant to the Act, or negligently or intentionally failing or refusing to comply with any final or emergency order of the Director of the Division.

b. Nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

7. **CIVIL AND CRIMINAL LIABILITIES**

The permittee is liable for civil or criminal penalties for noncompliance with this permit and must comply with applicable State laws including promulgated water quality standards. The permit cannot be interpreted to relieve the per mittee of this liability even if it has not been modified to incorporate additional requirements.

## 8. STATE LAWS

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or regulation.

## 9. EXPIRATION OF PERMIT

The permittee shall not operate the system after the expiration date. In order to receive permit renewal consideration to operate beyond the expiration date, the permittee shall submit such information, and NOI forms as are required by the Division no later than one-hundred-and-eighty (180) days prior to the expiration date.

## 10. SEVERABILITY

The provisions of this permit are severable. If any permit provision or the application of any permit provision to any circumstance is held invalid, the pro vision does not affect other circumstances or the remainder of this permit.

## 11. NMP CERTIFICATION AND COMPLIANCE SCHEDULE

a. Prior to coverage under the general permit, if the permittee was covered under NPDES Permit No. GAG930000 or LAS Permit No. GAU700000, the permittee must certify on forms as may be prescribed and furnished by the Division that the NMP was submitted and approved on or after March 15, 2011 and is valid for operation in accordance with the permit; or

b. If the permittee was covered under NPDES Permit No. GAG930000 or LAS Permit No. GAU700000 and the NMP was not submitted and approved on or after March 15, 2011, the permittee must submit an updated NMP no later than one-hundred-and-eighty (180) days after obtaining coverage under the general permit.

c. If the permittee was not covered under NPDES Permit No. GAG930000 or LAS Permit No. GAU700000, the NMP must be submitted and approved prior to obtaining coverage under this permit.

d. Failure to obtain an approved NMP will result in coverage under this permit being modified, terminated, or revoked and reissued in whole or in part during its term.

# General NPDES Permit

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## PART I. PERMIT AREA AND COVERAGE

### A. Permit Coverage - Animal (Non-Swine) Feeding Operations (AFOs)

The Environmental Protection Division of the Georgia Department of Natural Resources (hereinafter "the Division") is issuing this NPDES general permit to owners of:

1. existing AFOs in operation before February 28, 2001 with more than 1000 but equal to or less than 3000 animal units (AU);

2. new or expanding AFOs commencing on or after February 28, 2001 with more than 1000 but equal to or less than 3000 AU;

3. existing AFOs in operation before February 28, 2001 with more than 3000 AU.

### B. Permit Coverage - Concentrated Animal Feeding Operations (CAFOs)

Pursuant to regulations promulgated in accordance with the Federal Water Pollution Control Act, also known as the Clean Water Act (hereinafter "the Act"), a permit is required for any concentrated animal feeding operation (CAFO) that discharges or has a reasonable potential to discharge to waters of the United States (also see Parts I.C, D, and E). NPDES permits issued to CAFOs cover the confinement, storage, and handling areas as well as the land application activities under the control of the permitted CAFO owner.

A discharge of waste/wastewater is the discharge of pollutants from the animal confinement or storage and handling areas of a CAFO or from the improper use of land application area(s), under the control of the CAFO owner, which enters surface waters, such as a river, stream, creek, wetland, lake, or other waters of the United States. Discharges covered by this permit include, but are not limited to, the following:

1. Contaminated runoff from corrals, stock piled manure, and silage piles;

2. Overflow from manure storage facilities;

3. Discharges associated with improper land application of manure and/or wastewater activities under the control of the CAFO owner;

4. Manure and/or wastewater discharges from retention ponds, manure storage facilities, or lagoons; and

5. Discharges of manure and/or wastewater due to pipe breakage or equipment failure.

### C. Eligibility for Coverage

Owners of AFOs that are defined as CAFOs (Part VI - Definitions) or specified in the Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6 (hereinafter "State Rules") are eligible for coverage under this permit. Permittees must retain, on site, a copy of the permit and the comprehensive nutrient management plan (CNMP) as required by this permit and submit a copy of the CNMP to the Division in accordance with the Georgia Water Quality Control Act (hereinafter "State Act') and the State Rules.

**D. Application for Coverage**

1. Owners of AFOs or CAFOs seeking to be covered by this general permit (see Part I) must (1) submit an application within the time frame specified in the State Rules, (2) comply with the conditions of this general permit, and (3) submit and implement a CNMP in accordance with the State Rules. Owners of new/expanding AFOs or CAFOs should submit an application 180 days in advance of beginning the operation and shall have a complete CNMP.

2. The application must be signed by the owner or other authorized person in accordance with Part V.E of this permit and sent to:

   Georgia Environmental Protection Division
   Permitting, Compliance and Enforcement Program
   4220 International Parkway, Suite 101
   Atlanta, Georgia 30354 (Telephone 404-362-2680)

**E. Requiring an Individual Permit**

1. The Division may require any AFO or CAFO authorized by this general permit to apply for, and obtain, an individual NPDES permit. The Division will notify the owner, in writing, that an application for an individual permit is required and specify the time frame and procedure for application submission. Coverage of the operation under this general NPDES permit is automatically terminated when: (1) the owner fails to submit the required individual NPDES permit application within the defined time frame; or (2) the individual NPDES permit is issued by the Division.

2. When a final individual NPDES permit is issued to an owner otherwise subject to this general permit, the applicability of this general permit to the operation is automatically terminated on the effective date of the individual permit.

**F. Permit Expiration**

This permit will expire as shown on Page 1.

**PART II. PERMIT REQUIREMENTS**

**A. Effluent Limitations**

1. The following effluent limitations apply to the operation covered under this permit:

   Water Quality-based Effluent Limitations: There shall be no discharge of process wastewater pollutants from the feedlot(s) or manure storage area(s) to waters of the United States except when catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain:

a) All process wastewater resulting from the operation of the AFO or CAFO; plus,

b) All runoff from a 25-year, 24-hour rainfall event for the location of the AFO or CAFO.

For discharges associated with land application of process wastewater and/or manure under the control of the owner, the permittee must ensure that such activities comply with the requirements of Minimum Standard 9, in Table III.A, in Part III.A of this permit.

2. The permittee is required to comply with the special conditions established in Part III of this permit. These special conditions consist of compliance with minimum standards to protect water quality (Part III.A), the development and implementation of a site-specific CNMP in accordance with the State Rules (Part III.B), and other special conditions established by the Division (Part III.C).

## B. Other Legal Requirements

No condition of this permit shall release the permittee from any responsibility or requirements under other statutes or regulations, Federal, State or Local.

# PART III. SPECIAL CONDITIONS

## A. Minimum Standards to Protect Water Quality

This permit identifies (See Table III.A below) specific minimum standards that the permittee should meet to prevent pollutants from manure and/or wastewater from entering waters of the U.S., including standards that address proper land application of manure and wastewater. The minimum standards (or portions thereof) that should be addressed immediately upon issuance of this permit are indicated by an asterisk (*). The permittee should comply with the remaining minimum standards (or portions thereof) in accordance with the enforceable schedule in the State Rules for developing and implementing a CNMP, which is established in Section III. B. of this permit. All of the minimum standards to protect water quality must be incorporated into the site-specific CNMP developed and implemented for the permitted facility.

## Table III.A.
## Minimum Standards to Protect Water Quality in NPDES Permits for AFOs or CAFOs

**Each of the following minimum standards is designed to achieve the objective of preventing discharges of pollutants to waters of the U.S. from AFOs or CAFOs and from land application activities under the operational control of the AFO or CAFO. Minimum standards or portions of minimum standards to be addressed on the effective date of the permit are identified with an asterisk (*).**

**1. Minimum Standard: Buffers or Equivalent Practices**

Provide and maintain buffer strips or other equivalent practices near feedlots, manure storage areas, and land application areas that are sufficient to minimize discharge of pollutants to waters of the United States (e.g., soil erosion and manure and wastewater). These practices may include but are not limited to residue management, conservation crop rotation, grassed waterways, strip cropping, vegetative buffers, forested riparian buffers, terracing, and diversion.

**2. Minimum Standard: Divert Clean Water**

*Design and implement management practices to divert clean water and floodwaters from contact with feedlots and holding pens, animal manure, or manure and/or process wastewater storage systems. Clean water includes rain falling on the roofs of facilities, runoff from adjacent land, or other sources. In keeping with the objective of preventing discharges of pollutants to waters of the U.S., diversion should be implemented to the fullest extent practicable in accordance with the approved site-specific CNMP. Clean water and floodwaters that are not diverted should be accounted for in the volume of temporary storage and the capacity of the land application facilities.

**3. Minimum Standard: Prevent Direct Contact of Animals with Waters of the United States**

*Develop and implement appropriate controls to prevent direct access of animals in confinement to waters of the United States to protect water quality.

**4. Minimum Standard: Animal Mortality**

*Handle and dispose of dead animals in a manner that prevents contamination of surface waters of the United States.

**5. Minimum Standard: Chemical Disposal**

*Prevent introduction of chemicals into manure and wastewater storage structures for purposes of disposal. "Introduction" means direct introduction for purposes of disposal with manure. Examples include pesticides, hazardous and toxic chemicals, and petroleum products/by-products. However, chemicals such as soaps, disinfectants, and medicine residue and pesticides when used as directed on the labels are acceptable in minor amounts in the waste stream.

**6. Minimum Standard: Proper Operation and Maintenance**

*Implement an operation and maintenance program that involves periodic visual inspection and maintenance of all manure storage and handling equipment and structures and all runoff management devices (e.g., cleaning separators, barnyards, catch basins, screens, calibration of land application equipment, maintenance of filter strips) and to minimize discharges of pollutants in accordance with the State Rules.

All manure application equipment should be tested and calibrated to ensure proper application rates.

