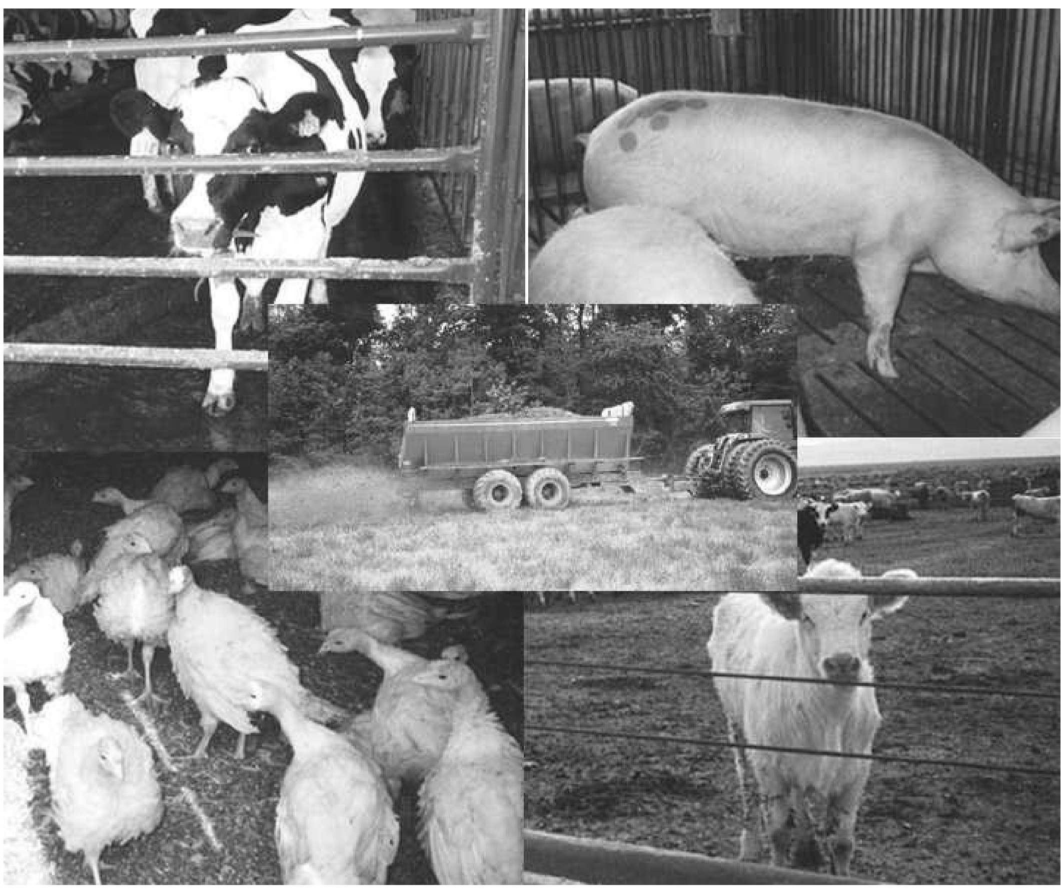
United States
Environmental Protection
Agency

Office of Water (4303)
Washington, DC 20460

EPA-821-R-01-003
January 2001

Development Document for the Proposed Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations



Development Document for the Proposed Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations

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January 2001

ACKNOWLEDGMENTS AND DISCLAIMER

This report has been reviewed and approved for publication by the Engineering and Analysis Division, Office of Science and Technology. This report was prepared with the support of Tetra Tech, Inc., and Eastern Research Group, Inc., under the direction and review of the Office of Science and Technology.

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CHAPTER 1

INTRODUCTION AND LEGAL AUTHORITY

1.0 INTRODUCTION AND LEGAL AUTHORITY

This chapter presents an introduction to the regulations being revised for the concentrated animal feeding operations (CAFOs) industry and describes the legal authority that the U.S. Environmental Protection Agency (EPA) has to revise these regulations. Section 1.1 describes the Clean Water Act; Section 1.2 reviews the Pollution Prevention Act; and Section 1.3 describes the Regulatory Flexibility Act.

1.1 Clean Water Act (CWA)

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Section 101(a)). The CWA gives EPA the authority to regulate point source discharges (including CAFOs) into waters of the United States through the National Pollutant Discharge Elimination System (NPDES) permitting program. Under the CWA, EPA issues effluent limitations guidelines, pretreatment standards, and new source performance standards for point sources, other than publicly owned treatment works (POTWs). Direct dischargers must comply with effluent limitations in NPDES permits, while indirect dischargers must comply with pretreatment standards. The remainder of this section describes the NPDES and effluent limitations guidelines and standards, as they apply to the CAFOs industry.

On October 30, 1989, Natural Resources Defense Council, Inc., and Public Citizen, Inc., filed an action against EPA in which they alleged, among other things, that EPA had failed to comply with CWA Section 304(m). *Natural Resources Defense Council, Inc., et al.* v. *Reilly*, Civ. No. 89-2980 (RCL) (D.D.C.). Plaintiffs and EPA agreed to a settlement of that action in a consent decree entered on January 31, 1992. The consent decree, which has been modified several times, established a schedule by which EPA is to propose and take final action for eleven point source categories identified by name in the decree and for eight other point source categories identified only as new or revised rules, numbered 5 through 12. After completing a preliminary study of the feedlots industry under the decree, EPA selected the swine and poultry portion of the feedlots industry as the subject for New or Revised Rule #8, and the beef and dairy portion of that industry as the subject for New or Revised Rule #9. Under the decree, as modified, the Administrator was required to sign a proposed rule for both portions of the feedlots industry on or before December 15, 2000, and must take final action on that proposal no later than December 15, 2002. As part of EPA's negotiations with the plaintiffs regarding the deadlines for this rulemaking, EPA entered into a settlement agreement dated December 6, 1999, under which EPA agreed, by December 15, 2000, to also propose to revise the existing NPDES permitting regulations under 40 CFR Part 122 for CAFOs. EPA also agreed to perform certain evaluations, analyses, or assessments and to develop certain preliminary options in connection with the proposed CAFO rules. (The Settlement Agreement expressly provides that nothing in the Agreement requires EPA to select any of these options as the basis for its proposed rule.)

1.1.1 National Pollutant Discharge Elimination System (NPDES)

The NPDES permit program regulates the discharge of pollutants from point sources to waters of the United States. The term “point source” is defined in the Clean Water Act (Section 502(14)) as a discernible, confined, and discrete conveyance from which pollutants are or may be discharged. CAFOs are explicitly defined as point sources in Section 502(14).

EPA promulgated the current NPDES regulations for CAFOs in the mid-1970s (see 41 F.R. 11458, March 18, 1976). Changes to the NPDES regulations for CAFOs are discussed in Section 9.

1.1.2 Effluent Limitations Guidelines and Standards

EPA promulgated effluent limitations guidelines and standards for the Feedlots Point Source Category in 1974 (40 CFR Part 412) (see 39 F.R. 5704, February 14, 1974). EPA is proposing to revise these regulations as discussed in Section 2.2.

Effluent limitations guidelines and standards for CAFOs are being proposed under the authority of Sections 301, 304, 306, 307, 308, 402, and 501 of the CWA, 33 U.S.C. 1311, 1314, 1316, 1317, 1318, 1342, and 1361. Effluent limitations guidelines and standards are summarized briefly below for direct and indirect dischargers.

Direct Dischargers

- Best Practicable Control Technology Currently Available (BPT) (304(b)(1) of the CWA) - In the guidelines for an industry category, EPA defines BPT effluent limits for conventional, toxic, and non-conventional pollutants. In specifying BPT, EPA looks at a number of factors. EPA first considers the cost of achieving effluent reductions in relation to the effluent reduction benefits. The Agency also considers the age of the equipment and facilities, the processes employed and any required process changes, engineering aspects of the control technologies, non-water quality environmental impacts (including energy requirements), and such other factors as the Agency deems appropriate (CWA 304(b)(1)(B)). Traditionally, EPA establishes BPT effluent limitations based on the average of the best performances of facilities within the industry of various ages, sizes, processes, or other common characteristics. Where existing performance is uniformly inadequate, EPA may require higher levels of control than currently in place in an industrial category if the Agency determines that the technology can be practically applied.

- Best Available Technology Economically Achievable (BAT) (304(b)(2) of the CWA) - In general, BAT effluent limitations represent the best existing economically achievable performance of direct discharging plants in the industrial subcategory or category. The factors considered in assessing BAT include the cost of achieving BAT effluent reductions, the age of equipment and facilities involved, the processes employed, engineering aspects of the control technology, potential process changes, non-water quality environmental impacts (including energy requirements), and such factors as the Administrator deems appropriate. The Agency retains considerable discretion in assigning the weight to be accorded to these factors. An additional statutory factor considered in setting BAT is economic achievability. Generally, the achievability is determined on the basis of the total cost to the industrial subcategory and the overall effect of the rule on the industry's financial health. BAT limitations may be based on effluent reductions attainable through changes in a facility's processes and operations. As with BPT, where existing performance is uniformly inadequate, BAT may be based on technology transferred from a different subcategory within an industry or from another industrial category. BAT may be based on process changes or internal controls, even when these technologies are not common industry practice.

- Best Conventional Pollutant Control Technology (BCT) (304(b)(4) of the CWA) - The 1977 amendments to the CWA required EPA to identify effluent reduction levels for conventional pollutants associated with BCT technology for discharges from existing industrial point sources. BCT is not an additional limitation, but replaces Best Available Technology (BAT) for control of conventional pollutants. In addition to other factors specified in Section 304(b)(4)(B), the CWA requires that EPA establish BCT limitations after consideration of a two part "cost-reasonableness" test. EPA explained its methodology for the development of BCT limitations in July 1986 (51 F.R. 24974). Section 304(a)(4) designates the following as conventional pollutants: biochemical oxygen demand (BOD5), total suspended solids (TSS), fecal coliform, pH, and any additional pollutants defined by the Administrator as conventional. The Administrator designated oil and grease as an additional conventional pollutant on July 30, 1979 (44 F.R. 44501).

- New Source Performance Standards (NSPS) (306 of the CWA) - NSPS reflect effluent reductions that are achievable based on the best available demonstrated control technology. New facilities have the opportunity to install the best and most efficient production processes and wastewater treatment technologies. As a result, NSPS should represent the greatest degree of effluent reduction attainable through the application of the best available demonstrated control technology for all pollutants (i.e., conventional, non-conventional, and priority pollutants). In establishing NSPS, EPA is directed to take into consideration the cost of achieving the effluent reduction and any non-water quality environmental impacts and energy requirements.

Indirect Dischargers

- Pretreatment Standards for Existing Sources (PSES) (307(b) of the CWA) - PSES are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. The CWA authorizes EPA to establish pretreatment standards for pollutants that pass through POTWs or interfere with treatment processes or sludge disposal methods at POTWs. Pretreatment standards are technology-based and analogous to BAT effluent limitations guidelines for removal of priority pollutants. EPA retains discretion not to issue such standards where the total amount of pollutants passing through a POTW is not significant.

  The General Pretreatment Regulations, which set forth the framework for the implementation of categorical pretreatment standards, are found at 40 CFR Part 403. Those regulations contain a definition of pass-through that addresses localized rather than national instances of pass-through and establish pretreatment standards that apply to all domestic dischargers (see 52 F.R. 1586, January 14, 1987).

- Pretreatment Standards for New Sources (PSNS) (307(b) of the CWA) - Like PSES, PSNS are designed to prevent the discharges of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. PSNS are to be issued at the same time as NSPS. New indirect dischargers have the opportunity to incorporate into their facilities the best available demonstrated technologies. The Agency considers the same factors in promulgating PSNS as it considers in promulgating NSPS. EPA retains discretion not to issue such standards where the total amount of pollutants passing through a POTW is not significant.

1.2 <u>Pollution Prevention Act (PPA)</u>

In the Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq., Pub. Law 101-508, November 5, 1990), Congress declared pollution prevention a national policy of the United States. The PPA declares that pollution should be prevented or reduced at the source whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner whenever feasible; pollution that cannot be prevented or recycled should be treated; and disposal or other release into the environment should be chosen only as a last resort and should be conducted in an environmentally safe manner. This proposed regulation for animal feeding operations was reviewed for its incorporation of pollution prevention as part of the Agency effort. Pollution prevention practices applicable to animal feeding operations are described in Chapters 4 and 8.

1.3 Regulatory Flexibility Act (RFA) as Amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA)

In accordance with Section 603 of the Regulatory Flexibility Act (RFA) (5 U.S.C. 601 et seq.), EPA prepared an initial regulatory flexibility analysis (IRFA) that examines the impact of the proposed rule on small entities along with regulatory alternatives that could reduce that impact. The IRFA (available in Chapter 9 of Economic Analysis of the Proposed Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations) concludes that the economic affect of regulatory options being considered might significantly impact a substantial number of small livestock and poultry operations.

As required by Section 609(b) of the RFA, as amended by SBREFA, EPA also conducted outreach to small entities and convened a Small Business Advocacy Review Panel to obtain the advice and recommendations of representatives of the small entities that potentially would be subject to the rule's requirements. Consistent with the RFA/SBREFA requirements, the panel evaluated the assembled materials and small entity comments on issues related to the elements of the IRFA. Participants included representatives of EPA, the Small Business Administration (SBA), and the Office of Management and Budget (OMB). Participants from the farming community included small livestock and poultry producers as well as representatives of the major commodity and agricultural trade associations. A summary of the panel's activities and recommendations is provided in the Final Report of the Small Business Advocacy Review Panel on EPA's Planned Proposed Rule on National Pollutant Discharge Elimination System (NPDES) and Effluent Limitations Guideline (ELG) Regulations for Concentrated Animal Feeding Operations (April 7, 2000). This document is included in the public record.