## Table III.A. (CONTINUED)

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|---|
| **7. MINIMUM STANDARD: RECORD KEEPING AND TESTING**<br><br>*Maintain a log that documents the visual inspections, findings, and preventive maintenance activities.<br><br>*Document the date, rate, location, type of crops, and methods used for application of manure and wastewater as well as other nutrients to land under the control of the AFO or CAFO owner.<br><br>Where manure and wastewater are not applied on land under the operational control of the AFO or CAFO owner, maintain a record of the transfer of the manure off-site.<br><br>*Record the results of manure and wastewater sampling to determine nutrient content in accordance with Part VII., State of Georgia Specific Permit Conditions.<br><br>*Record the results of representative soil sampling and analyses conducted in accordance with Part VII., State of Georgia Specific Permit Conditions to determine nutrient content. |
| **8. MINIMUM STANDARD: MAINTAIN PROPER STORAGE CAPACITY**<br><br>Maintain sufficient freeboard in liquid manure storage structures to ensure compliance with the permit conditions and State Rules.<br><br>*Store dry manure, such as that produced in certain poultry and beef operations, in production buildings or in storage facilities or otherwise store in such a way as to prevent polluted runoff (e.g., located on relatively flat land, away from water bodies, wetlands, and wells, and/or surrounded by a berm or buffer). Properly operating dry litter poultry operations are excluded in accordance with the State Rules, paragraph 391-3-6-.21(3)(d)(2) effective February 28, 2001.<br><br>Provide adequate storage capacity so that land application occurs only during periods when land or weather conditions are suitable for manure and wastewater application. (See Minimum Standard 9 below.) |
| **9. MINIMUM STANDARD: RATES AND TIMING OF LAND APPLICATION OF MANURE AND WASTEWATER**<br><br>*Land apply manure and/or wastewater in accordance with proper agricultural practices.<br><br>Land apply manure and/or wastewater in accordance with land application rates developed on a site-specific basis as needed to protect water quality. At a minimum, land application rates should (1) prevent application of nutrients at rates that will exceed the capacity of the soil and the planned crops to assimilate nutrients and minimize water pollution; and (2) be quantified and based on the most appropriate nutrient in the soil, type of crop, realistic crop yields, soil type, and all nutrient inputs in addition to those from manure and wastewater.<br><br>*Manure and wastewater should not be applied on land that is flooded, saturated with water, frozen or snow covered at the time of land application where the manure and wastewater may enter waters of the United States.<br><br>*Land application of manure and wastewater should be avoided during rainfall events and should be delayed if precipitation with the potential to create manure and/or wastewater runoff into waters of the United States is forecast within 24 hours of the planned application. |

## B. Comprehensive Nutrient Management Plan (CNMP)

1. Elements of a CNMP

Each AFO or CAFO covered by this permit shall develop and implement a site-specific CNMP that includes the following elements as appropriate to the needs and circumstances of the permitted facility: animal outputs: manure handling and storage, land application of manure and wastewater, site management, record keeping, and other manure utilization options. Not all operations will require all elements. The CNMP should include emergency response planning and a closure plan for abandonment of any facility used for the treatment or storage of animal waste. The CNMP must be developed and implemented to meet all of the minimum standards identified in Section A of this Part to protect water quality that are applicable to the permitted facility. The CNMP must be designed and implemented to meet the requirements of the Act.

Each CNMP shall specifically identify and describe practices that are to be implemented to assure compliance with the limitations and conditions of this permit. The CNMP shall identify a specific individual(s) at the facility responsible for its implementation. The activities and responsibilities of such personnel must be described in the CNMP. CNMPs are to be developed as a special condition of the NPDES permit, and must contain the following information:

a) Existing Information: Where a facility has previously prepared information that supports one or more of the five elements of a CNMP as outlined in the "NRCS Technical Guidance for Developing CNMPs," the AFO or CAFO may adopt this information for incorporation into the facility-specific CNMP.

b) Signatory Requirements: The CNMP shall be signed by the owner or other signatory authority in accordance with Part V.E (Signatory Requirements).

c) The Division may notify the permittee, at any time, that water quality is not being protected by the CNMP. The permittee shall update the CNMP as directed by the Division.

2. Schedule for Developing, Submitting, and Implementing a CNMP

Following the submission of the permit application or NOI, any AFO or CAFO covered by this NPDES general permit shall develop and implement a CNMP in accordance with the State Rules:

a) Existing operations - By October 31, 2002, the owner shall submit to the Division a CNMP for the AFO. The CNMP shall be of sufficient substance and quality as to be approvable by the Division. The owner should receive the Division's approval of the CNMP by July 1, 2003, and shall begin implementing the approved CNMP not later than October 31, 2003.

b) New or expanding operations - Prior to beginning operation of the AFO, the owner shall submit to the Division a CNMP for the AFO. The CNMP shall be of sufficient substance and quality as to be approvable by the Division.

3. Certified Specialists to Develop CNMPs

The CNMP must be developed or modified by a "specialist" certified by the Georgia Department of Agriculture. However, on a case-by-case basis, the Division may approve a CNMP by another qualified individual, such as a registered professional engineer. It is the permittee's sole responsibility to assure that the effective implementation of the CNMP results in compliance with all permit conditions.

4. CNMP is to be Maintained On Site

A current copy of the CNMP shall be kept on site in accordance with Part V.C.3 (Retention of Records) of this permit and provided to the Division upon request.

5. Duty to Amend the CNMP

The permittee must amend the CNMP whenever: (1) the facility makes a substantive change in how it manages its operations, including the location, method, timing or frequency of land application; or (2) a discharge occurs in violation of this NPDES permit. Where the facility is located in an impaired watershed, the Division may review the CNMP and direct the permittee to amend it as part of the TMDL process. The facility should complete an annual review of the CNMP to assess its adequacy in protecting water quality.

**C. Additional Special Conditions**

1. Emergency Discharge Impact Abatement: Discharges authorized by Part II.A(1) of this permit must, where practicable, be properly discharged to land application fields or held in secondary containment for filtering to minimize discharge to waters of U.S.

2. Irrigation Control: Irrigation systems shall be managed so as to: (1) reduce or minimize ponding or puddling of wastewater on land application fields; and (2) protect ground and surface water in accordance with the State Rules.

3. Spills of Oil, Radioactive Materials, and Hazardous Chemicals: Appropriate measures necessary to prevent and clean up such spills shall be taken. If possible spills are anticipated, materials handling procedures and storage must be specified in the CNMP. Procedures for cleaning up spills shall be identified, and the necessary equipment to implement clean up shall be made available to facility personnel. All spills of oil, radioactive materials, and hazardous chemicals must be reported immediately to the U.S. Environmental Protection Agency National Response Center (1-800-424-8802) and the Georgia Department of Natural Resources Emergency Operations Center (1-800-241-4113).

4. Measurement of Rainfall: A rain gauge shall be kept on site and properly

maintained. A log of all measurable rainfall events shall be kept by the AFO or CAFO owner.

5. <u>Liner Requirement:</u> Seepage from ponds, lagoons, and basins of the retention structure must not contaminate surface waters nor contaminate ground water in accordance with the State Rules as follows:

a) <u>Existing operations:</u> If it is determined that an existing waste storage lagoon is creating a ground water contamination problem, the Division shall require the owner to repair the lagoon, to close the lagoon, or to take other actions to protect the ground water.

b) <u>New or expanding operations:</u> Any waste storage lagoon must be constructed to ensure that seepage is limited to a maximum of 1/8 inch per day ($3.67 \times 10^{-6}$ cm/sec). For waste storage lagoons located within significant ground water recharge areas which fall within the categories defined in the Georgia Department of Natural Resources Rules for Environmental Planning Criteria, Chapter 391-3-15-.02, Paragraph 3(e), the lagoons must be provided with either a compacted clay or a synthetic liner such that the vertical hydraulic conductivity does not exceed $5 \times 10^{-7}$ cm/sec or other criteria as determined by the Division. Individual waste storage lagoons shall not exceed 100 acre-feet in volume.

6. <u>Employee Training:</u> Where employees are responsible for work activities which relate to permit compliance, those employees must be regularly trained or informed of any information pertinent to the proper operation and maintenance of the facility and waste disposal. Each AFO or CAFO covered by this permit shall comply with the certified operator requirements in the State Rules as implemented by the Georgia Department of Agriculture.

7. <u>Facility Closure:</u> The CNMP should include emergency response planning and a closure plan for abandonment of any facility used for the treatment or storage of animal waste. In accordance with the State Rules, when the owner ceases operation of the AFO, he must notify the Division of that fact within three months, and he must properly close all waste storage lagoons within eighteen months. In the case of voluntary closure, a period of twenty-four months from notification is allowed. Proper closure of a lagoon entails removing all waste from the lagoon and land applying it at agronomic rates, and in a manner so as not to discharge to any surface water.

## D. Requirements for Land Application Activities Not Under the Control of the Permitted AFO or CAFO Operator.

In cases where AFO or CAFO generated manure is sold or given away to be used for land application activities that are not under the operational control of the permitted AFO or CAFO, such land application does not need to be addressed in the permitted AFO or CAFO's CNMP. However, the permittee must ensure the environmentally acceptable use of the AFO or CAFO generated manure by complying with the following conditions:

1. Maintain records showing the date and amount of manure and/or wastewater that leaves the permitted operation;

2. For quantities of greater than one pick-up truck load per recipient per day, record the name and address of the recipient ("one pick-up truck load" is defined as 2 short tons or 1.81 metric tons loaded on any type of vehicle);

3. Provide the recipient(s) with representative information on the nutrient content of the manure and/or wastewater to be used in determining the appropriate land application rates; and

4. Inform the recipient of his/her responsibility to properly manage the land application of the manure and/or wastewater to minimize the discharge of pollutants to waters of the U.S.

These records should be retained on-site, and should be submitted to the permitting authority upon request.

## PART IV. DISCHARGE MONITORING AND NOTIFICATION REQUIREMENTS

### A. Notification of Discharges from Retention Structures and Improper Land Application

If, for any reason, there is a discharge of pollutants to a water of the U.S., the permittee is required to make immediate oral notification within 24-hours to the local Division District Office (or, if after office hours, the Georgia Department of Natural Resources Emergency Operations Center, 1-800-241-4113) and notify the Division District Office in writing within five (5) working days of the discharge from the facility. In addition, the permittee shall keep a copy of the notification submitted to the Division together with the CNMP. The 5-day written discharge notification shall include the following information:

1. Description of the discharge: A description of the discharge and its cause, including a description of the flow path to the receiving water body and an estimate of the flow and volume discharged.

2. Time of the discharge: The period of non-compliance, including exact dates and times, the anticipated time it is expected to continue, and steps taken or planned to reduce, eliminate and prevent recurrence of the discharge.

### B. Monitoring Requirements for Discharges from Retention Structures

In the event of any overflow or other discharge of pollutants from a manure and/or wastewater storage structure, the following actions shall be taken:

1. Analysis of the discharge: All discharges shall be sampled and analyzed. Samples must, at a minimum, be analyzed for the following parameters: five-day biochemical oxygen demand ($BOD_5$); and total suspended solids.

2. Estimate volume of the discharge: Record an estimate of the volume of the release and the date and time.

3. Sampling procedures: Samples shall consist of grab samples collected from the overflow or discharges from the retention structure. A minimum of one sample shall be collected from the initial discharge (within 30 minutes of becoming aware of the discharge). The sample shall be collected and analyzed in accordance with EPA approved methods for water analysis listed in 40 CFR 136. Samples collected for the purpose of monitoring shall be representative of the monitored discharge.