CHAPTER 2

SUMMARY AND SCOPE OF PROPOSED REGULATION

2.0 SUMMARY AND SCOPE OF PROPOSED REGULATION

The proposed regulations described in this document include revisions of two regulations that ensure manure, wastewater, and other process waters for concentrated animal feeding operations (CAFOs) do not impair water quality. These two regulations are the National Pollutant Discharge Elimination System (NPDES) described in Section 2.1 and the Effluent Limitations Guidelines and Standards for feedlots (beef, dairy, swine, and poultry) described in Section 2.2, which establish the technology-based standards that are applied to CAFOs. Both regulations were originally promulgated in the 1970s. EPA proposes revisions to these regulations to address changes that have occurred in the animal industry sectors over the last 25 years, to clarify and improve implementation of CAFO permit requirements, and to improve the environmental protection achieved under these rules.

2.1 National Pollutant Discharge Elimination System (NPDES)

As noted in Section 1, CAFOs are "point sources" under the Clean Water Act. The regulation at 40 CFR 122.23 specifies which animal feeding operations are CAFOs and therefore are subject to the NPDES program on that basis.

2.1.1 Applicability of the Proposed Regulation

The existing NPDES regulation uses the term "animal unit," or AU, to identify facilities that are CAFOs. The term AU is a metric unit established in the 1970 regulations that attempted to equate the characteristics of the wastes produced by different animal types. The existing regulation defines facilities with 1,000 animal units or more as CAFOs. The regulation also states that facilities with 300 to 1,000 animal units are CAFOs if they meet certain conditions.

The proposed rule presents two alternatives for how to structure the revised NPDES program for CAFOs, each of which offers comparable environmental benefits but differs in the administrative approach. Additional approaches considered but not proposed are described in Section 9. The first alternative proposal is a two-tier applicability structure that simplifies the definition of which facilities are CAFOs by establishing a single threshold for each animal sector. This proposal establishes a single threshold at the equivalent of 500 AU, above which operations are defined as CAFOs, and below which facilities become CAFOs only if designated by the permit authority. The 500 AU equivalent for each animal sector is as follows:

- 500 cattle (excluding mature dairy cattle or veal calves);
- 500 veal calves;
- 350 mature dairy cattle (whether milked or dry);
- 1,250 mature swine weighing over 55 pounds;
- 5,000 immature swine weighing 55 pounds or less;
- 50,000 chickens;
- 27,500 turkeys;
- 2,500 ducks;
- 250 horses; and/or
- 5,000 sheep or lambs.

The second alternative retains the three-tier applicability structure of the existing regulation:

1) All operations with 1,000 AUs or more are defined as CAFOs.

2) Operations with 300 to 1,000 AU would be CAFOs only if they meet certain conditions or if designated by the permitting authority.

3) Operations with fewer than 300 AU would be CAFOs only if designated by the permitting authority.

All facilities with 300 to 1,000 AU must either certify that they do not meet the conditions for being defined as a CAFO or else apply for a permit. The 300 to 1,000 AU equivalent numbers of animals for each sector are presented in Table 2-1.

Table 2-1. Number of Animals by Sector for 300 and 1,000 AU Equivalents

Animal Type	1,000 AU Equivalent (Number of Animals)	300 AU Equivalent (Number of Animals)
Cattle (excluding mature dairy or veal)	1,000	300
Veal	1,000	300
Mature dairy cattle	700	200
Swine weighing more than 55 pounds	2,500	750
Swine weighing 55 pounds or less	10,000	3,000
Chickens	100,000	30,000
Turkeys	55,000	16,500
Ducks	5,000	1,500
Horses	500	150
Sheep or lambs	10,000	3,000

The proposed rule also includes all types of poultry operations, regardless of manure handling system or watering system, and stand-alone immature swine and heifer operations.

2.1.2 Summary of Proposed Revisions to NPDES Regulations

EPA proposes to simplify the criteria for being designated as a CAFO by eliminating two specific criteria that have proven difficult to implement: the "direct contact" criterion and the "man-made device" criterion; however, the proposal retains the existing requirement for the permitting authority to consider a number of factors to determine whether the facility is a significant contributor of pollution to the waters of the United States. The proposal also retains the requirement for an on-site inspection in order to make this determination. EPA proposes to clarify its authority to designate facilities in states with NPDES authorized programs.

EPA also proposes to eliminate the 25-year, 24-hour storm event permit exemption and to impose a duty to apply for an NPDES permit. Under the current rule, an operation that otherwise meets the definition of a CAFO but that discharges only in the event of a 25-year, 24-hour storm is exempt from being defined as a CAFO. Currently, there are many operations that believe that they do not need to apply for a permit on this basis. EPA believes, however, that many operators have underestimated their discharges of manure and wastewater from the feedlot, manure storage areas, wastewater containment areas, and land application areas and have not applied for a permit when, in fact, they needed one. Under this proposal, all operations meeting the definition of a CAFO under either of the two applicability alternatives described in Section 2.1.1 would be required to apply for a permit. However, under this proposal, if the operator could demonstrate to the permitting authority that the facility has no potential to discharge, then the operator could request not to be issued a permit by the permitting authority.

Under the two-tier applicability structure, EPA estimates that approximately 26,000 operations will be required to apply for a NPDES permit. Under the three-tier applicability structure, EPA estimates that approximately 13,000 operations will be required to apply for a permit, and an additional 26,000 operations could either certify that they are not a CAFO or apply for a permit. Under the existing regulation, EPA estimates that about 12,000 facilities should be permitted, but only 2,530 have actually applied for a permit.

Under this proposal, the definition of a CAFO would explicitly include the production area (animal confinement area, manure storage area, waste containment area) as well as the land application area that is under the control of the CAFO owner or operator. Recent industry trends show more and larger feedlots with less cropland for application of manure, often resulting in significant manure excesses. EPA is concerned that as a result of these trends, manure is taking on the characteristic of a waste and is being applied to land in excess of agricultural uses, causing runoff or leaching into waters of the United States. The permit will address practices at the production area as well as the land application area, and will impose certain other record keeping requirements with regard to transfer of manure off site.

EPA further proposes to clarify that entities which exercise "substantial operational control" over the CAFO would be required to obtain a permit along with the CAFO operator. This provision is intended to address the increasing trend towards specialized animal production under contract with processors, packers, and other such integrators. Especially in the swine and poultry sector, the processor provides the animals, feed, medication, specifies growing practices, or a combination of these. This trend has resulted in growing concentrations of excess manure beyond agricultural needs in certain geographic areas. By making both parties liable for compliance with the terms of the permit as well as responsible for the excess manure generated by CAFOs, EPA intends that manure will be managed to prevent environmental harm.

In summary, the following components describe the general revisions that EPA is proposing to make to the NPDES regulations:

- Require the CAFO operator to develop a Permit Nutrient Plan for managing manure and wastewater at both the production area and the land application area;

- Require certain record keeping, reporting, and monitoring;

- Revise the definition of an animal feeding operation (AFO) to clarify coverage of winter feeding operations;

- Eliminate the term "animal unit" and eliminate the mixed-animal type calculation to simplify the regulation;

- Clarify the applicability of the regulation where there is ground water with a direct hydrological connection to surface water;

- Clarify how the exemptions in the Clean Water Act for storm water-related discharges relate to runoff associated with the land application of manure both at the CAFO and off site;

- Reiterate the existing CWA requirements that apply to dry weather discharges at AFOs;

- Require permit authorities to include special conditions in permits to:

  - require retention of a permit until proper facility closure;

  - establish the method for operators to calculate the allowable manure application rate;

  - specify restrictions on application of manure and wastewater to frozen, snow covered, or saturated land to prevent impairment of water quality;

- address risk of contamination via ground water with a direct hydrological connection to surface water;

- require that the CAFO operator obtain a certification from off-site recipients of CAFO manure that the recipients will properly manage the manure; and

- establish design standards to account for chronic storm events.

2.2 Effluent Limitations Guidelines and Standards

The proposed effluent limitations guidelines and standards regulations will establish the Best Practicable Control Technology (BPT), Best Conventional Pollutant Control Technology (BCT), and the Best Availability Technology (BAT) limitations as well as New Source Performance Standards (NSPS) on discharges from the production area as well as the land application areas at CAFOs. Section 2.2.1 describes the applicability of the proposed regulation; Section 2.2.2 summarizes proposed revisions to effluent limitations guidelines and standards.

2.2.1 Applicability of the Proposed Regulation

EPA has subcategorized the CAFOs Point Source Category based primarily on animal type. See Section 5 for a discussion of the basis considered for subcategorization. These subcategories are listed and described in Table 2-2.

Table 2-2. Basis Considered for Subcategorization of CAFOs

Subpart	Subcategory	Description
A	Horses, Sheep, and Lambs	CAFOs under 40 CFR 122.23 which confine horses, sheep, or lambs
B	Ducks	CAFOs under 40 CFR 122.23 which confine ducks
C	Beef and Dairy	CAFOs under 40 CFR 122.23 which confine mature dairy cows (either milking or dry) and cattle other than mature dairy or veal
D	Swine, Poultry, and Veal	CAFOs under 40 CFR 122.23 with swine, each weighing 55 pounds or more; swine, each weighing less than 55 pounds; veal calves; chickens, and/or turkeys

EPA is not proposing to revise the effluent guidelines requirements or the applicability for subcategory A (horses, sheep, and lambs) and subcategory B (ducks), even though the definition of a CAFO for these subcategories has changed.

The effluent guidelines requirements for subcategory C (beef and dairy) and subcategory D (swine, poultry, and veal) apply to any operations that are defined as CAFOs under either the two-tier or three-tier applicability structure of the NPDES regulation described in Section 2.1.

Under the two-tier applicability structure, the requirements apply to all operations defined as CAFOs having at least as many animals as listed below:

- 500 cattle (excluding mature dairy cattle or veal calves);
- 500 veal calves;
- 350 mature dairy cattle (whether milked or dry);
- 1,250 swine weighing over 55 pounds;
- 5,000 swine weighing 55 pounds or less;
- 50,000 chickens; or
- 27,500 turkeys.

Under the three-tier applicability structure, the requirements apply to all operations defined as CAFOs having at least as many animals as listed below:

- 300 cattle (excluding mature dairy cattle or veal calves);
- 300 veal calves;
- 200 mature dairy cattle (whether milked or dry);
- 750 swine weighing over 55 pounds;
- 3,000 swine weighing 55 pounds or less;
- 30,000 chickens; or
- 16,500 turkeys.

EPA is proposing several changes to the applicability of the existing regulation:

1) *Chickens* - Chickens refer to laying hens, pullets, broilers, breeders, and other meat-type chickens. EPA is proposing to clarify the effluent guidelines to ensure coverage of broiler and laying hen operations that do not use liquid manure handling systems or continuous overflow watering. EPA thus proposes to regulate chicken operations regardless of the type of watering system or manure handling system used.

2) *Mixed Animal Types* - EPA proposes to eliminate provisions in the existing regulation that apply to mixed animal operations. As discussed in Section 9, this will simplify the regulation. Note that once a facility is defined as a CAFO, the manure associated with <u>all</u> animals in confinement would be subject to NPDES requirements.

3) Immature Animals - EPA proposes to apply national technology-based standards to swine nurseries and to operations that confine immature dairy cows or heifers apart from the dairy.

EPA proposes to include stand-alone heifer operations under the subcategory C (Beef and Dairy). Any feedlot that confines heifers along with cattle for slaughter would also be subject to the subcategory C requirements. Furthermore EPA proposes to include swine facilities that confine swine weighing under 55 pounds each under the subcategory D.

4) *Veal Operations* - EPA proposes to establish a new subcategory that applies to the production of veal cattle. Veal production is included in the existing regulation as slaughter steer. However, veal production practices and wastewater and manure handling are very different from the practices used at beef feedlots, and meet a different BAT performance standard than beef feedlots. Therefore EPA proposes to establish a separate subcategory for veal.

2.2.2 Summary of Proposed Revisions to Effluent Limitations Guidelines and Standards

CAFOs in the beef, dairy, swine, poultry, and veal subcategories that meet the definition of a CAFO under either the two-tier or three-tier applicability structure of NPDES would be required under this rule to comply with the effluent limitations guidelines and standards. The proposed guidelines establish BPT, BCT, BAT, and NSPS by requiring effluent limitations and standards and specific best management practices that ensure that manure storage and handling systems are inspected and maintained adequately as described in the following subsections. EPA evaluated the following eight regulatory options for the proposed guidelines:

- Option 1: Nitrogen-Based Application;
- Option 2: Phosphorus-Based Application;
- Option 3: Phosphorus-Based Application + Ground Water Protection;
- Option 4: Phosphorus-Based Application + Ground Water Protection + Surface Water Protection;
- Option 5: Phosphorus-Based Application + Drier Manure;
- Option 6: Phosphorus-Based Application + Anaerobic Digestion;
- Option 7: Phosphorus-Based Application + Timing Restrictions; and
- Option 8: Phosphorus-Based Application + Minimized Potential for Discharge.

These options are described in detail in Section 10.0.

2.2.2.1 Best Practicable Control Technology (BPT)

EPA is proposing BPT limitations based on Option 2 for the beef and dairy subcategories and the swine, poultry, and veal subcategories. Table 2-3 shows the technology basis of BPT for these subcategories. Under BPT, EPA proposes zero discharge from the production area with an overflow due to catastrophic or chronic storms allowed. If the CAFO uses a liquid manure handling system, it must have a liquid storage structure or lagoon that is designed, constructed, and maintained to capture all process wastewater and manure, plus all of the storm water runoff from a 25-year, 24-hour storm.

BPT includes specific requirements on the application of manure and wastewater to land that is owned or under the operational control of the CAFO. CAFOs are required to apply their manure at a rate calculated to meet the requirements of the crop for either nitrogen or phosphorus, depending on the soil conditions for phosphorus. Livestock manure tends to be phosphorus-rich, meaning that if manure is applied to meet the nitrogen requirements of a crop, then the phosphorus is being applied at rates higher than needed by the crop. Repeated application of manure on a nitrogen basis may build up phosphorus levels in the soil, and result in saturation, thus contributing to the contamination of surface waters. Therefore, EPA also proposes that manure must be applied to cropland at rates not to exceed the crop requirements for nutrients and the ability of the soil to absorb any excess phosphorus.

BPT establishes specific record keeping requirements associated with ensuring the limitations are met for the production area and that the application of manure and wastewater is done in accordance with land application requirements. EPA also proposes to require the CAFO to maintain records on any excess manure that is transported off site. The CAFO must provide the recipient with information on the nutrient content of the manure transferred and the CAFO must keep these records on site.

2.2.2.2 Best Control Technology (BCT)

EPA proposes BCT equivalent to BPT for the beef and dairy subcategories and the swine, poultry, and veal subcategories. Table 2-3 shows the technology bases of BCT for these subcategories.

2.2.2.3 Best Available Technology (BAT)

EPA proposes BAT limitations based on Option 3 for the Beef and Dairy Subcategories and Option 5B for the Swine, Poultry, and Veal Subcategories. Table 2-1 shows the technology bases of BAT for these subcategories.

BAT limitations for the beef and dairy subcategories are based on the proposed BPT technology requirements with the additional requirement to achieve zero discharge via ground water beneath the production area, whenever the ground water has a direct hydrological connection to surface water. The proposed BAT requirements for the swine, poultry, and veal subcategories eliminate the allowance for overflow in the event of a chronic or catastrophic storm. CAFOs in these subcategories typically house their animals under roof instead of in open areas, thus avoiding or minimizing contaminated storm water and the need to contain storm water.

2.2.2.4 New Source Performance Standards (NSPS)

EPA proposes NSPS based on Option 3 for the beef and dairy subcategories and a combination of Option 3 and Option 5B for the swine, poultry, and veal subcategories. Table 2-3 shows the technology bases of NSPS for these subcategories.

EPA proposes to revise NSPS based on the same technology requirements as BAT for the beef and dairy subcategories. For the swine, poultry, and veal subcategories, EPA added to the BAT requirements that there be no discharge of pollutants through ground water beneath the production area, when the ground water has a direct hydrological connection to surface water. Both the BAT and NSPS requirements have the same land application and record keeping requirements as proposed for BPT.

Table 2-3. Summary of Technology Basis for CAFO Industry

Technology Basis	BPT and BCT		BAT		NSPS	
	Beef and Dairy Subcategory	Swine, Poultry, and Veal Subcategories	Beef and Dairy Subcategory	Swine, Poultry, and Veal Subcategories	Beef and Dairy Subcategory	Swine, Poultry, and Veal Subcategories
Zero discharge with a 25-year, 24-hour storm exemption	✓	✓	✓		✓	
Zero discharge with no allowance for overflow				✓		✓
Phosphorus-based Permit Nutrient Plan (where necessary, Nitrogen based elsewhere)	✓	✓	✓	✓	✓	✓
Hydrologic link assessment and zero discharge to groundwater beneath production area			✓		✓	✓
Additional Measures						
Periodic inspections	✓	✓	✓	✓	✓	✓
Depth marker for lagoons	✓	✓	✓	✓	✓	✓
Mortality handling requirements	✓	✓	✓	✓	✓	✓
100-foot land application setback	✓	✓	✓	✓	✓	✓
Manure samples at least once per year	✓	✓	✓	✓	✓	✓
Soil test every three years	✓	✓	✓	✓	✓	✓
Record keeping	✓	✓	✓	✓	✓	✓

CHAPTER 3

DATA COLLECTION ACTIVITIES

3.0 DATA COLLECTION ACTIVITIES

EPA collected and evaluated data from a variety of sources during the course of developing the proposed effluent limitations guidelines and standards for the concentrated animal feeding operations (CAFO) industry. These data sources include EPA site visits, industry trade associations, the U.S. Department of Agriculture, published literature, previous EPA Office of Water studies of the Feedlots Point Source Category, and other EPA studies of animal feeding operations. Each of these data sources is discussed below, and analyses of the data collected by EPA are presented throughout the remainder of this document.

3.1 Summary of EPA's Site Visit Program

The Agency conducted approximately 110 site visits to collect information about animal feeding operations (AFOs) and waste management practices. Specifically, EPA visited swine, poultry, dairy, beef, and veal AFOs throughout the United States. In general, the Agency visited a wide range of AFOs, including those demonstrating centralized treatment or new and innovative technologies. The majority of facilities were chosen with the assistance of the following industry trade associations:

- National Pork Producers Council;
- United Egg Producers and United Egg Association;
- National Turkey Federation;
- National Cattlemen's Beef Association;
- National Milk Producers Federation; and
- Western United Dairymen.

EPA also received assistance from environmental groups, such as the Natural Resources Defense Council and the Clean Water Network. The Agency contacted university experts, state cooperatives and extension services, and state and EPA regional representatives when identifying facilities for site visits. EPA also attended USDA-sponsored farm tours, as well as industry, academic, and government conferences.

Table 3-1 summarizes the number of site visits EPA conducted by animal industry sector, site locations, and size of animal operations.

Table 3-1. Number of Site Visits Conducted by EPA for the Various Animal Industry Sectors

Animal Sector	Number of Site Visits	Location(s)	Size of Operations
Swine	30	NC, PA, OH, IA, MN, TX, OK, UT	900 - 1 million head
Poultry	6 (broiler)	GA, AR, NC, VA, WV, MD, DE, PA, OH, IN, WI	20,000 - 1 million birds
	12 (layer)		
	6 (turkey)		
Dairy	25	PA, FL, CA, WI, CO	40 - 4,000 cows
Beef	30	TX, OK, KS, CO, CA, IN, NE, IA	500 - 120,000 head
Veal	3	IN	500 - 540 calves

In general, the Agency considered several factors when identifying representative facilities for site visits, including the following:

- Type of animal feeding operation;
- Location;
- Feedlot size; and
- Current waste management practices.

Facility-specific selection criteria are contained in site visit reports (SVRs) prepared for each facility visited by EPA. The SVRs are contained in the administrative record for this rulemaking.

During the site visits, EPA typically collected the following types of information:

- General facility information, including size and age of facility, number of employees, crops grown, precipitation information, and proximity to nearby waterways;

- Animal operation data, including flock or herd size, culling rate, and method for disposing dead animals;

- Description of animal holding areas, such as barns or pens, and any central areas, such as milking centers;

- Manure collection and management information, including the amount generated, removal methods and storage location, disposal information, and nutrient content;

- Wastewater collection and management information, including the amount generated, runoff information, and nutrient content;

- Nutrient management plans and any best management practices (BMPs); and

- Available wastewater discharge permit information.

This information, along with other site-specific information, is documented in the SVRs for each facility visited.

3.2 Industry Trade Associations

EPA contacted the following industry trade associations during the development of the proposed rule.

National Pork Producers Council (NPPC). NPPC is a marketing organization and trade association made up of 44 affiliated state pork producer associations. NPPC's purpose is to increase the quality, production, distribution, and sales of pork and pork products.

United Egg Producers and United Egg Association (UEP/UEA). UEP/UEA promotes the egg industry in the following areas: price discovery, production and marketing information, unified industry leadership, USDA relationships, and promotional efforts.

National Turkey Federation (NTF). NTF is the national advocate for all segments of the turkey industry, providing services and conducting activities that increase demand for its members' products.

National Chicken Council (NCC). NCC represents the vertically integrated companies that produce and process about 95 percent of the chickens sold in the United States. The association provides consumer education, public relations, and public affairs support, and is working to seek a positive regulatory, legislative, and economic environment for the broiler industry.

National Cattlemen's Beef Association (NCBA). NCBA is a marketing organization and trade association for cattle farmers and ranchers, representing the beef industry.

National Milk Producers Federation (NMPF). NMPF is involved with milk quality and standards, animal health and food safety issues, dairy product labeling and standards, and legislation affecting the dairy industry.

American Veal Association (AVA). AVA represents the veal industry, and advances the industry's concerns in the legislative arena, coordinates production-related issues affecting the industry, and handles other issues relating to the industry.

Western United Dairymen (WUD). WUD, a dairy organization in California, promotes legislative and administrative policies and programs for the industry and consumers.

Professional Dairy Heifer Growers Association (PDHGA). PDHGA is an association of heifer growers who are dedicated to growing high-quality dairy cow replacements. The association offers educational programs and professional development opportunities, provides a communication network, and establishes business and ethical standards for the dairy heifer grower industry.

All of the above organizations, along with several of their state affiliates, assisted EPA's efforts to understand the industry by helping with site visit selection, submitting supplemental data, and reviewing descriptions of the industry and waste management practices. These organizations also participated in and hosted meetings with EPA for the purpose of exchanging information with the Agency. EPA also obtained copies of membership directories and conference proceedings, which were used to identify contacts and obtain additional information on the industry.

3.3 U.S. Department of Agriculture (USDA)

EPA obtained data from several agencies within the USDA, including the National Agricultural Statistics Service (NASS), the Animal and Plant Health Inspection Service (APHIS), Natural Resources Conservation Service (NRCS), and the Economic Research Service (ERS) in order to better characterize the AFO industry. The collected data include statistical survey information and published reports. Data collected from each agency are described below.

3.3.1 National Agricultural Statistics Service (NASS)

NASS is responsible for objectively providing important, usable, and accurate statistical information and data support services of structure and activities of agricultural production in the United States. Each year NASS conducts hundreds of surveys and prepares reports covering virtually every facet of U.S. agricultural publications. The primary source of data is the animal production facility. NASS collects voluntary information using mail surveys, telephone and in-person interviews, and field observations. NASS is also responsible for conducting a Census of Agriculture, which is currently performed once every 5 years; the last census occurred in 1997. EPA gathered information from the following published NASS reports:

- *Hogs and Pigs: Final Estimates 1993 - 1997;*
- *Chickens and Eggs: Final Estimates 1994 - 1997;*
- *Poultry Production and Value: Final Estimates 1994 - 1997;*
- *Cattle: Final Estimates 1994 - 1998;*
- *Milking Cows and Production: Final Estimates 1993 - 1997; and*
- *1997 Census of Agriculture.*

The information EPA collected from these sources is summarized below.

Hogs and Pigs: Final Estimates 1993 - 1997
EPA used data from this report to augment the swine industry profile. The report presents inventory, market hogs, breeding herd, and pig crops. Specifically, the report provides the number of farrowings, sows, and pigs per litter. This report presents the number of operations with hogs; however, EPA did not use this report to estimate farm counts because the report provided limited data. Instead, EPA used the 1997 Census of Agriculture data to estimate farm counts, as discussed later in this section.

Chickens and Eggs: Final Estimates 1994 - 1997
EPA used data from this report to augment the poultry industry profile. The report presents national and state-level data for the top-producing states on chickens and eggs, including the number laid and production for 1994 through 1997.

Poultry Production and Value: Final Estimates 1994 - 1997
EPA also used data from this report to augment the poultry industry profile. The report presents national and state-level data for the top producing states on production (number and pounds produced/raised), price per pound or egg, and value of production of broilers, chickens, eggs, and turkeys for 1994 through 1997.

Cattle: Final Estimates 1994 - 1998
EPA used data from this report to augment the beef industry profile. The report provides the number and population estimates for beef feedlots that have a capacity of over 1,000 head of cattle, grouped by size and geographic distribution. This report provides national and state-level data for the 13 top-producing beef states, which include the number of feedlots, cattle inventory, and number of cattle sold per year by size class. The report also provides the total number of feedlots that have a capacity of fewer than 1,000 head of cattle, total cattle inventory, and number of cattle sold per year for these operations. EPA did not use this report to estimate farm counts because the report provided limited data. Instead, EPA used the 1997 Census of Agriculture data to estimate farm counts, as discussed later in this section.

Milking Cows and Production: Final Estimates 1993 - 1997
EPA used data from this report to augment the dairy industry profile. The report presents national and state-level estimates of dairy cattle inventory and the number of dairy operations by size group. This particular report presents data for all dairy operations with over 200 mature dairy cattle in one size class. EPA did not use this report to estimate farm counts because the report provided limited data. Instead, EPA used the 1997 Census of Agriculture data to estimate farm counts, as discussed below.

1997 Census of Agriculture
The Census of Agriculture is a complete accounting of U.S. agricultural production and is the only source of uniform, comprehensive agricultural data for every county in the nation. The census is conducted every 5 years. Prior to 1997, the Bureau of the Census conducted this activity. Starting with the 1997 Census of Agriculture, the responsibility passed to USDA NASS. The census includes all farm operations from which $1,000 or more of agricultural

products are produced and sold. The most recent census occurred in late 1997 and is based on calendar year 1997 data.

The census collects information relating to land use and ownership, crops, livestock, and poultry. This database is maintained by USDA; data used for this analysis were compiled with the assistance of staff at USDA NASS. (USDA periodically publishes aggregated data from these databases and also compiles customized analyses of the data for members of the public and other government agencies. In providing such analyses, USDA maintains a sufficient level of aggregation to ensure the confidentiality of any individual operation's activities or holdings.)

Several size groups were developed to allow tabulation of farm counts by farm size using different criteria than those used in the published 1997 Census of Agriculture. EPA developed algorithms to define farm size in terms of capacity, or number of animals likely to be found on the farm at any given time. To convert sales of hogs and pigs and feeder pigs into an inventory, EPA divided total sales by the number of groups of pigs likely to be produced and sold in a given year. EPA estimates that the larger grow-finish farms produce 2.8 groups of pigs per year. Farrow-finish operations produce 2.0 groups of pigs per year. Nursery operations produce up to 10 groups per year. Data used to determine the groups of pigs produced per year were obtained from a survey performed by USDA APHIS (1999).