4. Reasons for not sampling the discharge: In accordance with the State Rules, it shall be the permittee's duty to immediately take all reasonable and necessary steps to prevent injury to property and downstream water users. In the performance of this duty, the permittee may not have sufficient time and resources for sampling. Further, conditions may not be safe for sampling. For example, the permittee may be unable to collect samples during dangerous weather conditions (such as local flooding, high winds, hurricanes, tornadoes, electrical storms, etc.). However, the permittee shall collect a sample from the retention structure (pond or lagoon) from which the discharge occurred.

## C. General Inspection, Monitoring, and Record-keeping Requirements

The permittee shall inspect, monitor, and record the results of such inspection and monitoring in accordance with Table IV.C:

### IV.C. PERIODIC INSPECTION AND MONITORING REQUIREMENTS

| PARAMETER | UNITS | FREQUENCY |
|---|---|---|
| **Facility inspection**[1] | | |
| Review all facilities and land application areas addressed in the CNMP to evaluate whether measures to reduce pollutant loadings identified in the CNMP are adequately and properly implemented in accordance with the terms of the permit or whether additional control measures are needed. | NA | Annually |
| **Lagoon or storage structure monitoring and inspection** | | |
| Freeboard[2] | Feet | Weekly |
| Structural integrity (i.e., integrity of berms)[3] | NA | Weekly |
| Integrity of liners[4] | NA | Annually |
| **Sampling of waste/wastewater and land application soils**[5] | | |
| Sample waste and wastewater to determine available nutrient content (Total Kjeldahl Nitrogen and Nitrate Nitrogen) | ppm | See Part VII., State of Georgia Specific Permit Conditions. |
| Sample land application soils to determine pH and nutrient content (soil test phosphorus by Mehlich-1 extraction) | N/A | See Part VII., State of Georgia Specific Permit Conditions. |

| Table IV.C (CONTINUED) Land application activities | | |
|---|---|---|
| Duration of land application activities[5] | Hours/day | Daily |
| Quantity of waste/wastewater applied to land application fields[5] | Gallons/day or Cubic Feet/day | Daily |
| Application rate[5] | lb/acre | Daily |
| Application area[5] | Acres | Daily |
| **Precipitation** | | |
| Rainfall[6] | Inches | Daily |

Footnotes:

[1] A complete inspection of the facility shall be done and a report made annually.

[2] For lagoons or other liquid storage basins, report the water level as feet below the emergency overflow level. For solid manure storage structures, report the percentage of remaining storage capacity. See the State Rules for specific freeboard requirements.

[3] Documentation of compliance with this requirement must be compiled in an inspection report to be kept at the facility.

[4] Inspect visible portions of all liners for uniformity, damage, and imperfections as follows: 1) soil based and admixed liners for imperfections that may increase permeability, e.g., cracks and root holes; 2) synthetic liners for tight seams and joints, and absence of tears. Permittee shall document compliance with this requirement by preparing a report that must be kept at the facility.

[5] Monitor in accordance with Part VII., State of Georgia Specific Permit Conditions. Land application practices must be conducted in accordance with the permittee's CNMP.

[6] The permittee shall maintain a precipitation gauge at each permitted facility and record the rainfall for each 24-hour period.

## D. Additional Monitoring Requirements

1. Additional analysis: Part VII., State of Georgia Specific Permit Conditions contains requirements for routine monitoring of lagoon contents, ground water, and soils. Upon request by the Division, the permittee may be required to collect and analyze additional samples including but not limited to soils, surface water, ground water, and/or stored waste in a manner and frequency specified by the Division.

2. Additional monitoring for some high risk operations: Upon notification by the Division, the permittee may be required to conduct ambient monitoring of surface and/or ground water. For example, facilities with historical compliance problems, especially large facilities, facilities with significant environmental concerns, or facilities impacting impaired water bodies.

## PART V. STANDARD PERMIT CONDITIONS

### A. General Conditions

1. Introduction: In accordance with the provisions of 40 CFR Part 122.41, et. seq., this permit incorporates by reference ALL conditions and requirements applicable to NPDES Permits set forth in the Clean Water Act, as amended, (hereinafter known as the "Act") as well as ALL applicable regulations.

2. Duty to Comply: The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Act and is grounds for enforcement action; for permit termination, revocation, and reissuance; for denial of a permit renewal application; and/or for requiring a permittee to apply for and obtain an individual NPDES permit.

3. Toxic pollutants: The permittee shall comply with effluent standards and prohibitions established under section 307(a) of the Act for toxic pollutants within the time provided in the regulations that establish these standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement.

4. Permit actions: This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

5. Property rights: The issuance of this permit does not convey any property rights of any sort, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

6. Duty to provide information: The permittee shall furnish to the Division, within a reasonable time, any information which the Division may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit. The permittee shall also furnish to the Division, upon request, copies of records required to be kept by this permit.

7. Criminal and Civil Liability: Nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance. Any false or materially misleading representation or concealment of information required to be reported by the provisions of the permit, the Act, or applicable regulations, which avoids or effectively defeats the regulatory purpose of the permit may subject the permittee to criminal enforcement pursuant to 18 U.S.C. Section 1001.

8. State Laws: Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State Rule, law or regulation under authority preserved by Section 510 of the Act.

9. Severability: The provisions of this permit are severable, and if any provision of this permit or the application of any provision of this permit to any circumstance, is held

invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

**B. Proper Operation and Maintenance**

1. Need to halt or reduce activity not a defense: It shall not be a defense for a permittee in an enforcement action to plead that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

2. Duty to mitigate: The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

3. Proper operation and maintenance: The permittee shall, at all times, properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes the operation of backup or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of the permit.

**C. Monitoring and Records**

1. Inspection and entry: The permittee shall allow the Division or EPA, or an authorized representative of the Division or EPA, upon the presentation of credentials and other documents as may be required by law, to:

a) Enter the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

b) Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

c) Inspect, at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit,

d) Sample or monitor, at reasonable times, for the purpose of assuring permit compliance or as otherwise authorized by the Act, any substances or parameters at any location.

2. Representative sampling: Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

3. Retention of records: The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least three years from the date of the sample, measurement, report, or application. This period may be extended upon written notification by the Division.

4. Record content: Records of monitoring information shall include:

a) The date, exact place, and time of sampling or measurements;

b) The individual(s) who performed the sampling or measurements;

c) The date(s) analyses were performed;

d) The individual(s) who performed the analyses;

e) The analytical techniques or methods used; and

f) The results of such analyses.

5. Monitoring procedures:

a) Monitoring must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in this permit or approved by the Regional Administrator of the U.S Environmental Protection Agency (hereinafter "the Administrator").

b) The permittee shall calibrate and perform maintenance procedures on all monitoring and analytical instruments at intervals frequent enough to insure accuracy of measurements and shall maintain appropriate records of such activities.

c) An adequate analytical quality control program, including the analyses of sufficient standards, spikes, and duplicate samples to insure the accuracy of all required analytical results shall be maintained by the permittee or designated commercial laboratory.

## D. Reporting Requirements

1. Anticipated Noncompliance: The permittee shall give advance notice to the Division of any planned physical alterations or additions or changes in activity which may result in noncompliance with requirements in this permit.

2. Transfers: This permit is not transferable to any person except in accordance with Part VII., State of Georgia Specific Permit Conditions.

3. Twenty-four hour reporting: The permittee shall report any noncompliance that may endanger human health or the environment. Any information must be provided orally to within 24 hours from the time that the permittee becomes aware of the circumstances to the Division. A written submission shall also be provided to Division within 5 days of the time the permittee becomes aware of the circumstances. The 5-day written report shall contain the following information:

a) A description of the noncompliance and its cause;

b) The period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and,

c) Steps being taken to reduce, eliminate, and prevent recurrence of the noncompliance.

4. Other information: Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Division, it shall promptly submit such facts or information to the permitting authority.

**E. Signatory requirements**

All applications, reports, or information submitted to the Division shall be signed and certified consistent with 40 CFR §122.22:

1. All permit applications shall be signed as follows:

a) For a corporation: By a responsible corporate officer. For the purpose of this section, a responsible corporate officer means:

i) A president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision-making functions for the corporation; or,

ii) The manager of one or more manufacturing, production, or operating facilities, provided, the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures; or

b) For a partnership or sole proprietorship: By a general partner for a partnership or the proprietor, respectfully.

2. All reports required by the permit and other information requested by the Division shall be signed by a person described above or by a duly authorized representative of that person. A person is a duly authorized representative only if:

a) The authorization is made in writing by a person described above;

b) The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, owner of a well or a well field, superintendent, position of equivalent responsibility, or any individual or position having overall responsibility for environmental matters for the company. A duly authorized representative may thus be either a named individual or an individual occupying a named position; and,

c) The written authorization is submitted to the Division.

## F. Certification

Any person signing a document under this section shall make the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

## G. Availability of Reports

Any information submitted pursuant to this permit may be claimed as confidential by the submitter. If no claim is made at the time of submission, information may be made available to the public without further notice.

## H. Penalties for Violations - Federal Water Pollution Control Act

### 1. Criminal Penalties

a) Negligent violations: The Act provides that any person who negligently violates Section 301, 302, 306, 307, 308, 318, or 405 of the Act or any condition or limitation implementing those provisions in a permit issued under Section 402 is subject to a fine of not less than $2,750 nor more than $27,500 per day of violation, or by imprisonment for not more than one year, or both.

b) Knowing violations: The Act provides that any person who knowingly violates Sections 301, 302, 306, 307, 308, 318, or 405 of the Act or any permit conditions implementing those provisions is subject to a fine of not less than $5,500 nor more than $55,000 per day of violation, or by imprisonment for not more than three years, or both.

c) Knowing endangerment: The Act provides that any person who knowingly violates Sections 301, 302, 303, 306, 307, 308, 318, or 405 of the Act or permit conditions implementing those provisions and who knows at that time that he is placing another person in imminent danger of death or serious bodily injury is subject to a fine of not more than $275,000, or by imprisonment for not more than 15 years, or both.

d) False statements: The Act provides that any person who knowingly makes any false material statement, representation, or certification in any application, record, report, plan, or other document filed or required to be maintained under the Act or who knowingly falsifies, tampers with, or renders inaccurate, any monitoring device or method required to be maintained under the Act, shall upon conviction, be punished by a fine of not more than $11,000, or by imprisonment for not more than two years, or by both. If a conviction of a person is for a violation committed after a first conviction of such person under this paragraph, punishment shall be by a fine of not more than $22,000 per day of violation, or by imprisonment of not more than four years, or by both. [See Section 309(c)4 of the Act]

2. **Civil penalties**

The Act provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a civil penalty not to exceed $27,500 per day for each violation. [See Section 309(d)]

3. **Administrative penalties**

The Act provides that the Administrator may assess a Class I or Class II administrative penalty if the Administrator finds that a person has violated Sections 301, 302, 306, 307, 308, 318, or 405 of the Act or a permit condition or limitation implementing these provisions, as follows [See Section 309(g)]:

a) Class I penalty: Not to exceed $11,000 per violation nor shall the maximum amount exceed $27,500.

b) Class II penalty: Not to exceed $11,000 per day for each day during which the violation continues nor shall the maximum amount exceed $137,500.