For beef operations, EPA estimates the larger feedlots produce up to 3.5 groups of cattle per year, while the smaller operations produce only 1 to 1.5 groups per year (ERG, 2000b). The newly aggregated data better depict the size and geographic distribution of AFOs needed for EPA's analysis, particularly smaller beef feedlots (fewer than 1,000 head capacity) and larger dairies (more than 200 mature dairy cattle). EPA used the census data to gather more details on the larger dairies, such as the number of operations and number of head for additional size classes (200 to 499, 500 to 999, and more than 1,000 head).

USDA NRCS also compiled and performed analyses on census data that EPA used for its analyses. These data identify the number of feedlots, their geographical distributions, and the amount of cropland available to land apply animal manure generated from their confined feeding operations (based on nitrogen and phosphorus availability relative to crop need). EPA used these estimates to identify feedlots that may not own sufficient land to apply all of the animal manure to the land. EPA used the results of this analysis to estimate the number of AFOs that may incur additional manure transportation costs under the various regulatory options considered under the proposed rule (see Chapter 10).

3.3.2 Animal and Plant Health Inspection Service (APHIS)/National Animal Health Monitoring System (NAHMS)

APHIS provides leadership in ensuring the health and care of animals and plants, improving agricultural productivity and competitiveness, and contributing to the national economy and public health. One of its main responsibilities is to enhance the care of animals. In 1983, APHIS initiated the National Animal Health Monitoring System (NAHMS) as an information-gathering program to collect, analyze, and disseminate data on animal health, management, and productivity across the United States. NAHMS conducts national studies to gather data and generate descriptive statistics and information from data collected by other industry sources. NAHMS has published national study reports for various food animal populations (e.g., swine, dairy cattle).

EPA gathered information from the following NAHMS reports:

- *Swine '95 Part I: Reference of 1995 Swine Management Practices*;
- *Swine '95 Part II: Reference of Grower/Finisher Health & Management Practices*;
- *Layers '99 Parts I and II: Reference of 1999 Table Egg Layer Management in the U.S.*;
- *Dairy '96 Part I: Reference of 1996 Dairy Management Practices*;
- *Dairy '96 Part III: Reference of 1996 Dairy Health and Health Management*;
- *Beef Feedlot '95 Part I: Feedlot Management Practices; and*
- *Feedlot '99 Part I: Baseline Reference of Feedlot Management Practices*.

EPA also collected information from NAHMS fact sheets, specifically the *Swine '95* fact sheets, which describe biosecurity measures, vaccination practices, environmental practices/ management, and antibiotics used in the industry.

Swine '95 Part I: Reference of 1995 Swine Management Practices

This report provides references on productivity, preventative and vaccination practices, biosecurity issues, and environmental programs (including carcass disposal). The data were obtained from a sample of 1,477 producers representing nearly 91 percent of the U.S. hog inventory from the top 16 pork-producing states. Population estimates are broken down into farrowing and weaning, nursery, grower/finisher, and sows.

Swine '95 Part II: Reference of Grower/Finisher Health & Management Practices

This report provides additional references on feed and waste management, health and productivity, marketing, and quality control. The data were collected from 418 producers with operations having 300 or more market hogs (at least one hog over 120 pounds) and represent about 90 percent of the target population. NAHMS also performed additional analyses for EPA that present manure management information for the swine industry by two size classes (fewer than 2,500 marketed head and more than 2,500 marketed head) and three regions (Midwest, North, and Southeast) (USDA APHIS, 1999).

Layers '99 Parts I and II: Reference of 1999 Table Egg Layer Management in the U.S.

The Layers '99 study is the first NAHMS national study of the layer industry. Data were obtained from 15 states, which account for over 75 percent of the table egg layers in the United States. Part I of this report provides a summary of the study results, including descriptions of farm sites and flocks, feed, and health management. Part II of this report provides a summary of biosecurity, facility management, and manure handling.

Dairy '96 Part I: Reference of 1996 Dairy Management Practices and Dairy '96 Part III: Reference of 1996 Dairy Health and Health Management

These reports present the results of a survey that was distributed to dairies in 20 major states to collect information on cattle inventories; dairy herd management practices; health management; births, illness, and deaths; housing; and biosecurity. The results represent 83 percent of U.S. milk cows, or 2,542 producers. The reports also provide national data on cattle housing, manure and runoff collection practices, and irrigation/land application practices for dairies with more than 200 or fewer than 200 mature dairy cattle. NAHMS provided the same information to EPA with the results reaggregated into three size classes (fewer than 500, 500 to 699, and more than 700 mature dairy cattle) and into three regions (East, West, and Midwest) (ERG, 2000a).

Beef Feedlot '95 Part I: Feedlot Management Practices

This report contains information on population estimates, environmental programs (e.g., ground water monitoring and methods of waste disposal), and carcass disposal at small and large beef feedlots (fewer than and more than 1,000 head capacity). The data were collected from 3,214 feedlots in 13 states, representing almost 86 percent of the U.S. cattle-on-feed inventory.

Feedlot '99 Part I: Baseline Reference of Feedlot Management Practices

This report also contains information on population estimates, environmental programs, and carcass disposal at beef feedlots. The data were collected from 1,250 feedlots in 12 states, representing 77 percent of all cattle on feed in the United States.

3.3.3 Natural Resources Conservation Services (NRCS)

NRCS provides leadership in a partnership effort to help people conserve, improve, and sustain our natural resources and the environment. NRCS relies on many partners to help set conservation goals, work with people on the land, and provide assistance. Its partners include conservation districts, state and federal agencies, NRCS Earth Team volunteers, agricultural and environmental groups, and professional societies.

NRCS publishes the *Agricultural Waste Management Field Handbook*, which is an agricultural/engineering guidance manual that explains general waste management principles, and provides detailed design information for particular waste management systems. The handbook reports specific design information on a variety of farm production and waste management practices at different types of feedlots. The handbook also reports runoff calculations under normal and peak precipitation as well as information on manure and bedding characteristics. EPA used this information to develop its cost and environmental analyses. NRCS personnel also contributed technical expertise in the development of EPA's estimates of compliance costs and environmental assessment framework by providing EPA with estimates of manure generation in excess of expected crop uptake.

3.3.4 Economic Research Service (ERS)

ERS provides economic analyses on efficiency, efficacy, and equity issues related to agriculture, food, the environment, and rural development to improve public and private decision making. ERS uses data from the Farm Costs and Returns Survey (FCRS) to examine farm financial performance (USDA ERS, 1997). This report developed 10 regions that were intended to group agricultural production into broad geographic regions of the United States: Pacific, Mountain, Northern Plains, Southern Plains, Lake States, Corn Belt, Delta, Northeast, Appalachian, and Southern. EPA further consolidated the 10 sectors into 5 regions in order to analyze aggregated Census of Agriculture data.

ERS is also responsible for the Agricultural Resource Management Study (ARMS), USDA's primary vehicle for collection of information on a broad range of issues about agricultural resource use and costs and farm sector financial conditions. The ARMS is a flexible data collection tool with several versions and uses. Information is collected via surveys, and it provides a measure of the annual changes in the financial conditions of production agriculture.

3.4 <u>Literature Sources</u>

EPA performed several Internet and literature searches to identify papers, presentations, and other applicable materials to use in developing the proposed rule. Literature sources were identified from library literature searches as well as through EPA contacts and industry experts. Literature collected by EPA covers such topics as housing equipment, fertilizer and manure application, general agricultural waste management, air emissions, pathogens, and construction cost data. EPA used literature sources to estimate the costs of design and expansion of waste management system components at AFOs. EPA also used publicly available information from several universities specializing in agricultural research for industry profile information, waste management and modeling information, and construction cost data, as well as existing computer models, such as the FarmWare Model that was developed by EPA's AgStar program.

3.5 <u>References</u>

ERG. 2000a. *Development of Frequency Factors for the Beef and Dairy Cost Model*. Memorandum from Eastern Research Group, Inc. to the Feedlots Rulemaking Record. December 11, 2000.

ERG. 2000b. *Facility Counts for Beef, Dairy, Veal, and Heifer Operations*. Memorandum from Eastern Research Group, Inc. to the Feedlots Rulemaking Record. December 15, 2000.

USDA ERS. 1997. *Financial Performance of U.S. Commercial Farms*, 1991-94. U.S. Department of Agriculture Economic Research Service. AER-751. June 1997.

USDA APHIS. 1999. *Re-aggregated Data from the National Animal Health Monitoring System's (NAHMS) Swine '95 Study*. Aggregated by Eric Bush of the U.S. Department of

Agriculture, Animal and Plant Health Inspection System, Centers for Epidemiology and Animal Health.

CHAPTER 4

INDUSTRY PROFILES

4.0 INTRODUCTION

This chapter describes the current organization, production processes, and facility and waste management practices of the Animal Feeding Operations (AFO) and Concentrated Animal Feeding Operations (CAFO) industries. Farm production methods, operation sizes, geographical distributions, pollution reduction activities, and waste treatment practices in use are described separately for the swine, poultry, beef, and dairy subcategories. Discussions of changes and trends over the past several decades are also provided.

Information on animal production was generally obtained from USDA's 1997 Census of Agriculture, USDA's National Agricultural Statistics Service (NASS), and information gathered from site visits and trade associations. For information obtained from the 1997 Census of Agriculture, EPA divided the U.S. into five production regions and designated them the South, Mid-Atlantic, Midwest, West, and Central regions. Originally, the USDA Economic Research Service (ERS) established ten regions so that it could group economic information. EPA condensed these regions into the five AFO regions because of similarities in animal production and manure handling techniques, and to allow for the aggregation of critical data on the number of facilities, production quantities, and financial conditions, which may otherwise not be possible due to concerns about disclosure.[1] The production regions are defined in Table 4-1.

[1] For example, USDA Census of Agriculture data are typically not released unless there is a sufficient number of observations to ensure confidentially. Consequently, if data were aggregated on a state basis (instead of a regional basis), many key data points needed to describe the industry segments would be unavailable.

Table 4-1. Animal Feeding Operation (AFO) Production Regions

Region	States Included
Central	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Oklahoma, Texas, Utah, Wyoming
Midwest	Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin
Mid-Atlantic	Connecticut, Delaware, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia, West Virginia
Pacific	Alaska, California, Hawaii, Oregon, Washington
South	Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, South Carolina

4.1 Swine Industry Description

Swine feeding operations include facilities that confine swine for feeding or maintenance for at least 45 days in any 12-month period. These facilities do not have significant vegetation in the confinement area during the normal growing season, thus swine pasture operations are generally not included. Facilities that have swine feeding operations may also include other animal and agricultural operations such as crop farming.

This section discusses the following aspects of the swine industry:

- 4.1.1: Distribution of the swine industry by size and region
- 4.1.2: Production cycles of swine
- 4.1.3: Swine facility types and management
- 4.1.4: Swine waste management practices
- 4.1.5: Pollution reduction
- 4.1.6: Waste disposal

The swine industry is a significant component of the domestic agricultural sector, generating farm receipts ranging from $9.2 billion to more than $11.5 billion annually during the past decade (USDA NASS, 1998a). Total annual receipts from the sale of hogs average approximately 12 percent of all livestock sales and 5 percent of all farm commodity sales. Annual swine output ranks fourth in livestock production value, after cattle, dairy products, and broilers. During 1997, more than 17 billion pounds of pork were processed from 93 million hogs. The retail value of pork sold to consumers exceeded $30 billion. The National Pork Producers Council estimates that the pork industry supports more than 600,000 jobs nationally (NPPC, 1999).

As described in the following sections, the swine industry has undergone a major transformation during the past several decades. Swine production has shifted from small, geographically dispersed family operations to large "factory farms" concentrated primarily in 10 states in the Midwest and the South. The number of hog operations, which approached 3 million in the 1950s, had declined to about 110,000 by 1997. The rate of consolidation has increased dramatically in the last decade, which has seen more than a 50 percent decline in the number of swine operations (USDA NASS, 1999a). All indications are that this trend toward consolidation is continuing.

Swine production has also changed dramatically in terms of the production process and the type of animal produced. The hog raised for today's consumer is markedly different from the one produced in the 1950s: Today hogs contain approximately 50 percent less fat and are the result of superior genetics and more efficient diets. The average whole-herd feed conversion ratio (pounds of feed per pound of live weight produced) used to be between 4 and 5 and has steadily decreased with current averages between 3.6 and 3.8. The most efficient herds have whole-herd feed conversion ratios under 3.0 (NPPC, 1999). Hence, a well-run swine operation can currently produce a 250-pound hog using only 750 pounds of animal feed during its lifetime.

The domestic hog industry is increasingly dominated by large, indoor, totally confined operations capable of handling 5,000 hogs or more at a time (USDA NASS, 1999b, and USDA NASS, 1999c). These operations typically produce no other livestock or crop commodities. In addition, there has been greater specialization as more swine operations serve only as nursery or finishing operations.

Another growing trend in the industry is that more hogs are being produced under contract arrangement whereby large hog producers, typically referred to as integrators or contractors, establish production contracts with smaller growers to feed hogs to market weight. The producer-integrator provides management services, feeder pigs, food, medicine, and other inputs, while the grower operations provide the labor and facilities. In return, each grower receives a fixed payment, adjusted for production efficiency. These arrangements allow integrators to grow rapidly by leveraging their capital. For example, instead of investing in all the buildings and equipment required for a farrow-to-finish operation, the integrator can invest in specialized facilities, such as farrowing units, while the growers pay for the remaining facilities, such as the nurseries and finishing facilities (Martinez, 1999). Occasionally other forms of contracts may be used.