### I. Penalties for Violations - Georgia Water Quality Control Act

See Part VII., State of Georgia Specific Permit Conditions.

## PART VI. DEFINITIONS

**"25-year, 24-hour storm event"** is the maximum 24-hour precipitation event expressed in inches with a probable recurrence interval of once in 25 years, as defined by the National Weather Service of the United States Department of Commerce in Technical Paper Number 40, "Rainfall Frequency Atlas of the United States," May 1961, and subsequent amendments.

**Animal feeding operation (AFO)** means a lot or facility (other than an aquatic animal production facility) where the following conditions are met: (i) animals (other than aquatic animals) have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and (ii) crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility. Two or more animal feeding operations under common ownership are considered to be a single animal feeding operation if they adjoin each other, or if they use a common area or system for the disposal of wastes.

**Animal unit (AU)** is a unit of measurement for any AFO calculated by adding the following numbers: the number of slaughter and feeder cattle multiplied by 1.0, plus the number of mature dairy cattle multiplied by 1.4, plus the number of swine weighing over 25 kilograms (approximately 55 pounds) multiplied by 0.4, plus the number of sheep multiplied by 0.1, plus the number of horses multiplied by 2.0.

a) "300 AU" means three hundred animal units. The numbers of animals in any of the following categories are equivalent to 300 AU:

1. 300 slaughter and feeder cattle,
2. 200 mature dairy cattle (whether milked or dry cows),
3. 150 horses,
4. 750 swine each weighing over 25 kilograms (approximately 55 pounds),
5. 3,000 sheep or lambs,
6. 16,000 turkeys,
7. 30,000 laying hens or broilers (if the facility has continuous overflow watering),
8. 9,000 laying hens or broilers (if the facility has a liquid manure handling system),
9. 1,500 ducks

b) "1000 AU" means one thousand animal units. The numbers of animals in any of the following categories are equivalent to 1000 AU:

1. 1,000 slaughter and feeder cattle,
2. 700 mature dairy cattle (whether milked or dry cows),
3. 2,500 swine each weighing over 25 kilograms (approximately 55 pounds),
4. 500 horses,
5. 10,000 sheep or lambs,
6. 55,000 turkeys,
7. 100,000 laying hens or broilers (if the facility has continuous overflow watering),
8. 30,000 laying hens or broilers (if the facility has a liquid manure handling system),
9. 5,000 ducks

c) "3000 AU" means three thousand animal units. The numbers of animals in any of the following categories are equivalent to 3000 AU:

1. 3,000 slaughter and feeder cattle,
2. 2,100 mature dairy cattle (whether milked or dry cows),
3. 7,500 swine each weighing over 25 kilograms (approximately 55 pounds),
4. 1,500 horses,
5. 30,000 sheep or lambs,
6. 165,000 turkeys,
7. 300,000 laying hens or broilers (if the facility has continuous overflow watering),
8. 90,000 laying hens or broilers (if the facility has a liquid manure handling system),
9. 15,000 ducks

**Application** means the EPA standard national forms for applying for an NPDES permit, including any additions, revisions or modifications to the forms; or forms approved by EPA for use in "approved States," including any approved modifications or revisions [e.g. for this NPDES general permit, Form 1 and 2B].

**Catastrophic rainfall event** is equivalent to a 25-year, 24-hour storm event. Catastrophic events include tornadoes, hurricanes, or other catastrophic conditions that would cause an overflow from the waste retention structure that is designed, constructed, operated, and maintained to meet all the requirements of this permit.

**Chronic rainfall** is a series of wet weather conditions that preclude dewatering of properly maintained waste retention structures.

**Concentrated animal feeding operation (CAFO)** means an "animal feeding operation" which meets the criteria in 40 CFR Part 122, Appendix B, or which the Director designates (see definition of designation below) as a significant contributor of pollution pursuant to 40 CFR 122.23. Animal feeding operations defined as "concentrated" in 40 CFR 122 Appendix B are as follows:

a. Operations that stable or confine and feed or maintain for a total of 45 days or more in any 12-month period more than the numbers of animals specified in any of the following categories:

    1. 1,000 slaughter or feeder cattle,
    2. 700 mature dairy cattle (whether milked or dry cows),
    3. 2,500 swine each weighing over 25 kilograms (approximately 55 pounds),
    4. 500 horses,
    5. 10,000 sheep or lambs,
    6. 55,000 turkeys,
    7. 100,000 laying hens or broilers (if the facility has continuous overflow watering),
    8. 30,000 laying hens or broilers (if the facility has a liquid manure handling system),
    9. 5,000 ducks, or
    10. 1,000 animal units;

b. Operations where pollutants are discharged into waters of the U.S. either: (a) through a man-made ditch, flushing system, or other similar man-made device, or (b) directly into waters of the U.S. which originate outside of and pass over, across, or through the facility or otherwise come into direct contact with the confined animals, and which stable or confine and feed or maintain for a total of 45 days or more in any 12-month period more than the numbers or types of animals in the following categories:

    1. 300 slaughter or feeder cattle,
    2. 200 mature dairy cattle (whether milked or dry cows),
    3. 750 swine each weighing over 25 kilograms (approximately 55 pounds),
    4. 150 horses,
    5. 3000 sheep or lambs,

6. 16,500 turkeys,
7. 30,000 laying hens or broilers (if the facility has continuous overflow watering),
8. 9000 laying hens or broilers (if the facility has a liquid manure handling system),
9. 1,500 ducks, or
10. 300 animal units.

Provided, however, that no animal feeding operation is a concentrated animal feeding operation as defined above if such animal feeding operation discharges only in the event of a 25-year, 24-hour storm event.

**Designation** means that the Division may designate any animal feeding operation as a concentrated animal feeding operation upon determining that it is a significant contributor of pollution to waters of the U.S. In making this determination, the Division shall consider the following factors:

1. The size of the animal feeding operation and the amount of wastes reaching waters of the United States,

2. The location of the animal feeding operation relative to waters of the United States,

3. The means of conveyance of animal wastes and process wastewater to waters of the United States,

4. The slope, vegetation, rainfall, and other factors affecting the likelihood or frequency of discharge of animal wastes and process wastewater into waters of the United States, and

5. Other relevant factors.

No animal feeding operation with less than the numbers of animals set forth in 40 CFR §122 Appendix B shall be designated as a concentrated animal feeding operation unless: (1) pollutants are discharged into waters of the U.S. through a manmade ditch, flushing system, or other similar manmade device; or (2) pollutants are discharged directly into waters of the U.S. which originate outside of the facility and pass over, across or through the facility or otherwise come into direct contact with the animals confined in the operation.

**Division** means the Environmental Protection Division of the Georgia Department of Natural Resources.

**EPA means the United States Environmental Protection Agency.**

**Ground water** means water below the land surface in a zone of saturation (40 CFR §258.2)

**Land application** means the application of manure and/or wastewater onto or by incorporation into the soil.

**Liner** means any barrier in the form of a layer, membrane or blanket, installed to prevent discharges to waters of the U.S.

**Process wastewater** means any process-generated wastewater and any precipitation (e.g., rain or snow) which comes into contact with any manure, litter or bedding, or any other raw material or intermediate or final material or product used in or resulting from the production of animal or poultry or direct products (e.g. milk, eggs).

**Process-generated wastewater** means any water directly or indirectly used in the operation of a feedlot for any of the following: spillage or overflow from animal or poultry watering systems; washing, cleaning or flushing pens, barns, manure pits, or other feedlot facilities; direct contact swimming, washing or spray cooling of animals, and dust control.

**Retention facility or retention structures** means all collection ditches, conduits and swales for the collection of runoff and wastewater, and all basins, ponds and lagoons used to store wastes, wastewater and manures.

**State Act** means the Georgia Water Quality Control Act (Official Code of Georgia Annotated; Title 12, Chapter 5, Article 2), as amended.

**State Rules** means the Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6, latest edition.

**The Act** means Federal Water Pollution Control Act as amended, also known as the Clean Water Act as amended, found at 33 USC 1251 et seq.

**Toxic pollutants** means any pollutant listed as toxic under Section 307(a)(1) of the Act.

**Waters of the United States** means: (1) all waters that are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters that are subject to the ebb and flow of the tide; (2) all interstate waters, including interstate wetlands; (3) all other waters such as intrastate lakes, rivers, and streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any such waters which are or could be used by interstate or foreign travelers for recreational or other purposes; from which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or, which are or could be used for industrial purposes by industries in interstate commerce; (4) all impoundments of waters otherwise defined as waters of the U.S.; (5) tributaries of waters identified in (1) through (4) of this definition; (6) the territorial sea; and (7) wetlands adjacent to waters (other than waters that are themselves wetlands) identified in items (1) through (6) of this definition.

## PART VII. STATE OF GEORGIA SPECIFIC PERMIT CONDITIONS

The permittee will conform to the specific permit conditions for land application systems at non-discharging NPDES permitted animal (non-swine) feeding operations effective June 13, 2002 hereby incorporated by reference in NPDES Permit No. GAG930000. These specific permit conditions consist of monitoring and reporting, limitations and monitoring requirements, general requirements, and special requirements.

# University of Georgia Swine Center

# CNMP

## *SWINE COMPREHENSIVE NUTRIENT MANAGEMENT PLAN*

**GA CNMP Generator, Version 06.4, Updated 10/01/2007**

Farm Name: UGA Swine Center
Owner: Board of Regents of the University System of Georgia
Address:

Telephone No:

Fax:
E-mail:

UGA Contact:

Farm Manager:

Farm Physical Address:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted, is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Owner/Operator ________________________________ date _______

Certified Planner ________________________________ date _______
GA Dept. of Agriculture # 0000

Certified Planner Contact phone ___ e-mail_

---

Review:
GA Dept. of Agriculture ________________________________ date _______

Approval:
*GA Dept. Nat. Res. EPD* ________________________________ *date* _______

## Farm Information

**Site Location:**

1.5 miles south of Athens Highway 10 Loop on S. Milledge Ave.