According to a survey conducted for the USDA, 11 percent of the nation's hog inventory at the end of 1993 was produced under long-term contracts. This percentage was expected to increase to 29 percent by 1998 (Martinez, 1997). Regionally, the Mid-Atlantic region has the greatest proportion of contracted hogs, with more than 65 percent of the hogs grown at facilities where the grower does not own the hogs (USDA NASS 1999c).

These changes at both the industry and farm levels represent a significant departure from earlier eras, when hogs were produced primarily on relatively small but integrated farms where crop production and other livestock production activities occurred and where animals spent their complete life cycle. The following sections describe the current production and management practices of domestic swine producers.

4.1.1 Distribution of Swine Operations by Size and Region

EPA's 1974 CAFO Effluent Limitations Guidelines and Standards generally apply to swine feeding operations with more than 2,500 head, but counts only those swine weighing more than 55 pounds. (See Chapter 2 for the definition of a CAFO, and Chapter 5 for a discussion of the basis for revisions to the swine subcategory.) Most data sources cited in this section do not distinguish swine by weight, but may provide other information that distinguishes sows and other breeding pigs, feeder pigs, litters, and market pigs. Where numbers of head are presented in the following sections, feeder pigs were not included in the counts unless specified in the text.

4.1.1.1 *National Overview*

The estimated number of domestic swine operations has continuously declined since the 1950s. As recently as 1970, there were more than 870,000 producers of swine. By 1997, this number had decreased to about 110,000 (USDA NASS, 1999b).[2] The decline has been especially dramatic over the past decade. As shown in Table 4-2, the number of operations has steadily decreased over the years.

Table 4-2. Changes in the Number of U.S. Swine Operations and Inventory 1982-1997

Year	Operations	Inventory
1982	329,833	55,366,205
1987	243,398	52,271,120
1992	191,347	57,563,118
1997	109,754	61,206,236

Source: USDA NASS, 1999b

As the number of operations has decreased, however, hog inventories have actually risen due to the emerging market dominance by larger operations. Inventories increased from 55.4 million head in 1982 to 61.2 million head in 1997 (USDA NASS, 1999b).

4.1.1.2 *Operations by Size Class*

The general trend in the U.S. swine industry is toward a smaller number of large operations (Table 4-3). As the percentage of smaller producers decreases, there is a consistent increase in the percentage of herds with a total inventory of 2,000 or more head. The increase in the number

[2] USDA defines an operation as any place having one or more hogs or pigs on hand at any time during the year.

of large operations has predominantly occurred in conjunction with extended use of total confinement operations, which separate the three production phases described in 4.1.2.

Table 4-3. Percentage of U.S. Hog Operations and Inventory by Herd Size

Year	0-1,999 Head		2,000-4,999 Head		More Than 5,000 Head	
	Operations	Inventory	Operations	Inventory	Operations	Inventory
1982	99.3	85.7	0.6	9.5	0.1	4.8
1987	98.9	79.0	1.0	12.9	0.2	8.1
1992	97.9	68.7	1.6	15.2	0.4	17.0
1997	94.4	39.3	3.9	20.8	1.7	40.2

Source: USDA NASS, 1999b

In terms of farm numbers, small operations still dominate the industry; however, their contribution to total annual hog production has decreased dramatically in the past decade. For example, operations with up to 1,999 head, which produced 85.7 percent of the nation's hogs in 1982, raised only 39.3 percent of the total in 1997. In contrast, in 1982, the 0.1 percent of operations that reported more than 5,000 head produced approximately 5 percent of the swine; in 1997 these large operations (1.7 percent of all operations) produced over 40 percent of the nation's hogs.

4.1.1.3 *Regional Variation in Hog Operations*

Swine farming historically has been centered in the Midwest region of the U.S., with Iowa being the largest hog producer in the country. Although the Midwest continues to be the nation's leading hog producer (five of the top seven producers are still in the Midwest), significant growth has taken place in other areas. (See Table 4-4.) Perhaps the most dramatic growth has occurred in the Mid-Atlantic Region, in North Carolina. From 1987 to 1997, North Carolina advanced from being the 12th largest pork producer in the nation to second behind only Iowa. Climate and favorable regulatory policies played a major role in the growth of North Carolina's swine industry.

North Carolina's winters are mild and summers are tolerable, and this has allowed growers to use open-sided buildings. Such buildings are less expensive than the solid-sided buildings made necessary by the Midwest's cold winters. Midwestern growers must also insulate or heat their buildings in the winter. Tobacco farmers, who found hogs a means of diversifying their operations, also fueled North Carolina's pork boom. The idea of locating production phases at different sites was developed in North Carolina. The state also has a much higher average inventory per farm than any of the states in the Corn Belt. Whereas Iowa had an average of fewer than 850 head per farm, North Carolina had an average of more than 3,200 head per farm in 1997. In recent years, significant growth has occurred elsewhere as well: in the Central Region in the panhandle area of Texas and Oklahoma, Colorado, Utah, and Wyoming as well as in the Midwest Region in northern Iowa and southern Minnesota.

Tables 4-4 through 4-7 present the distribution of different types of swine operations for the key producing regions. For the purposes of these tables, breeder operations, also known as farrowing operations, have large numbers of sows and sell or transfer the pigs when they have been weaned or grown to approximately 55 pounds (feeder pigs); some farrowing operations may also keep boars. Nursery operations receive weaned pigs and grow them to approximately 55 pounds. Grow-finish operations are operations that receive feeder pigs and grow them out to marketable weight; these pigs are often labeled “swine for slaughter.” Combined operations perform all phases of production, known in the industry as “farrow-to finish,” or just the final two phases such as “wean-finish.” Note that no large independent nurseries are depicted by the 1997 census data. EPA is aware that several large nurseries have recently begun operation or are under construction. The considerable amount of growth in the Central (Southwest) Region that has occurred in the past 3 years is not reflected in the 1997 statistics presented in this section.

Table 4-4 shows the number of operations for six different size classes of facilities. Table 4-5 presents the average herd size by operation type, region, and operation size. Table 4-6 presents the percentage of total swine animal counts at combined and slaughter operations by region and operation size. Table 4-7 presents the distribution of different animal types in combined swine operations by region and operation size.

Table 4-4. Total Number of Swine Operations by Region, Operation Type, and Size in 1997

<table>
<tr><th rowspan="2">Region [a]</th><th rowspan="2">Operation Type [b]</th><th colspan="7">Number of Swine Operations (Operation Size Presented by Number of Head)</th></tr>
<tr><th>>0-750</th><th>>750-1,875</th><th>>1,875-2,500</th><th>>2,500-5,000</th><th>>5,000-10,000</th><th>>10,000</th><th>Total</th></tr>
<tr><td rowspan="2">Mid Atlantic</td><td>combined</td><td>6,498</td><td>421</td><td>82</td><td>185</td><td>130</td><td>135</td><td>7,451</td></tr>
<tr><td>slaughter</td><td>8,120</td><td>344</td><td>150</td><td>413</td><td>281</td><td>119</td><td>9,427</td></tr>
<tr><td rowspan="2">Midwest</td><td>combined</td><td>35,263</td><td>5,212</td><td>782</td><td>1,106</td><td>410</td><td>213</td><td>42,986</td></tr>
<tr><td>slaughter</td><td>27,081</td><td>2,194</td><td>425</td><td>521</td><td>142</td><td>48</td><td>30,411</td></tr>
<tr><td rowspan="2">Other</td><td>combined</td><td>10,821</td><td>359</td><td>74</td><td>135</td><td>60</td><td>45</td><td>11,494</td></tr>
<tr><td>slaughter</td><td>13,502</td><td>83</td><td>50</td><td>91</td><td>45</td><td>10</td><td>13,781</td></tr>
<tr><td rowspan="4">National</td><td>combined</td><td>52,582</td><td>5,992</td><td>938</td><td>1,426</td><td>600</td><td>393</td><td>61,931</td></tr>
<tr><td>slaughter</td><td>48,703</td><td>2,621</td><td>625</td><td>1,025</td><td>468</td><td>177</td><td>53,619</td></tr>
<tr><td>breeder</td><td>2,227</td><td colspan="2">15</td><td colspan="3">3</td><td>2,245</td></tr>
<tr><td>nursery</td><td colspan="4">83</td><td colspan="2">0</td><td>83</td></tr>
</table>

[a] Mid Atlantic= ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest= ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Other= ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK, WA, OR, WA, OR, CA, AK, HI, AR, LA, MS, AL, GA, SC, FL
[b] Operation type: combined=breeding inventory, finishing (average of inventory and sold/2.8), and feeders (sold/10); slaughter=finishing (average of inventory and sold/2.8); breeding (inventory); and nursery (feeders sold/10).

Table 4-5. Average Number of Swine at Various Operations by Region Operation Type, and Size in 1997

Region [a]	Operation Type [b]	Average Swine Animal Counts (Operation Size Presented by Number of Head)						
		>0-750	>750-1,875	>1,875-2,500	>2,500-5,000	>5,000-10,000	>10,000	All Operations
Mid-Atlantic	combined	74	1,182	2,165	3,509	5,021	28,766	851
	slaughter	32	1,242	2,184	3,554	6,877	13,653	641
Midwest	combined	209	1,137	2,152	3,444	6,761	27,403	637
	slaughter	135	1,161	2,124	3,417	6,791	19,607	355
Other	combined	51	1,255	2,150	3,455	7,052	59,172	410
	slaughter	13	1,291	2,215	3,626	6,830	14,901	85
National	combined	160	1,147	2,153	3,453	6,413	31,509	621
	slaughter	84	1,176	2,146	3,491	6,846	15,338	336

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Other=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC, WA, OR, CA, AK, HI, AR, LA, MS, AL, GA, SC, FL

[b] Operation type: combined=breeding inventory, finishing (average of inventory and sold/2.8), and feeders (sold/10); slaughter=finishing (average of inventory and sold/2.8).

Source: USDA NASS, 1999c

Table 4-6. Distribution of Swine Herd by Region, Operation Type, and Size in 1997

Region [a]	Operation Type [b]	Percentage of Total Swine Animal Counts by Size Group (Operation Size Presented by Number of Head)						
		>0-750	>750-1,875	>1,875-2,500	>2,500-5,000	>5,000-10,000	>10,000	Total
Mid Atlantic	combined	1.25	1.30	0.46	1.69	1.70	10.10	16.50
	slaughter	1.45	2.37	1.82	8.16	10.74	9.03	33.56
Midwest	combined	19.14	15.42	4.38	9.91	7.21	15.18	71.24
	slaughter	20.26	14.16	5.02	9.89	5.36	5.23	59.92
Other	combined	1.44	1.17	0.41	1.21	1.10	6.93	12.26
	slaughter	0.94	0.60	0.62	1.83	1.71	0.83	6.52
National	combined	21.83	17.88	5.25	12.81	10.01	32.21	100.00
	slaughter	22.65	17.13	7.45	19.88	17.80	15.09	100.00

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Other=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC, WA, OR, CA, AK, HI, AR, LA, MS, AL, GA, SC, FL

[b] Operation type: combined=breeding inventory, finishing (average of inventory and sold/2.8), and feeders (sold/10); slaughter=finishing (average of inventory and sold/2.8).

Source: USDA NASS, 1999c

Table 4-7. Distribution of Animal Type in Swine Herds at Combined Facilities by Region, Operation Type, and Size in 1997

Region [a]	Swine Type [b]	Percentage of Breeding, Finishing, and Feeder Hogs at Combined Facilities (Operation Size Presented by Number of Head)						
		>0-750	>750-1,875	>1,875-2,500	>2,500-5,000	>5,000-10,000	>10,000	All Operations
Mid Atlantic	Breeding	19.84	17.38	15.59	17.68	16.66	17.19	17.31
	Finishing	73.96	71.74	72.46	65.56	59.02	58.55	61.61
	Feeder	6.20	10.88	11.95	16.75	24.32	24.25	21.08
Midwest	Breeding	17.85	16.14	16.55	15.88	15.23	14.65	16.18
	Finishing	78.33	79.59	76.66	76.38	77.77	80.32	78.59
	Feeder	3.82	4.26	6.80	7.73	7.00	5.03	5.23
Other	Breeding	22.47	19.95	19.54	18.38	20.84	17.54	18.74
	Finishing	73.03	61.02	69.00	71.39	64.45	78.57	73.89
	Feeder	4.48	19.04	11.46	10.23	14.71	3.90	7.37
National	Breeding	18.27	16.50	16.70	16.36	16.16	16.10	16.66
	Finishing	77.73	77.70	75.66	74.44	71.78	72.63	74.91
	Feeder	4.00	5.79	7.63	9.21	12.05	11.27	8.40

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Other=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC, WA, OR, CA, AK, HI, AR, LA, MS, AL, GA, SC, FL
[b] Swine type: Breeding = inventory; finishing = average of inventory and sold/2.8; and feeder = sold/10.
Source: USDA NASS, 1999c

4.1.2 Production Cycles of Swine

Swine production falls into three phases. Pigs are farrowed, or born, in farrowing operations. Sows are usually bred for the first time when they are 180 to 200 days old. Farrowing facilities range from pasture systems to completely confined housing systems. A sow's gestation period is about 114 days. Farrowings are typically 9 to 11 pigs per litter, with a practical range of 6 to 13. The highest death losses in the pig-raising cycle occur within 3 to 4 days of birth. The average number of pigs weaned per litter in 1997 was 8.67. See Table 4-8. Producers incur significant expenses in keeping a sow, so the survival of each pig is critical to overall profitability. Sows usually resume sexual activity within a week after a litter is weaned. Growers are able to roughly synchronize production by weaning all their baby pigs on the same day. When they do this, all the sows in a farrowing group become sexually active again at roughly the same time and may be bred again at the same time. The sows will then farrow at about the same time, over a period of about a week. In this way, growers are able to keep groups of pigs together as they move from one phase of production to another. Sows normally produce five to six litters before they are culled and sold for slaughter at a weight of 400 to 460 pounds.

Table 4-8. Productivity Measures of Pigs

Year	Number of Pigs Weaned per Litter	Per Breeding Animal per Year		Average Live Weight per Pig (pounds)
		Litters	Head to Slaughter	
1992	8.08	1.69	13.08	252
1993	8.13	1.68	13.06	254
1994	8.19	1.73	13.36	255
1995	8.32	1.68	13.64	256
1996	8.50	1.64	13.51	257
1997	8.67	1.72	13.79	260
Average	8.32	1.69	13.41	256

Source: NPPC, 1999

Baby pigs are typically allowed to nurse from the sow, and then are relocated to a nursery, the second phase of swine production. In the nursery phase, pigs are weaned at 3-4 weeks of age and weigh 10 to 15 pounds. In the nursery, the pigs are raised to 8 to 10 weeks of age and 40 to 60 pounds. In practice, the weaning phase may take as few as 10 days, and may exceed 35 days.

During the third phase of production, growing pigs are raised to a market weight of 240 to 280 pounds. Finishing takes another 15 to 18 weeks, thus hogs are typically sent to market when they are about 26 weeks old (see Table 4-9). The growing and finishing phases were once separate production units, but are now combined in a single unit called grow-finish. In the growing–finishing unit, pigs are raised from 50 or 60 pounds to final market weight. The average grow-finish facility will produce approximately 2.8 turns (also called life cycles, herds, or groups) annually. Typically, finished pigs are from 166 to 212 days old, resulting in a range of 2.4 to 3.4 turns (or groups) of pigs produced from the grow-finish unit per year. Average farrow-to-finish operations will produce 2.1 groups per sow per year. The range of annual turnover frequency at farrow-to-finish farms is from 1.8 to 2.5.

Table 4-9. Age of Pigs Leaving Grow-Finish Unit in 1995

Age of Pig on Leaving Grow-Finish Unit (days)	Percentage of Operations and Pigs	
	Percentage of Operations	Percentage of Pigs
120 - 159	12.5	12.2
160 - 165	16.7	12.6
166 - 180	49.6	45.8
181 - 209	16.3	24.9
210 or more	4.9	4.5
Weighted Average	173 days	175 days

Source: USDA APHIS, 1995

In 1995, most operations had a farrowing facility, whereas slightly less than half of the facilities nationwide had a separate nursery facility. Most operations (85.6 percent) did have a finishing facility. Finishing operations get their pigs from on-site farrowing and nursery units (76.7 percent), off-site farrowing operations (10.2 percent), feeder pig producers under both contract and noncontract arrangements (13.8 percent), or livestock auctions or sales (5.9 percent). Large finishing operations (>10,000 head marketed) were more likely (56.3 percent) to get their pigs from off-site sources (USDA APHIS, 1995). Tables 4-10 and 4-11 present the frequency of the three major production phases by region and size. The sample profile of the Swine '95 survey indicates that 61.9 percent of respondents were farrow-to-finish operations and that 24.3 percent were grow-finish operations.

Table 4-10. Frequency of Production Phases in 1995 on Operations That Marketed Less Than 5,000 Hogs in a 6–Month Period

Production Phase	USDA APHIS Region[a]		
	Midwest	North	Southeast
Farrowing	76.6	68.6	69.3
Nursery	20.1	51	57.8
Finishing	78.8	79.7	93.4

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
Source: USDA APHIS, 1995

Table 4-11. Frequency of Production Phases in 1995 on Operations That Marketed 5,000 or More Hogs in a 6–Month Period

Production Phase	USDA APHIS Region[a]		
	Midwest	North	Southeast
Farrowing	44.8	80.4	89
Nursery	75	67.1	97.4
Finishing	45.8	69.7	62.8

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
Source: USDA APHIS, 1995

Although many large operations continue to have the full range of production phases at one facility, these operations are no longer the norm. More frequently, in new operations, several specialized farms are linked, or horizontally integrated, into a chain of production and marketing. Pigs begin in sowherds on one site, move to a nursery on another, and then move again to a finishing facility. Specialized operations can take advantage of skilled labor, expertise, advanced technology, streamlined management, and modern housing. However, the primary advantage of specialization is disease control. In a farrow-to-finish operation, a disease outbreak that begins in one phase of the operation can spread to the other phases. Physically separating the phases makes it easier to break this disease cycle. At the same time, separating phases spreads the cost of establishing swine operations, particularly if the different operations are owned by different persons.

Thus other categories of swine operations may comprise two or three of the three phrases described: combined farrow-nursery operations, which breed pigs and sell them at 40 to 60 pounds to finishing operations; wean-to-finish operations, which finish weaned pigs; and farrow-to-finish operations, which handle all phases of production from breeding through finishing. The emerging trend in the mid to late ‘90s was to produce pigs in two production phases rather than in three. In two-phase production, the weaned pigs may go straight into the grower building or finishing building, bypassing the nursery. The advantages of such practices are reduced transportation costs, lessened animal stress, and reduced animal mortality.

4.1.3 Swine Facility Types and Management

Table 4-12 summarizes the five major housing configurations used by domestic swine producers.

Although there are still many operations at which pigs are raised outdoors, the trend in the swine industry is toward larger confinement facilities where pigs are raised indoors. A typical confinement farrowing operation houses 3,000 sows, although some farrowing operations house as many as 10,000 sows at one location, and farms are being planned that will house as many as

15,000 sows at one location. Typical nursery operations are much smaller with a capacity of only about 1,500 head, but as stated earlier, separate nursery facilities are relatively uncommon.

Table 4-12. Summary of Major Swine Housing Facilities

Facility Type[a]	Description	Applicability
Total confinement	Pigs are raised in pens or stalls in an environmentally controlled building.	Most commonly used in nursery and farrowing operations and all phases of very large operations. Particularly common in the Southeast.
Open building with no outside access	Pigs are raised in pens or stalls but are exposed to natural climate conditions.	Relatively uncommon but used by operations of all sizes.
Open building with outside access	Pigs are raised in pens or stalls but may be moved to outdoors.	Relatively uncommon, but used by some small to mid-sized operations.
Lot with hut or no building	Pigs are raised on cement or soil lot and are not confined to pens or stalls.	Used by small to mid-sized operations.
Pasture with hut or no building	Pigs are raised on natural pasture land and are not confined to pens or stalls.	Traditional method of raising hogs currently used only at small operations.

[a] These are the main facility configurations contained in the *Swine '95* Survey conducted by USDA APHIS, 1995.

The economic advantages of confined facilities have been the primary driving factor (especially at large operations) for farmers to abandon dry lot or pasture raising of hogs. Although controlled-environment buildings require a greater initial capital investment than traditional farm operations, labor costs per unit output are significantly reduced. Furthermore, these facilities allow for far greater control of the production process, protect both animals and workers from weather, and usually result in faster growth-to-market weight and better feed efficiency. Most controlled-environment facilities employ "all in, all out" production, in which pigs are moved in groups and buildings are cleaned and disinfected between groups. It should be noted that the success of a controlled-environment operation is highly dependent on properly functioning ventilation, heating and cooling, and waste removal systems. A prolonged breakdown of any of these systems during extreme weather conditions can be catastrophic to the pig herd and economically devastating to the operator.

Facility requirements differ somewhat for each phase in a hog's life cycle, and hence farrowing, nursery, and growing/finishing facilities are configured differently. For example, farrowing operations require more intense management to ensure optimal production and reduce piglet mortality. A typical farrowing pen measures 5 by 7 feet, and the litter is provided with a protected area of approximately 8 square feet. The sow is relegated to a section of the pen and is separated from the piglets by low guard rails that reduce crushing but do not interfere with suckling. Floors are usually slatted under or to the rear of the sow area to facilitate waste removal (NPPC, 1996).

Newly born piglets require special care because of their vulnerability to injury and disease. Nursery systems are typically designed to provide a warm, dry, and draft-free environment in which animal stress is minimized to promote rapid growth and reduce injury and mortality. Nursery rooms are regularly cleaned and sanitized to reduce the piglets' exposure to pathogens. Nursery buildings are cleaned and disinfected thoroughly between groups of pigs to prevent the transmission of disease from one herd to another. Nursery pens usually hold 10 to 20 pigs. Pigs are held in the nursery from weaning until they are 8 to 12 weeks old (NPPC, 1996).

Finishing pigs at finishing facilities tend to require less intensive management than piglets and can tolerate greater variations in environmental conditions without incurring health problems. In an environmentally controlled building, growing and finishing pens hold 15 to 40 pigs and allow about 6 square feet per pig. Overcrowding leads to stress and aggressive behavior and can result in reduced growth rates and injury. Slatted concrete floors are the most common (NPPC, 1996).

As shown in Tables 4-13 through 4-18, smaller facilities tend to use open buildings, with or without access to the outside. Usually, hogs raised in these building are also confined to pens or stalls. Depending on the climate, the building might require ventilation and mist sprayer systems to prevent heat stress in the summer. Bedding might be needed during the winter months to protect the animals from the cold.

Hogs raised on dry lots or pasture require care and management similar to that for animals raised indoors, plus additional measures to protect the herds from extreme weather conditions. They must be provided with sufficient shade to reduce heat stress in the summer. Where natural shade is not available, facilities can be constructed to protect the herd from the sun in the summer and from wind and cold during the winter. Windbreaks are used under certain environmental conditions.

The most comprehensive information on swine facility and waste management systems currently in use by farm type, size, and state location was collected in conjunction with USDA's *Swine '95* study (USDA APHIS, 1995). Included in the study were 16 major pork-producing states that accounted for almost 91 percent of the U.S. hog inventory and more than 70 percent of the pork producers. The samples for the major swine-raising operations were statistically designed to provide inferences to the nation's swine population. Although the survey was conducted by the Animal and Plant Health Inspection Service (APHIS) and focused on swine health issues, it contains much information on swine production and on facility and waste management. Tables 4-13 and 4-14 present information on the housing types used in the farrowing phase. Tables 4-15 and 4-16 present information on the housing types used in the nursery phase. Tables 4-17 and 4-18 present information on the housing types used in the finisher phase. These tables clearly demonstrate that the larger facilities tend to use total confinement in all regions.

Table 4-13. Housing Frequency (in percent) in 1995 of Farrowing Facilities at Operations That Marketed Fewer Than 5,000 Hogs in a 6–Month Period

Variable	USDA APHIS Region[a]		
	Midwest	North	Southeast
Total Confinement	22.6	53.1	56
Open Building; no outside access	13.1	8.0	8.8
Open Building; outside access	25.7	33.8	31.2
Lot	16.2	3.2	1.1
Pasture	22.4	1.9	2.8

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
Source: USDA APHIS, 1995

Table 4-14. Housing Frequency (in percent) in 1995 of Farrowing Facilities at Operations That Marketed 5,000 or More Hogs in a 6–Month Period

Variable	USDA APHIS Region[a]		
	Midwest	North	Southeast
Total Confinement	98.3	100	100

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
Source: USDA APHIS, 1995

Table 4-15. Housing Frequency (in percent) in 1995 of Nursery Facilities at Operations That Marketed Fewer Than 5,000 Hogs in a 6–Month Period

Variable	USDA APHIS Region[a]		
	Midwest	North	Southeast
Total Confinement	52.3	55.4	62
Open Building; no outside access	9.1	11.5	8.8
Open Building; outside access	27.7	33.8	31.2
Lot	7.0	not available	3.7

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
Source: USDA APHIS, 1995

Table 4-16. Housing Frequency (in percent) in 1995 of Nursery Facilities at Operations That Marketed 5,000 or More Hogs in a 6–Month Period

Variable	USDA APHIS Region[a]		
	Midwest	North	Southeast
Total Confinement	99	100	96.4

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
Source: USDA APHIS, 1995

Table 4-17. Housing Frequency (in percent) in 1995 of Finishing Facilities at Operations That Marketed Fewer Than 5,000 Hogs in a 6–Month Period

Variable	USDA APHIS Region[a]		
	Midwest	North	Southeast
Total Confinement	19.9	36.5	23.4
Open Building; no outside access	15.4	14.1	9.5
Open Building; outside access	24.5	42.1	55.9
Lot	17.1	4.6	9.3
Pasture	23.0	2.5	1.9

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
Source: USDA APHIS, 1995

Table 4-18. Housing Frequency (in percent) in 1995 of Finishing Facilities at Operations That Marketed 5,000 or More Hogs in a 6–Month Period

Variable	Region[a]		
	Midwest	North	Southeast
Total Confinement	96.8	95.5	83.9

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
Source: USDA APHIS, 1995

4.1.4 Swine Waste Management Practices

Removal of manure from the animals' living space is critical for animal and farm worker well-being. Odor, gases, and dust carried by ventilation exhaust air are also affected by the waste management system used. Swine waste management systems can be separated into collection, storage, and treatment practices. An overview of the major practices in each of these areas is presented below; more detailed information on waste collection, storage, and treatment practices is provided in Section 8 of this document. Although the practices described below do not represent all of the waste management practices in use today, they are the predominant practices currently used at swine operations.

Swine Waste Collection Practices

Indoor raising of hogs requires that animals be physically separated from their waste products. Separation in larger facilities is usually accomplished through the use of concrete flooring with slots that allow the waste to drop below the living area and be transferred to a pit or trough beneath the pen. Smaller facilities hand clean pens to collect wastes.

The most frequently reported waste management system used in 1990 was hand cleaning (41.6 percent), which declined in use to 28.3 percent of operations in 1995 (USDA APHIS, 1995). This decrease in hand cleaning is highly correlated to the decrease in smaller facilities. Some facilities separate solid material from liquids before moving the material to storage. (A discussion of solid-liquid separation is presented in Section 8.) Slatted floors are now more commonly used to separate the manure from the animals at larger facilities. The waste is then deposited in an under floor pit or gutter where it is stored or moved to another type of storage. There are two main types of under-floor collection practices in which the waste is moved for storage elsewhere.