**Farm Description:**

The Swine Research Center is a farrow-to-finish operation located in Clarke County, Georgia. The facility is located in the Upper Oconee Watershed and located immediately adjacent to the State Botanical Garden of Georgia. The farm is located in gently rolling hills with dominant soil series mapped on the farm as Pacolet and Louisburg (see attached soils and topographic maps.) The center has an average inventory of 130 breeding animals producing an average inventory of approximately 2200 pigs per year. There are approximately 800 pigs over 55 pounds on the farm at any given time or just over 300 animal units. The facility consists of eleven buildings including 9 with pull-plug or wash-down manure handling systems, two dry-bedded manure barns, and a hoop structure used for composting mortalities. The teaching and research unit include one gestation, two farrowing, two nursery, two pit finishing barns, two dry bedded finishing barns, and two boar test buildings which are currently used as finishing barns. Some of these are totally enclosed buildings while others are partially open. Wastewater is irrigated on fields via a low-pressure reel traveling gun system.

All pull-plug facilities are emptied of waste once per week while wash down facilities are cleaned daily. There are four active lagoons on the farm (Lagoons 1, 2, 3 and 4 on the map). Lagoon 1 gravity flows to 2, and 2 is pumped into lagoon 3. Lagoon 1 is the primary treatment lagoon and contains most of the sludge. Lagoon 2 is a secondary treatment lagoon, and contains less sludge. Lagoon 4 is a primary lagoon for the two boar-test/finish buildings. Excess is pumped to 3. Lagoon 3 contains little sludge. Effluent is recirculated from this lagoon to refill the pits under slats in the buildings. Effluent can be pumped out of all four lagoons, but is primarily pumped from #3. Field 1receives lagoon waste water application while field 2 receives mortality compost and lagoon sludge periodically when lagoon sludge is removed from lagoons. Lagoons are agitated periodically as needed to reduce sludge accumulation. Lagoons are sampled either while being agitated or not depending upon whether agitation will be used during application.

Do animals have direct access to surface water while in confinement?
No.
Coordinates of Largest Building or Lagoon:

| | | | |
|---|---|---|---|
| Latitude | 33.903852 deg. N | Longitude | 83.37366 deg. W |

**Map Attached:**

| | |
|---|---|
| Site Location Map: | Yes. |
| Soils Map: | Yes. |
| Topographic Map: | Yes. |
| Farm Map: | Yes. |

## Waste Handling Systems on the Farm

System1: Anaerobic Lagoon - 2 or more Cells

1. Liner description: No engineered liner, built according to NRCS recommendations
   The four cells were installed at different times and by different engineers and agencies. See details below.

2. Size:
   Lagoon 1 installed in 1971 and is approximately 100 x 100 x 15-ft with a total capacity of 137,345 cu. ft. The liner is clay, but nothing is known about the degree of compaction or the exact type of clay. Lagoon 2 was also built in 1971 and is approx. 80 x 100 x 10 ft with a total capacity of 56,826 cu. ft. Again, the degree of compaction of the clay liner is unknown. Lagoon 3 was installed 12/1984 by Robert Stovall, NRCS engineer. It is approximately 100 x 140 x 15 and has a total capacity of 150,696 cu. ft. based on NRCS design at that time. Lagoon 4 was installed in 1973, designed by Edwards and Rosser, Consulting Engineers. It is approximately 100 x 100 x 8 ft. and has a total capacity of 46,464 from design plans. The clay liner was not tested or compacted to any known standard.

3. This system is designed to hold a 25yr/24hr storm event.

4. Capacity:
   a. Total to maximum fill height (ft3): 391,000
   b. Pumpable (Storage) (ft3): 130,000

5. Total storage time: 10 months

6. All surface water is diverted.

7. Leakage (prevention and inspection):
   All berms/diversions inspected for leaks, proper vegetative cover, tree growth, and rodent damage at least monthly.

8. Operating Levels (liquid systems) :
   Maximum liquid level (ft below overflow): 2
   Stop pumping level (ft below overflow): 8
   A gauge is present in the lagoon.

9. Solid separation: None

Note1: The four cells were installed at different times and by different engineers and agencies. (See details in item 2)
Note2: Operating levels apply to lagoon 3 only since others automatically overflow or are pumped into cell 3.
Freeboard for lagoon 1 is set by gravity overflow at 1.5 ft from top of berm.
Minimum freeboard for lagoon 2 is 3 ft and lagoon 4 is 2 ft. They are pumped to lagoon 3 whenever they reach that level or before.

System2: Manure and Bedding Held in Covered Structure

1. Storage structure:
   a. Storage pile covered by tarp - this is where manure removed from the hoop structure is stored until it is transported to the UGA Bioconversion center
   b. Hoop structure where morality is composted and stored

2. Size:
   a. 50 x 100 x 5 ft.
   b. 40 x 100 x 4 ft.

3. Capacity of Structure:
   a. 250,000 cu. ft
   b. 9600 cu. ft

4. Storage Capacity:
   a. 2 years
   b. 10 years

5. All surface water is diverted from the storage area.

6. Inspection:
   Structures or storage areas are checked regularly to ensure storm water does not enter manure storage.

Note1: Storage pile is used to temporarily store manure and bedding from dry bedded buildings only. Material is transported periodically (every 1-2 years) to UGA Bioconversion Center for composting

## Manure nutrient generation calculation

### Annual Average Manure Generation based on calculator

| Number of Swine | | | Unit | N | P205 | K20 |
|---|---|---|---|---|---|---|
| Sows | 130 | Lagoon Liquid | lbs/acre-inch | 44 | 26 | 68 |
| Boars | 2 | Lagoon Solids | lbs/1000gal | 38 | 116 | 9 |
| Gilts | 25 | Separated Solids | lbs/ton | 0 | 0 | 0 |
| Nursing Pigs | 2250 | Slurry | lbs/ton | 0 | 0 | 0 |
| Grow/Finish | 2200 | Manure Solids | lbs/ton | 16 | 22 | 12 |
| | | Composted Mortality | lbs/ton | 29 | 25 | 13 |

Notes for nutrient analysis: Nutrient concentrations were determined using an average of all samples analyzed from 2005-2008.

| Nutrition Excretion (Pounds/Year) | | |
|---|---|---|
| | Total | Collected |
| Nitrogen(N) | 26382 | 26382 |
| Phosphate(P2O5) | 16418 | 16418 |
| Potash(K2O) | 14343 | 14343 |

| Nutrients After Storage Losses (Pounds/Year) | | | | |
|---|---|---|---|---|
| Type | N | | P2O5 | K2O |
| | Low | High | | |
| Lagoon Liquid | 2021 | 4041 | 4454 | 7360 |
| Separated Solids | 0 | 0 | 0 | 0 |
| Slurry | 0 | 0 | 0 | 0 |
| Manure Solids | 2779 | 3396 | 3507 | 2869 |
| Total | 4799 | 7438 | 7961 | 10229 |
| Lagoon Solids | 1010 | 1010 | 7636 | 2265 |
| Composted Mortality | 29 | 29 | 13 | 25 |
| **Grand Total** | 5839 | 8477 | 15623 | 12507 |

## Land application

### Land application methods:

Method 1: Big Gun Irrigation

1. There are 1 systems of this type.
2. Description: The gun system was installed and began operation February 13, 2009. The system has a 3 inch hard hose reel with a maximum length of 400 ft. and a flow rate of 125 gal/min. Width of wetted area was measured to be 180 feet.

Method 2: Dry Manure Spreader

1. There are 1 systems of this type.
2. Description: Flail type rear discharge box spreader: dimensions of spreader are 15'x5'x2' which on average has the capacity of hold 4.5 tons of material from the solid separator. The application width is 20 ft.

## Field application:

| | | | | |
|---|---|---|---|---|
| Field No. | 1 | Soil Test P | 470 | |
| Field Name | Field 8 | Soil Test K | 123 | |
| Field Size | 9.1 | pH | 5.77 | |
| Spreadable Acres | 9 | Manure used | Lagoon Liquid | |
| Soil Series | PACOLET | App. Method | Irrigated | |
| Real. Yield Exp. | 3 T/acre and 6T/acre | | | |
| Crops | Fescue/Bermuda | | | |
| Nutrient Balance (lbs/A) | | N | P2O5 | K2O |
| Crop Nutrient Needs: | | 225 | 0 | 85 |
| Commercial Fertilizer Used: | | 0 | 0 | 0 |
| Manure Nut. Conc. lbs/A-Inch | | 44 | 26 | 68 |
| Residual N From Legumes: | | 0 | | |
| N based application: 10.2 Inches/A | | | | |
| Applied | | 225 | 213 | 695 |
| Balance | | 0 | 213 | 610 |
| P based application: 0 Inch/A | | | | |
| Applied | | 0 | 0 | 0 |
| Balance | | -225 | 0 | -85 |
| Actual application: 9 Inch/A | | | | |
| Applied | | 198 | 187 | 612 |
| Balance | | -27 | 187 | 527 |
| | | | | |
| | | | | |

| | | | | | |
|---|---|---|---|---|---|
| P – Index | | | | | |
| Soil Test P (P2O5 lb/A) | 470 | Fertilizer P (P2O5 lb/A) | N/A | Organic P (P2O5 lb/A) | 187 |
| Fertilizer P Method | N/A | Organic P Method | Irrigated | | |
| Curve Number for runoff | 58 | Yearly Erosion (tons/A/yr) | 5 | Vegetated Buffer Width (feet) | 0 |
| Hydrologic Soil Group | B | Depth to Water Table (feet) | 10 | Soil Test P of Buffer (lb P/A) | 0 |
| P-Index: | 33 | | | | |
| P-Index description: | Low Risk | | | | |
| Note | | | | | |

| | |
|---|---|
| BMPs | |
| BMPs: | 1. Application timing: no wet weather application |
| Application timing: | Manure is applied to field 1 year round except for 2 weeks before harvest. With the new traveling gun system, on average the gun is ran 2- 400 ft pulls twice a week. Each 400 ft pull applies a total of 0.55 ac-inches which equals 2.2 ac-inches applied each week. Manure will need to be applied a total of 82 days throughout the year to meet the planned total of 90 ac-inches. Pulls will be appropriately spaced so that manure is applied evenly across the 9 acres. |
| Note | |