- *Pit recharge*. Pit recharge is the periodic draining of the pit contents by gravity to storage, followed by recharging the pit with new or recycled water. Regular pit draining removes much of the manure solids that would otherwise settle and remain in the bottom of the pit. The regular dissolution of settled solids increases the likelihood the solids will be removed at the next pit draining. Recharge systems use a 16- to 18-inch-deep in-house pit with 6 to 8 inches of water, which is emptied every 7 days to an anaerobic lagoon. Previously, 24-inch-deep pits were preferred, but now shallower pits are used with the hog slat system.

- *Flush.* Flush systems may use fresh water or recycled lagoon water for frequent removal of feces and urine from under-floor collection gutters or shallow pits. Like pit recharge systems, flush systems also improve animal health and performance as well as human working conditions in the swine houses by avoiding prolonged storage. Flush tanks with the capacity to release at least 1.5 gallons per 100 pounds of live animal weight per flush are placed at the end of the swine houses. Pit floors should be level from side to side, and wide pits should be divided into individual channels no wider than 4 to 5 feet. The floor slope for most flush systems is between 1 and 2 percent. Floors are flushed at least 1 to 12 times per day; the flush tanks are filled with new or recycled lagoon water before every flush. The flushed waste is collected and removed from the houses into storage through a system similar to that used in pit recharge systems.

Swine Waste Storage Practices

Waste storage is critical to the proper management of wastes from animal feeding operations because manure nutrients are best applied to farmland only at certain times of the year, as determined by crops, climate, and weather. Storage practices include deep pits, anaerobic and aerobic lagoons, aboveground and belowground slurry storage (tanks or pits), and dry storage. Most large hog farms (more than 80 percent) have from 90 to 365 days of waste storage capacity. (See Table 4-19.)

Table 4-19. Percentage of Swine Facilities With Manure Storage in 1998

Annual Marketed Head	0-3 months	3-6 months	6-9 months	9-12 months	None or NA
NA	3.2	3.7	3.2	7.4	82.5
0-1,000	31.9	27.2	12.3	17.4	11.3
1,000-2,000	14.9	38.0	20.7	19.4	7.1
2,000-3,000	10.1	35.4	21.9	28.1	4.4
3,000-5,000	5.8	33.5	22.8	32.6	5.3
5,000-10,000	6.1	29.2	22.1	35.6	7.0
10,000-20,000	4.7	26.4	21.1	40.9	6.8
20,000-50,000	6.0	23.5	22.8	39.2	8.6
50,000 +	4.0	19.5	28.7	28.0	19.8

Source: NPPC, 1998

An overview of common waste storage practices is provided below; More detailed information can be found in Section 8 of this document.

- *Deep pit manure storage.* Many operations use pits that are 6– to 8– feet deep and provide for up to 6 months' storage under the house. Commonly, slurry is removed from the pit twice a year. The slurry is disposed of through direct surface application or subsurface injection, transferred to an earthen storage facility, or pumped to an aboveground or belowground storage tank. This slurry system produces a waste stream with higher dry matter content (4 to 5 percent) and higher nutrient content than other liquid manure systems. The aboveground and belowground storage systems conserve more nitrogen than other systems (nitrogen loss of only 10 to 30 percent). Operations use this system to avoid problems associated with lagoons, such as odor, ammonia volatilization, and ground water impact resulting from leaking lagoons.

- *Lagoon Systems.* Lagoon systems can serve as both storage and treatment units. Anaerobic lagoons are the most common type of lagoon and are characterized by anaerobic decomposition of organic wastes. When properly designed an anaerobic lagoon will have a minimum total capacity that includes appropriate design treatment capacity, additional storage for sludge accumulation, and temporary storage for rainfall and wastewater inputs. A lagoon should also have sufficient freeboard and an indicator of the highest safe water level, to prevent the wastewater from overflowing the embankment.

  Lagoons usually fill to capacity within 2 to 3 years of startup due to the accumulated waste volume and, depending on the region, rainfall in excess of evaporation. When the lagoon is full, water overflow will occur unless the operator is in a position to apply the excess water to the land. Lagoon water drawdown by irrigation or other methods is usually begun before the water reaches the maximum wastewater storage level. Several states require that liquid level indicators be placed in the lagoon to be sure that the liquid stays below the level required to contain the 24-hour, 25-year storm.

  In addition to anaerobic lagoons, there are aerobic lagoons (which mix and aerate waste via mechanical aerators or ozone generators), two-stage lagoons (typically a constant volume covered treatment cell followed by a storage cell), and multi-stage cell lagoons. Technical information and a discussion of the advantages and disadvantages of these types of lagoons is presented in Section 8 of this document.

- *Settling and evaporation ponds.* Earthen ponds are used by some swine operations for solids separation. These ponds are designed to remove 40 percent of the total solids (in a 6 percent solids form) based on 3 months' storage. The material is then moved to another earthen pit, which serves as a drying bed, or flow is diverted to a parallel solids removal pond. The slurry dries to about 38 percent solids and 3-inch thickness within 6 months. The material is then moved with a front-end loader into a box-type spreader and applied to the land. Solids drying ponds and beds are not covered and therefore exposed to rainfall. A floating pump is located half the lagoon distance from the inlet, with a screen over the intake to protect sprinkler nozzles. The supernatant is pumped and used to irrigate fields. Another variation is to use a single lagoon followed by an evaporation pond that is 6 feet deep and as big as possible. Some evaporation ponds dry up during the summer. Because of odor problems, there is a trend away from the earthen pond for solids separation to either a single anaerobic lagoon or an anaerobic lagoon and an evaporation pond.

- *Waste runoff storage.* These systems described above can also be associated with operations that maintain hogs on an outside lot for at least part of the time. Such operations might also use housing similar to the systems described above, but allow outside access for the animals. Dry lot areas may be paved or dirt, and manure is stored in piles that are created by tractor or scraping system. Although controls might be in place to contain manure from enclosed areas through use of a deep pit or lagoon, they are not generally protective of the outside environment. Other typical runoff controls include surface diversions to prevent rainwater from running onto the lot and/or a crude settling basin with a slotted overflow.

- *Other*. Other types of waste management practices currently used include above-and belowground tanks (possibly covered and/or aerated), and hoop housing/deep bedding systems.

Swine Waste Treatment Practices

Many types of technology are used to treat swine wastes. These technologies work in a variety of ways to reduce the nitrogen, chemical oxygen demand, and the volatile solids content of waste or to change the form of the waste to make it more concentrated and thus easier to handle. The most common type of treatment practice is the anaerobic lagoon.

- *Lagoon treatment systems.* Lagoons designed to treat waste can reduce organic content and nitrogen by more than 50 percent (PADER, 1986). Anaerobic lagoons are generally preferred over aerobic lagoons because of their greater ability to handle high organic load. Nonetheless, incomplete anaerobic decomposition of organic material can result in offensive by-products, primarily hydrogen sulfide, ammonia, and intermediate organic acids, which can cause disagreeable odors. Therefore, proper design, size, and management are necessary to operate an anaerobic lagoon successfully.

  New lagoons are typically half filled with water before waste loading begins. Starting up during warm weather and seeding with bottom sludge from a working lagoon speeds establishment of a stable bacterial population. Proper lagoon maintenance and operation is absolutely necessary to ensure that lagoon liner integrity is not affected, that berms and embankments are stable, and the required freeboard and rainfall storage are provided.

  Even when bacterial digestion is efficient, significant amounts of sludge accumulate in anaerobic lagoons. Although lagoons can be designed with enough storage to minimize the frequency of bottom sludge removals, at some point sludge accumulation will greatly diminish the treatment capacity of most lagoons. Without the proper treatment volume, anaerobic decomposition will be incomplete, and odors will usually become more pronounced. Inadequate maintenance of treatment volume is the single most common reason for the failure of lagoon treatment systems. The method used most frequently to remove sludge entails vigorous mixing of sludge and lagoon water by means of an agitator/chopper pump or propeller agitator. The operation of the agitator/chopper must be continuously monitored to prevent damage to the liner berms, or embankments, which could result in contamination of surface or ground water. The sludge mixture is then pumped through an irrigation system onto cropland.

Some lagoons are covered with a synthetic material. There can be multiple advantages to covering a lagoon: A cover will prevent rainfall from entering the system, which can result in additional disposal costs. Nitrogen volatilization is minimized, making the waste a more balanced fertilizer and potentially saving expenses for the purchase of nitrogen fertilizers. The EPA AgSTAR Program has demonstrated that biogas production and subsequent electricity generation from covered lagoons and digesters can be cost effective, help control odor, and provide for more effective nutrient management.

- *Digesters*. Conventional aerobic digestion is frequently used to stabilize biosolids at small municipal and industrial facilities as well as at some animal feeding operations. Waste is aerated for relatively long periods of time to promote microbial growth. Substantial reductions in total and volatile solids, biochemical and chemical oxygen demand, and organic nitrogen as well as some reduction in pathogen densities can be realized. Autoheated aerobic digesters use the heat released during digestion to increase reaction rates and allow for more rapid reduction of pathogens. The biosolids created by digesters concentrate solids resulting in easier handling. Additional information on the operational considerations, performance, and advantages and disadvantages of digesters can be found in Section 8.

- *Sequencing batch reactors*. Manure is treated in sequence, typically in a vessel of metal construction. The vessel is filled, reacted (aeration cycled on and off), and then allowed to settle. Organic carbon and ammonia are reduced and phosphorus is removed through biosolids generation or chemical precipitation. The biosolids generated are in a concentrated form, allowing for ease in handling.

- *Other*. Many other practices are used separately or in combination with the practices listed above to treat swine wastes. Constructed wetland treatment cells, trickling filters, composting, oxidation ditches, are a few of the other ways to treat swine wastes. Systems being developed or under trial studies include Y- or V- shaped pits with scrapers for solid-liquid separation at the source, membrane filtration, chemical treatments, high-rise hog buildings, oligolysis, hydroponic cultivation, photosynthetic digesters, and closed loop water use systems using ultraviolet disinfection. Information on the operational considerations, performance, and advantages and disadvantages of these and other treatment practices can be found in Section 8.

4.1.4.1 *Waste Management Practices by Operation Size and Geographical Location*

The use of a particular waste management system is driven by the size of the operation and geographic considerations (e.g., climate). For example, operation of a confined facility with the use of a lagoon for treatment requires substantial capital investment. Below a certain number of head, such a system would be cost-prohibitive since the high start-up and maintenance costs of such a facility have to be spread over a large number of animals to ensure economic viability. Geographic considerations also play a role in waste management. Anaerobic lagoons are common in the Southeast, where factors such as land availability and climate conditions are favorable. Midwestern farms are more likely to use pit storage with slurry transport to aboveground or belowground tanks. The *Swine '95* Survey (USDA APHIS, 1995) provides a detailed picture of swine management practices by operation type, size, and location.

Waste Management Practice by Operation Size

As mentioned previously, large operations (greater than 2,000 head marketed in the past 12 months) are much more likely to use water for waste management than small operations. Smaller operations (less than 500 head) typically manage waste by hand cleaning or mechanical scraper/tractor. They also use pit-holding and flushing systems because of their relatively lower labor requirements. While larger operations also use pit storage and slurry storage in tanks, they are far more likely to move waste from the housing facility to a lagoon. Tables 4-20, 4-21, and 4-22 present the frequency of operations using the most common types of waste management systems for swine farrowing, nursery, and finishing phases, respectively. Table 4-23 presents the frequency of waste storage system use by size of operation. Table 4-24 presents the frequency of waste storage system use by region for operations that marketed 5,000 or more hogs in a 12-month period. It should be noted that the percentages do not add to 100 percent. This is because an operation may use more than one waste storage system. For example, many large facilities in the southeast have below floor slurry storage that is then moved to lagoon storage.

Table 4-20. Frequency (in percent) of Operations in 1995 by Type of Waste Management System Used Most in the Farrowing Phase

Variable	Number of Hogs Marketed in Past 12 Months		
	<2,000	2,000 - 10,000	>10,000
None	14.1	5.6	1.7
Pit-holding	24.4	53.9	49
Scraper / Tractor	12.3	3.6	6.0
Hand cleaned	39.7	0.6	0
Flush - under slats	4.6	20.8	39.3
Flush - gutter	3.0	2.7	2.6
Other	1.8	13	1.5

Source: USDA APHIS, 1995

Table 4-21. Frequency (in percent) of Operations in 1995 by Type of Waste Management System Used Most in the Nursery Phase

Variable	Number of Hogs Marketed in Past 12 Months		
	<2,000	2,000 - 10,000	>10,000
None	4.4	3.3	0
Pit-holding	32.3	55	48
Scraper / Tractor	18.5	3.9	1.7
Hand cleaned	31.7	1.6	0
Flush - under slats	8.7	19.6	10.2
Flush - gutter	2.1	1.7	3.4
Other	2.3	15	6.8

Source: USDA APHIS, 1995

Table 4-22. Frequency (in percent) of Operations in 1995 by Type of Waste Management System Used Most in the Finishing Phase

Variable	Number of Hogs Marketed in Past 12 Months		
	<2,000	2,000 - 10,000	>10,000
None	15.2	4.6	0
Pit-holding	22.1	53	45.3
Scraper / Tractor	25.5	8.6	11.4
Hand Cleaned	28.0	3.0	0
Flush - under slats	1.9	17.5	30.0
Flush - gutter	3.3	7.8	6.0
Other	4.0	5.5	7.4

Source: USDA APHIS, 1995

Table 4-23. Frequency (in percent) of Operations in 1995 That Used Any of the Following Waste Storage Systems by Size of Operation

Waste Storage System	Percentage of Operations by Number of Head Marketed for Slaughter		
	<2,000 Head	2,000 - 10,000 Head	>10,000 Head
Below-floor slurry	43.6	70.4	47.9
Aboveground slurry	4.1	10.3	8.3
Belowground slurry	17.3	25.6	26.8
Anaerobic lagoon with cover	2.2	0.5	2.0
Anaerobic lagoon without cover	17.4	29.2	81.8
Aerated lagoon	1.3	6.9	1.0
Oxidation ditch	2.9	0.1	0.0
Solids separated from liquids	4.1	5.9	4.7
Other	0.6	0.0	1.1

Source: USDA APHIS, 1995

With minor exceptions, there are consistent trends in operation management from one part of the country to another. The multi-site model that separates production phases is being adopted across the country; finishing age and number of litters per year already tend to be the same from one part of the nation to another. With the exception of the Midwest, producers tend to farrow small groups of sows weekly (USEPA, 1998). In the Midwest, some producers farrow only twice a year, usually in the spring and fall. This is usually done on smaller operations, where sows are maintained outdoors and then moved indoors for farrowing. The buildings in which pigs are housed in the Midwest tend to differ from those in more temperate parts of the country, and waste is managed differently in the Midwest than in other parts of the country. Confined, three-site operations predominate in the Southeast, south-central region, and West, although there are some smaller outdoor operations in the south-central region and the West.