| Field No. | 2 | Soil Test P | 88.22 |
|---|---|---|---|
| Field Name | 2 | Soil Test K | 608 |
| Field Size | 5.3 | pH | 5.5 |
| Spreadable Acres | 5 | Manure used | Lagoon Solids |
| Soil Series | PACOLET | App. Method | Irrigated |
| Real. Yield Exp. | 5 tons/acre | | |
| Crops | mixed grass | | |

| **Lagoon Solids - Irrigated** | | | |
|---|---|---|---|
| Nutrient Balance (lbs/A) | N | P2O5 | K2O |
| Crop Nutrient Needs: | 150 | 0 | 0 |
| Commercial Fertilizer Used: | 0 | 0 | 0 |
| Manure Nut. Conc. lbs/1000gal | 38 | 116 | 9 |
| **N based application: 9.9 1000gal/A** | | | |
| Applied | 150 | 801 | 89 |
| Balance | 0 | 801 | 89 |
| **P based application: 0 1000gal/A** | | | |
| Applied | 0 | 0 | 0 |
| Balance | -150 | 0 | 0 |
| **Actual application: 10 1000gal/A** | | | |
| Applied | 152 | 812 | 90 |
| Balance | 2 | 812 | 90 |

| P – Index | | | | | |
|---|---|---|---|---|---|
| Soil Test P (P2O5 lb/A) | 88.22 | Fertilizer P (P2O5 lb/A) | N/A | Organic P (P2O5 lb/A) | 812 |
| Fertilizer P Method | N/A | Organic P Method | Irrigated | | |
| Curve Number for runoff | 58 | Yearly Erosion (tons/A/yr) | .6 | Vegetated Buffer Width (feet) | 0 |
| Hydrologic Soil Group | B | Depth to Water Table (feet) | 12 | Soil Test P of Buffer (lb P/A) | 0 |
| P-Index: | 33 | | | | |
| P-Index description: | Low Risk | | | | |

| **Mortality Compost - Surface applied not incorporated, May-Oct** | | | |
|---|---|---|---|
| Nutrient Balance (lbs/A) | N | P2O5 | K2O |
| Crop Nutrient Needs: | 150 | 0 | 0 |
| Commercial Fertilizer Used: | 0 | 0 | 0 |
| Manure Nut. Conc. lbs/ton | 29 | 25 | 13 |
| Residual N From Legumes: | 0 | | |
| **N based application: 10.3 tons/A** | | | |
| Applied | 150 | 181 | 121 |
| Balance | 0 | 181 | 121 |
| **P based application: 0 tons/A** | | | |
| Applied | 0 | 0 | 0 |
| Balance | -150 | 0 | 0 |
| **Actual application: 5 tons/A** | | | |
| Applied | 72 | 88 | 59 |
| Balance | -78 | 88 | 59 |

| P – Index | | | | | |
|---|---|---|---|---|---|
| Soil Test P (P2O5 lb/A) | 88.22 | Fertilizer P (P2O5 lb/A) | N/A | Organic P (P2O5 lb/A) | 87.5 |
| Fertilizer P Method | N/A | Organic P Method | Surface applied, not incorporated, May-Oct | | |
| Curve Number for runoff | 58 | Yearly Erosion (tons/A/yr) | .6 | Vegetated Buffer Width (feet) | |
| Hydrologic Soil Group | B | Depth to Water Table (feet) | 12 | Soil Test P of Buffer (lb P/A) | 0 |
| P-Index: | 12 | | | | |
| P-Index description: | Low Risk | | | | |
| Note | | | | | |

| BMPs | |
|---|---|
| BMPs: | 1. Terraces or other water control structures<br>2. Application timing: no wet weather application<br>3. Application timing: apply only within 1 month of maximum plant nutrient uptake |
| Application timing: | Lagoon Solids are agitated and applied in the spring once every 5 years at the rate above. Same with the composted mortality, it will be applied at the rate above every 5 years |
| Note | Soil Sample for this field is from 2005 but no nutrients have been applied for the past 4 years |

## Land Application Summary: Lagoon Liquid

| Field No. | N | P2O5 | Application Method |
|---|---|---|---|
| 1 | 3564 | 2106 | Irrigated |

| | N (lbs) | P2O5 (lbs) |
|---|---|---|
| Total Manure(lagoon Liquid) Nutrient Used on Field 1: | 3564 | 2106 |
| Total Manure (Lagoon Liquid) Nutrient Generated on Farm: | 2021 | 4454 |
| Balance: | -1543 | 2348 |

| | N (lbs) | P2O5 (lbs) | Excess | |
|---|---|---|---|---|
| Lagoon Liquid | -1543 | 2348 | -35 | (A-Inches) |

Lagoon Solids and Mortality Compost are not applied every year - typically applied once every 5 years. Lagoon solids and mortality compost will NOT be applied in the same year. Below is the application summary for the 5 year application

## Land Application Summary (5 year): Manure Solids, Lagoon Solids, and Mortality Compost

| Field No. | N | P2O5 | Application Method |
|---|---|---|---|
| 2 | 2625 | 6425 | Multiple |

| | N (lbs) | 5 yr N (lbs) | P2O5 (lbs) | 5 yr P2O5 (lbs) |
|---|---|---|---|---|
| Total Manure Nutrient Used on Field: | | 2625 | | 6425 |
| Total Manure Nutrient Generated on Farm (except lagoon liquid): | 3934 | 19670 | 11268 | 56340 |
| Balance: | | 17045 | | 49915 |

| **5 Year Total** | N (lbs) | P2O5 (lbs) | Excess | |
|---|---|---|---|---|
| Manure Solids | 13895 | 17535 | 868 | (tons) |
| Lagoon Solids | 3150 | 32380 | 83 | (1000 gal) |
| Manure Solids | 0 | 0 | 0 | (tons) |

## Off Farm Application

| Off Farm Application | |
|---|---|
| Amount Removed from Farm (tons, gal, etc.) | Person or Company that will purchase or remove manure and end use |
| 174 tons manure from hoop structures | All manure solids from hoop barns are transported to the UGA Bioconversion Center for composting |
| 83 (1000 gal) | Transported to across Milledge to the Beef unit |

## Emergency Action Plan

***As part of this plan, the following is made available and each employee is trained and aware of the following procedures. All that apply are checked:***

| | |
|---|---|
| Y | Emergency Phone Number List Posted at Each Phone **(required)** |
| N | General Farm Information Sheet and Facility Map |
| N | Location of Pre-Arranged Emergency Supply Equipment and Supplies |
| Y | Runoff Retention Plan **(required)** |
| Y | Fire Emergency Information and Response Plan |
| Y | Power Outage Information |
| Y | Information and Medical Emergency Response Procedures |

## General Emergency Action Plan

| | |
|---|---|
| Farm name and phone number: | UGA Swine Center 404.656.2249 - Sandra Neuse (Leagal Representation for Board of Regents) |
| UGA Contact:<br><br><br><br>Farm Manager:<br><br>Exact location/address: | Dr. Robert Shulstad<br>109 Conner Hall<br>Athens, GA 30602<br><br>Mike Daniel<br><br>2500 S Milledge Ave., Athens, GA 30605<br>706-369-5721 |
| Directions to the farm: | 1.5 miles south of Athens Hiway 10 Loop on S. Milledge Ave. |

**Fire Emergency Response Information**

| | |
|---|---|
| Farm Fire Protection District | Clarke County Post 13 |
| 911 Coordinates for farm | 2500 South Milledge Ave, Athens, GA 30605 |
| Is there a disconnect between the meter base and the buildings? | Yes |
| If so, where? | On the pole underneath each of the 3 meters |
| Do you have a standby alternator? | No |
| Give the location (sketch preferable) of electrical panels in buildings | Every building has a disconnect either on a pole just outside the structure or at a very visible location just inside the door |
| Location and size of propane tanks | 3- 500 gal propane tanks 1-south of the prefab small nursery, 1-north of the second nursery, 1-west end of farrow |
| Are there hazardous materials stored in facilities | No |

**Known medical conditions for EMS personnel:**

| Name | Condition(s) |
|---|---|
| | |
| | |

## Emergency Phone List and Manure Spill Procedure

**In Case Of Manure Spill:**

1) Shut off all flow in to storage areas, lagoons, or land application areas.

2) Contact Farm Supervisors:

| | Name | Phone |
|---|---|---|
| Primary contact (Owner/Operator): | Mike Daniel | 706-769-6853 |
| Second contact: | Robert Dove | 706-583-0796 |

3) Contact Emergency or Assistance Agencies:
General Emergency Response: 911
Spill Reporting: 1-800-241-4113

| | Name | Phone |
|---|---|---|
| Local fire department: | | 911 |
| Local police department: | UGA Police | 542-2200, 911 |
| Local EPD: | Stephanie Cahill | 706-369-6376 |
| Local health department: | | 706-542-8600 |
| Pumping assistance: | Oconee RC&D | 706-769-7922 |
| Local NRCS office: | Oconee Co. | 706-769-3990 |
| Extension office: | Clarke Co. | 706-613-3640 |
| Additional help: | Gale Webber | 706-353-9708 |
| Gas company: | Amerigas | 706-742-2185 |
| Power company: | GA Power | 888-660-5890 |
| Additional emergency response procedures: | | |
| All employees are made aware of the emergency response procedures. | | |

Be prepared to provide the following information during emergency:

- *Your name.*
- *Description of Emergency.*
- *Estimated amounts of spill, area covered, distance traveled from storage area.*
- *Whether manure has reached ditches, waterways, streams or crossed property lines.*
- *Any obvious damage: employee injury, fish kill, or property damage.*
- *What is being done and what assistance is needed.*

4) Contain spill, prevent further movement.

5) Begin clean-up and complete report documents and procedures.

## Mortality management

| | | | | |
|---|---|---|---|---|
| Typical annual mortality rates(animals/yr) | | 4 sows, 150 newborns, 34 nursery pigs, 42 finishers | | |
| Estimate description | Past Experience | | | |
| Disposal practice methods (%) | | | | |
| Burial/Pit | Composting | Incineration | Rendering | Other |
| 0 | 100 | 0 | 0 | 0 |
| Catastrophic mortality plan | Site identified for mass burial. OR<br>UGA Vet School Incinerator<br>State Vet's office will be consulted in any incidence of catastrophic mortality. | | | |
| Dept. Agriculture Permit Number | | | Permit applied for | |

## Closure Plan

When the lagoons are is no longer needed, we plan to close all 4 cells down by removing pipes that empty into the lagoons, removing as much waste as possible, and either converting it to a pond or restoring the ground to its approximate original shape. The waste will be applied on agricultural land at agronomic rates in a manner that will not allow runoff into streams or neighboring property. All exposed earth will be re-vegetated to prevent erosion. All composted mortality material will be land applied and all manure material in hoop structures will be removed and transported to UGA Bioconversion Center for composting

Appendix A

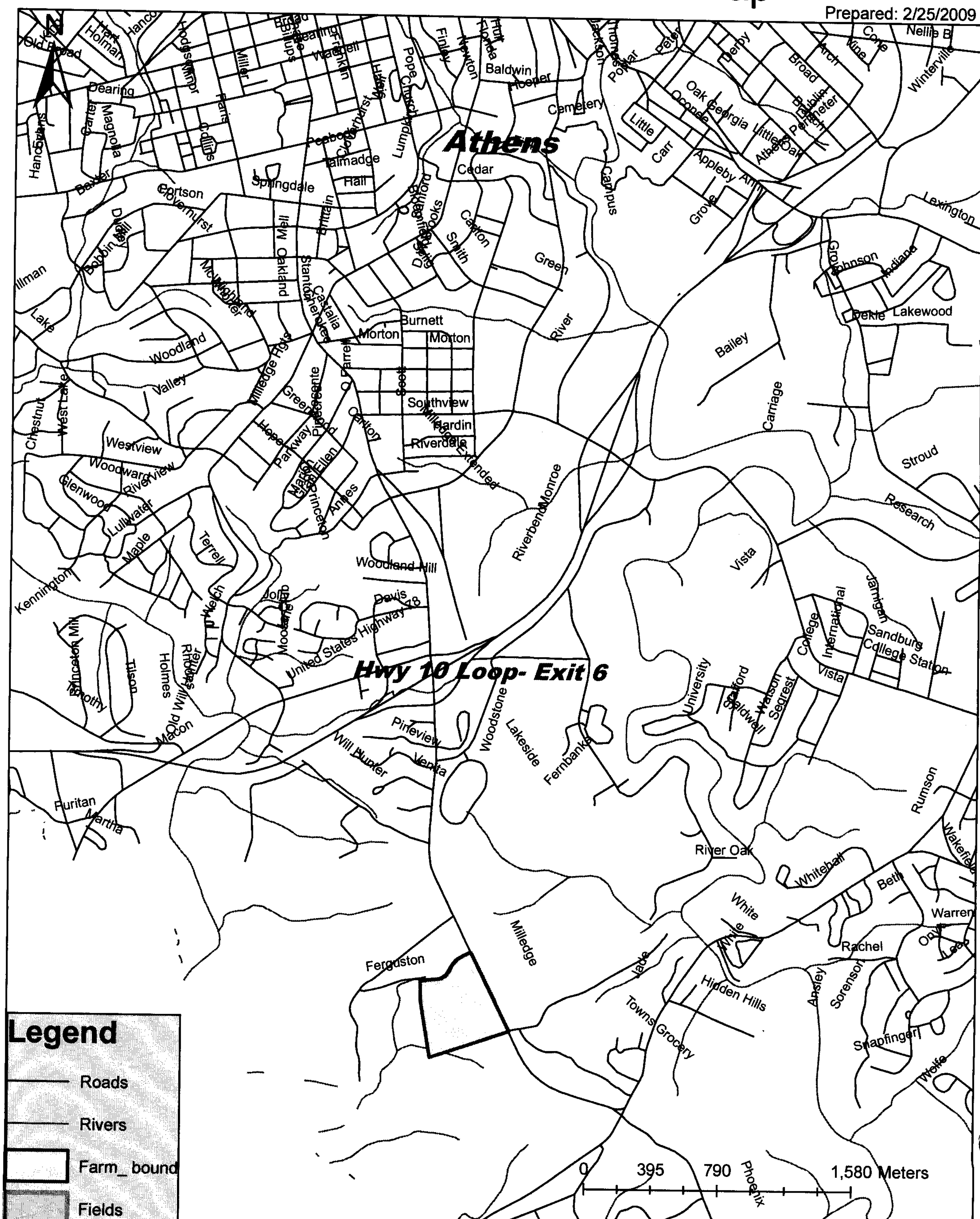
## Records kept on farm

**Yields** (Records of actual crop yields harvested from fields where manure is applied)

**Soil tests** (Copies of all soil test results from fields where manure is applied)
**Manure analysis** (Copies of all manure analyses)
**Water quality monitoring** (if required by permit – required for all NPDES permits for liquid manure systems and for some LAS permits when designated by EPD)

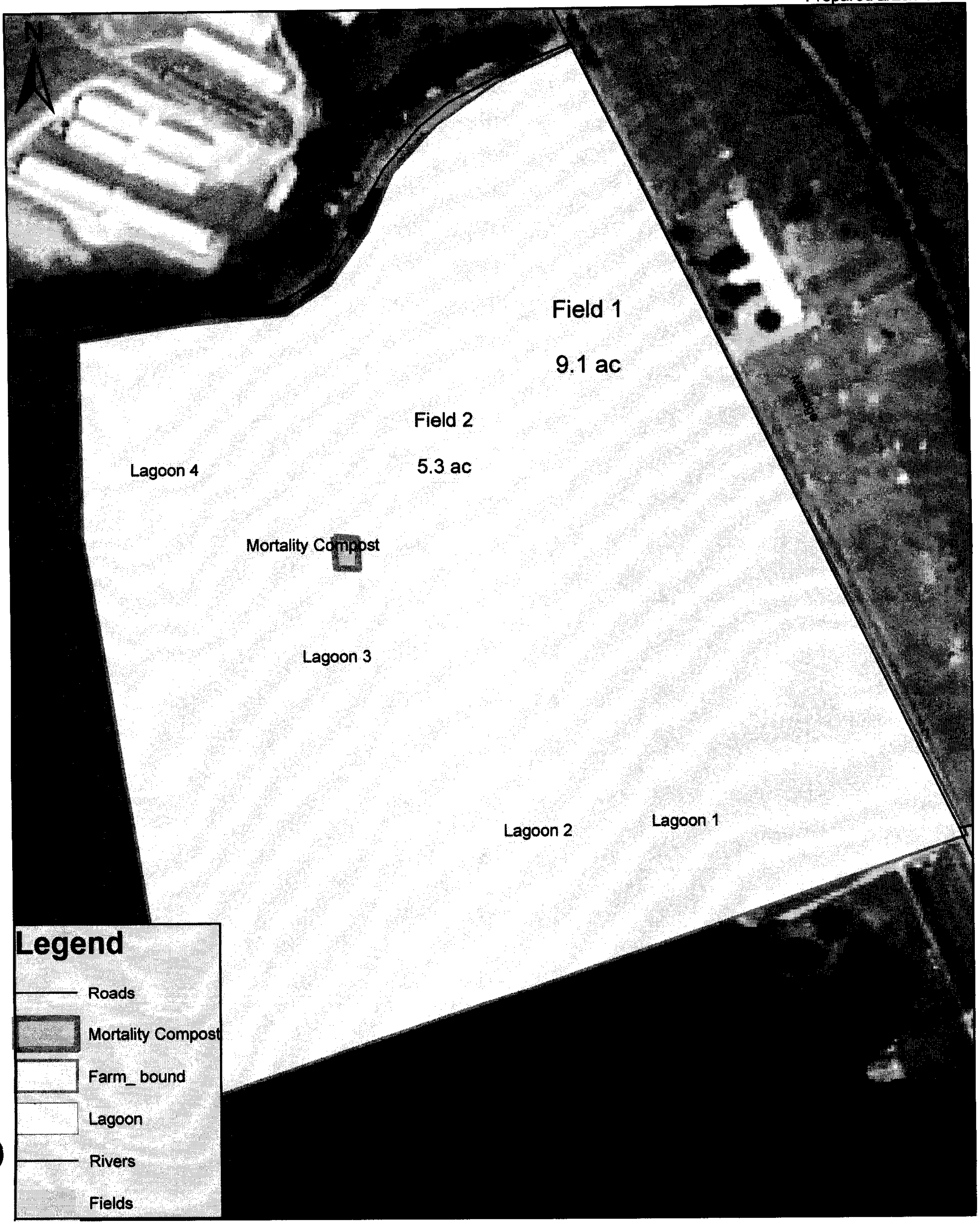
**Land application** (records of each application event)
**Off-farm shipment records**
**Inspection checklists** (for lagoons/manure storage structures/diversions) (Weekly if NPDES permit, monthly otherwise)
**Equipment calibration and maintenance**
(Records of **Annual calibration for all application equipment** and any maintenance event that might affect the performance of application equipment, i.e. replacement of nozzles, rebuilding of pumps)
**Any changes made to Nutrient Management Plan**
(Including Field nutrient budget sheets, changes in application equipment, number of animals)
**Daily Rainfall Records**

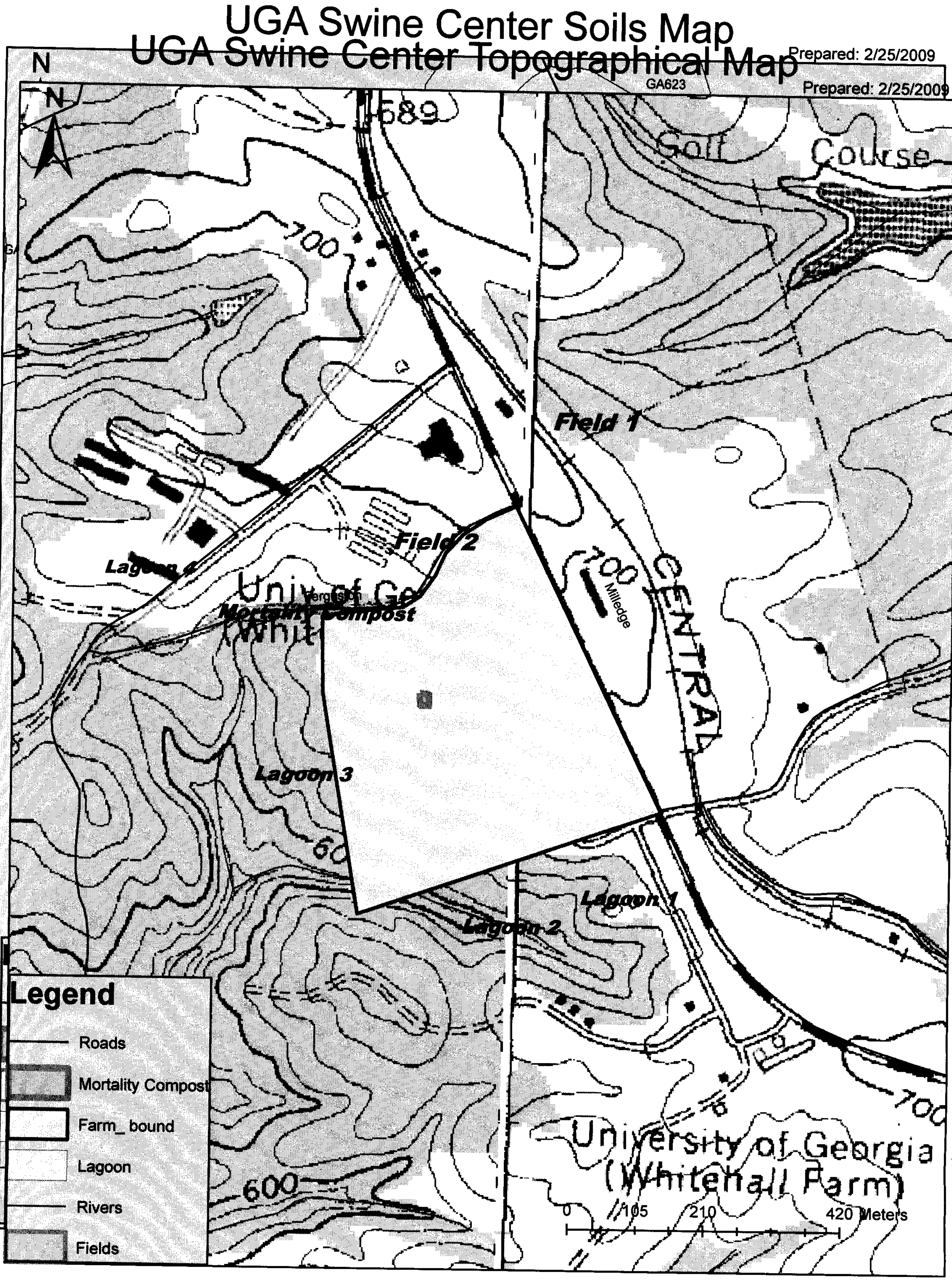
# UGA Swine Center Location Map



# UGA Swine Center Farm Map

Prepared 2/25/2009




UGA Swine Center Soils Map
UGA Swine Center Topographical Map
Prepared: 2/25/2009
Prepared: 2/25/2009
N
N
GA623
689
700
Golf Course
Field 1
Field 2
Lagoon 4
Univ of Ge
Whit
Mortality Compost
700
Milledge
CENTRAL
Lagoon 3
60
Lagoon 1
Lagoon 2
Legend
Roads
Mortality Compost
Farm_ bound
Lagoon
Rivers
Fields
700
600
University of Georgia
(Whitehall Farm)
0
105
210
420 Meters

## *Field 1*

# UGA Research Soil Report

### Soil, Plant, and Water Laboratory

| *Client Information* | *Lab Information* | *Contact* |
|---|---|---|
| **Mike Daniel**<br>Animal & Dairy Science, Swine Center | Completed: Nov 25, 2008<br>Printed: Feb 18, 2009 | **Soil, Plant, and Water Laboratory**<br>2400 College Station Road<br>Athens, GA 30602<br>ph: 706-542-5350<br>e-mail: soiltest@uga.edu |

## Results

| | | |
|---|---|---|
| **Lab** | | 19978 |
| **Sample** | | **S1** |
| **LBC [1]** (mg/kg $CaCO_3$/pH) | | **643.0** |
| **$pH_{CaCl_2}$ [2]** | | **4.97** |
| **Equivalent water pH** | | **5.57** |
| **Ca** | (mg/kg) | **3094** |
| **K** | (mg/kg) | **123.0** |
| **Mg** | (mg/kg) | **290.4** |
| **Mn** | (mg/kg) | **38.64** |
| **$NH_4$-N** | (mg/kg) | **4.210** |
| **$NO_3$-N** | (mg/kg) | **46.72** |
| **P** | (mg/kg) | **470.5** |

## *Field 2*

# UGA Soil Report

**Soil, Plant, and Water Laboratory**

| *Client Information* | *Lab Information* | *Contact* |
|---|---|---|
| **Mike Daniel**<br>Animal & Dairy Science | Completed: Jun 24, 2005<br>Printed: Feb 18, 2009 | **Soil, Plant, and Water Laboratory**<br>2400 College Station Road<br>Athens, GA 30602<br>ph: 706-542-5350<br>e-mail: soiltest@uga.edu |

## Results

| | |
|---|---|
| **Lab** | 61810 |
| **Sample** | SS |
| **LBC** [1] (mg/kg $CaCO_3$/pH) | **708.0** |
| $\mathbf{pH_{CaCl_2}}$ [2] | **4.92** |
| **Equivalent water pH** | **5.52** |
| **Ca** (lbs/acre) | **1868** |
| **K** (lbs/acre) | **608.0** |
| **Mg** (lbs/acre) | **407.2** |
| **Mn** (lbs/acre) | **46.66** |
| **P** (lbs/acre) | **88.22** |
| **Zn** (lbs/acre) | **31.65** |

## UGA Swine Center Manure Analysis 2005-2008

| Date | Lab | Sample | Name | Address | Type | ppm TKN | ppm P | ppm K |
|---|---|---|---|---|---|---|---|---|
| 12/20/2005 | 789 | L-1 | Mike Daniel | UGA Swine Center | Lagoon Effluent | 204.0 | 47.5 | 220.8 |
| 12/20/2005 | 789 | L-1 | Mike Daniel | UGA Swine Center | Lagoon Effluent | 204.0 | 47.5 | 220.8 |
| 7/17/2006 | 1975 | L-1 | Mike Daniel | UGA Swine Center | Lagoon Effluent | 169.0 | 58.1 | 311.6 |
| 3/16/2007 | 1016 | L-1 | Mike Daniel | UGA Swine Center | Lagoon Effluent | 205.0 | 50.0 | 255.4 |
| 1/11/2008 | 596 | SL-2 | Mike Daniel | UGA Swine Center | Lagoon Effluent | 192.0 | 50.3 | 246.6 |
| Notes: | P x 2.29 = P2O5 | | | | Average | 194.8 | 50.7 | 251.0 |
| | K x 1.2 + K2O | | | | | N | $P_2O_5$ | $K_20$ |
| | ppm x 0.2269 = lbs/ac-in | | | | Average lbs/ac-in | 44.2 | 26.3 | 68.4 |

| Date | Lab | Sample | Name | Address | Type | ppm TKN | ppm P | ppm K |
|---|---|---|---|---|---|---|---|---|
| 12/20/2005 | 790 | SL-1 | Mike Daniel | UGA Swine Center | Lagoon Sludge | 5877.0 | 5396.0 | 580.0 |
| 12/20/2005 | 790 | SL-1 | Mike Daniel | UGA Swine Center | Lagoon Sludge | 5877.0 | 5396.0 | 580.0 |
| 7/17/2006 | 1976 | SL-1 | Mike Daniel | UGA Swine Center | Lagoon Sludge | 5329.0 | 7944.0 | 1210.6 |
| 3/16/2007 | 1017 | LS-1 | Mike Daniel | UGA Swine Center | Lagoon Sludge | 7112.0 | 3674.0 | 608.8 |
| 6/28/2007 | 1580 | 1 | Mike Daniel | UGA Swine Center | Lagoon Sludge | 4025.0 | 8256.0 | 559.4 |
| 6/28/2007 | 1581 | 2 | Mike Daniel | UGA Swine Center | Lagoon Sludge | 3796.0 | 13144.0 | 1844.8 |
| 6/28/2007 | 1582 | 4 | Mike Daniel | UGA Swine Center | Lagoon Sludge | 3484.0 | 5728.0 | 1574.0 |
| 1/11/2008 | 595 | SL-1 | Mike Daniel | UGA Swine Center | Lagoon Sludge | 2320.0 | 2324.0 | 514.8 |
| 11/17/2008 | 739 | LS1 | Mike Daniel | UGA Swine Center | Lagoon Sludge | 2861.0 | 2544.0 | 591.8 |
| Notes: | P x 2.29 = P2O5 | | | | Average | 4520.1 | 6045.1 | 896.0 |
| | K x 1.2 + K2O | | | | | N | $P_2O_5$ | $K_20$ |
| | ppm x 0.00835 = lbs/1,000 gal | | | | Avg lbs/1,000 gal | 37.7 | 115.6 | 9.0 |

| Date | Lab | Sample | Name | Address | Type | ppm TKN | ppm P | ppm K |
|---|---|---|---|---|---|---|---|---|
| 3/19/2007 | 2154 | MC-2 Swine | Mike Daniel | UGA Swine Center | Manure Compost | 10393.0 | 5496.0 | 6404.0 |
| 3/19/2007 | 2155 | MC-1 (Morta | Mike Daniel | UGA Swine Center | Manure Compost | 3480.0 | 2500.0 | 1623.4 |
| 1/15/2008 | 1184 | 2 | Mike Daniel | UGA Swine Center | Manure Compost | 6820.0 | 4936.0 | 3730.0 |
| 7/17/2006 | 6 | C-2 | Mike Daniel | UGA Swine Center | Manure Compost | 5746.0 | 4410.0 | 4998.0 |
| 11/17/2008 | 741 | MC1 | Mike Daniel | UGA Swine Center | Manure Compost | 13084.0 | 6260.0 | 7860.0 |
| Notes: | P x 2.29 = P2O5 | | | | Average | 7904.6 | 4720.4 | 4923.1 |
| | K x 1.2 + K2O | | | | | N | $P_2O_5$ | $K_20$ |
| | ppm x 0.002 = lb/ton | | | | Avg lbs/ton | 15.8 | 21.6 | 11.8 |

| Date | Lab | Sample | Name | Address | Type | ppm TKN | ppm P | ppm K |
|---|---|---|---|---|---|---|---|---|
| 7/17/2006 | 5 | C-1 | Mike Daniel | UGA Swine Center | Mortality Compost | 7265.0 | 5912.0 | 5910.0 |
| 1/15/2008 | 1183 | 1 | Mike Daniel | UGA Swine Center | Mortality Compost | 16100.0 | 3086.0 | 3656.0 |
| 11/17/2008 | 691 | MC2 | Mike Daniel | UGA Swine Center | Mortality Compost | 19369.0 | 7140.0 | 6090.0 |
| Notes: | P x 2.29 = P2O5 | | | | Average | 14244.7 | 5379.3 | 5218.7 |
| | K x 1.2 + K2O | | | | | N | $P_2O_5$ | $K_20$ |
| | ppm x 0.002 = lb/ton | | | | Avg lbs/ton | 28.5 | 24.6 | 12.5 |