Table 4-24. Frequency (in percent) of Operations in 1995 That Used Any of the Following Waste Storage Systems by Region for Operations That Marketed 5,000 or More Hogs in a 12–Month Period

Waste Storage System	USDA APHIS Region[a]		
	Midwest	North	Southeast
Below-floor slurry	21.5	28.5	85.7
Aboveground slurry	NA	NA	27.2
Belowground slurry	NA	NA	43.3
Anaerobic lagoon	91.2	4.8	33.3
Aerated lagoon	NA	X[b]	NA
Solids separated from liquids	NA	NA	14.4

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
[b] The standard error for the aerated lagoons in the northern region as evaluated by NAHMS exceeds 21 percent and was therefore determined by NAHMS not to be statistically valid. Note that the aerated lagoon is reportedly found in roughly 70 percent of the operations in the north region.

Source: USDA APHIS, 1995

Most types of waste management systems are also similar across most regions with only minor deviations. For example, the pit recharge systems with aboveground storage and land application are nearly identical among farms in the Midwest, the south-central region, and the Northeast. The primary waste management system that has the most variation among and within regions is known as the hand wash system. Hand wash systems are found predominantly on operations with fewer than 500 pigs; most of the operations using hand washing as their primary waste management system have fewer than 100 pigs. On these operations, it is in the farrowing house and/or nursery phases of production that hand washing is used to remove waste from the buildings. Either the wash water exits the building and enters the environment directly or a collection basin is located underneath or at one end of the building. In the case of collection, the wash water is stored and used for land application at a later time or is allowed to evaporate over time. Frequency of hand washing varies among operations from 3 times a day to once a week.

Another type of system identified as a primary waste management system on small operations in the Midwest and New England (USDA APHIS, 1995) uses a flat blade on the back of a tractor to scrape or remove manure from feeding floors. The popularity of this system apparently has waned, and the system no longer represents a major means for removing wastes from swine feeding operations (NCSU, 1998a).

Swine Waste Management Systems in the Pacific Region

Descriptive information about the waste management systems in this region is provided in Table 4-25. In general, the region is characterized by operations with fewer than 500 pigs that use hand washing and dry lots as their primary waste management system. In contrast, the majority of pigs are raised on operations with more than 1,000 animals that use either deep pit/aboveground storage or pit recharge/lagoon.

Table 4-25. Distribution of Predominant Waste Management Systems in the Pacific Region[a] in 1997

Farm Size (number of pigs)	Primary Waste Management System
Fewer than 500	1. Hand Wash/Dry Lots 2. Scraper/Aboveground Storage/Land Application
500 to 1,000	1. Hand Wash/Dry Lots 2. Deep Pit/Aboveground Storage/Land Application
More than 1,000	1. Deep Pit/Aboveground Storage/Land Application 2. Pit Recharge/Covered Anaerobic Lagoon/Irrigation

[a] Alaska, California, Hawaii, Oregon, and Washington
Source: Adapted from NCSU, 1998a

Swine Waste Management Systems in the Central Region

Table 4-26 presents information for the Central region. It is the fastest-growing area of swine production in the nation at the present time. As a result, large operations (>2,000 head) account for almost all of the swine in these states. As a group, these large operations appear to rely on evaporation from lagoons, aeration of anaerobic lagoons, or biogas production from lagoons as the main means for storing and treating swine waste.

Circle 4, one of the largest operations in the country, uses a pit-recharge system that is emptied about three times per week. Wastewater treatment is by a two-stage evaporative lagoon system. The primary stage is designed for treatment of volatile solids, with additional volume for 20 years of sludge storage. The exact treatment volume design is operation- (or complex-) specific and takes into consideration the diet, feed digestibility, and absorption and conversion efficiency of the animal for each group of confinement houses. The primary stage is sized on the basis of volume per input of volatile solids plus an additional volume for 20 years of sludge storage. The secondary stage lagoon volume and surface area are specified to allow evaporation of all excess water not required for pit recharge. Waste management plans call for sludge removal on the order of 20 years. Because the operation has not reached its design life at this time, this system cannot be evaluated.

Table 4-26. Distribution of Predominant Waste Management Systems in the Central Region[a] in 1997

Farm Size (number of pigs)	Primary Waste Management System
Fewer than 500	1. Hand Wash/Dry Lots
500 to 1,000	1. Flush or Pit Recharge/Anaerobic Lagoon/Irrigation 2. Deep Pit/Aboveground Storage/Land Application
More than 1,000	1. Flush or Pit Recharge/Aeration of Anaerobic Lagoon/Irrigation 2. Flush or Pit Recharge/Covered Anaerobic Lagoon/Land Application 3. Pit Recharge/Evaporation from Two-Stage System

[a] Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Oklahoma, Texas, Utah, Wyoming
Source: NCSU 1998a

Swine Waste Management Systems in the Mid-Atlantic Region

Table 4-27 summarizes descriptive information for the region. Only North Carolina and Pennsylvania grow a significant number of swine. The medium and large operations rely on either anaerobic lagoons and wastewater irrigation or aboveground storage and land application as their primary means of waste management. Operations in the remaining states typically have fewer than 500 animals each, and they use hand washing in conjunction with dry lots as their primary waste management system.

The design and operation of the anaerobic lagoon and irrigation system are different in the two key states. In Pennsylvania, lagoon loading rates are lower to accommodate the lower temperatures, and storage requirements must be increased to accommodate the longer inactive period during winter. Average yearly rainfall is about the same in the two states, with rainfall in excess of evapotranspiration requiring increased storage requirements.

Table 4-27. Distribution of Predominant Waste Management Systems in the Mid-Atlantic Region[a] in 1997

Farm Size (number of pigs)	Primary Waste Management System
Fewer than 500	1. Hand Wash/Dry Lots 2. Gravity Drain/Collection Basin/Land Application
500 to 1,000	1. Deep Pit/Aboveground Storage/Land Application 2. Pit Recharge/Anaerobic Lagoons/Irrigation 3. Scraper/Aboveground Storage/Land Application
More Than 1,000	1. Deep Pit/Aboveground Storage/Land Application 2. Pit Recharge/Anaerobic Lagoons/Irrigation

[a] Connecticut, Delaware, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia, and West Virginia
Source: Adapted from NCSU 1998a

Swine Waste Management Systems in the South Region

Table 4-28 summarizes descriptive information for the region. Large operations (more than 1,000 head) represent only a small fraction of the operations in the states of the region. The predominant waste management system is a flush or pit-recharge system for removal of waste from buildings, an anaerobic lagoon for treatment and storage of waste, and reincorporation of treated wastewater back into the environment by irrigation. In these states, housing is usually enclosed, with ventilation and a concrete floor surface.

Table 4-28. Distribution of Predominant Waste Management Systems in the South Region[a] in 1997

Farm Size (number of pigs)	Primary Waste Management System
Fewer than 500	1. Hand Wash/Dry Lots 2. Scraper System/ Aboveground Storage/Land Application
500 to 1,000	1. Flush or Pit Recharge/Anaerobic Lagoon/Irrigation
More Than 1,000	1. Flush or Pit Recharge/Anaerobic Lagoon/Irrigation

[a] Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, and South Carolina
Source: Adapted from NCSU 1998a

Swine Waste Management Systems in the Midwest Region

Table 4-29 summarizes descriptive information for this region. Small operations account for most of the operations in this region; however, recent construction of large units in Iowa, Minnesota, Missouri, and South Dakota indicate that the trend toward production in larger units seen in the southeastern U.S. is probably occurring in the Midwest Region as well. Primary waste management systems for operations with fewer than 500 pigs are hand wash coupled with dry lots with and without collection basins. In contrast, medium and large operations rely on storage of waste either under buildings with deep pits or in aboveground structures in conjunction with direct land application for crop production.

Table 4-29. Distribution of Predominant Waste Management Systems in the Midwest Region[a] in 1997

Farm Size (number of pigs)	Primary Waste Management System
Fewer than 500	1. Hand Wash/Dry Lots 2. Hand Wash/Dry Lots and Collection Basin/Land Application 3. Deep Pit/Land Application
500 to 1,000	1. Deep Pit/Aboveground Storage/Land Application 2. Pit Recharge/Aeration of Anaerobic Lagoons/Irrigation 3. Deep Pit/Land Application
More than 1,000	1. Deep Pit/Aboveground Storage/Land Application 2. Pit Recharge/Covered Anaerobic Lagoon/Irrigation

[a] Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin
Source: NCSU 1998a

4.1.5 Pollution Reduction

4.1.5.1 *Swine Feeding Strategies*

Swine producers use a variety of feed ingredients to achieve a balanced diet for a pig at each phase of the animal's development. Various grain products, including corn, barley, milo, and sometimes wheat form the foundation of the growing pig's diet and supply most of the carbohydrates and fat. Oilseed meals are the primary source of protein, and they foster muscle and organ development (NPPC, 1999). Producers also supplement the basic diet with minerals and vitamins as needed. A pig's diet changes as the animal grows. For example, finishing pigs typically receive a diet containing 13 to 15 percent crude protein versus the 20 to 22 percent protein diet received by young pigs. The *Swine '95* survey indicates that more than 96 percent of grower-finisher operations use multiple diets from time of entry to market weight. Almost 70 percent of the operations feed their pigs three or more diets during this phase.

Swine operations can use feeding strategies both to maximize growth rates and to reduce excretion of nutrients. The following feeding strategies can be used to reduce nitrogen and phosphorus manure content.

Grinding. Fine grinding and pelleting are simple but effective ways to improve feed utilization and decrease nitrogen and phosphorus excretion. By reducing the particle size, the surface area of the grain particles is increased, allowing for greater interaction with digestive enzymes. When particle size is reduced from 1,000 microns to 400 microns, nitrogen digestibility increases by approximately 5 to 6 percent. As particle size is reduced from 1,000 microns to 700 microns, excretion of nitrogen is reduced by 24 percent. The current average particle size is approximately 1,100 microns; the recommended size is between 650 and 750 microns. Reducing particle size below 650 to 750 microns greatly increases the energy costs of grinding and reduces the throughput of the mill. The use of so small a particle size will also increase the incidence of stomach ulcers in the hogs (NCSU, 1998b).

Amino Acid Supplemental Diets. Supplementing the diet with synthetic lysine to meet a portion of the dietary lysine requirement is an effective means of reducing nitrogen excretion by hogs. This process reduces nitrogen excretion because lower-protein diets can be fed when lysine is supplemented. Research studies have shown that protein levels can be reduced by 2 percentage points when the diet is supplemented with 0.15 percent lysine (3 pounds lysine-HC1/ton of feed) without negatively affecting the performance of grow-finish pigs. Greater reductions in protein are possible, but only if threonine, tryptophan, and methionine are also supplemented.

Table 4-30 shows the theoretical effect of feeding low-protein, amino acid-supplemented diets on nitrogen excretion of finishing pigs. Note that reducing the protein level from 14 percent to 12 percent and adding 0.15 percent lysine results in an estimated 22 percent reduction in nitrogen excretion. Reducing the protein further to 10 percent and adding 0.30 percent lysine, along with adequate threonine, tryptophan, and methionine, reduces the estimated nitrogen excretion by 41 percent.

Although it is currently cost-effective to use supplemental lysine and methionine, supplemental threonine and tryptophan are currently too expensive to use in widespread diets. However, because of rapid technological advances in fermentation procedures for synthesizing amino acids, the price of threonine and tryptophan will likely decrease in the next few years.

Table 4-30. Theoretical Effects of Reducing Dietary Protein and Supplementing With Amino Acids on Nitrogen Excretion by 200-lb Finishing Pig[a,b]

Diet Concentration	14 Percent CP	12 Percent CP + Lysine	10% CP + Lysine + Threonine + Tryptophan + Methionine
N balance			
N intake, g/d	67	58	50
N digested and absorbed, g/d	60	51	43
N excreted in feces, g/d	7	7	7
N retained, g/d	26	26	26
N excreted in urine, g/d	34	25	17
N excreted, total, g/d	41	32	24
Reduction in N excretion, %	----	22	41
Change in dietary costs, $/ton[b]	0	-0.35	+$14.50

[a] Assumes an intake of 6.6 lb/d and a growth rate of 1.98 lb/d. [b] Costs used L-Lysine HCl, $2.00/lb; corn, $2.50/bushel; SBM, $250/ton; L-Threonine, $3.50/lb; DL-Methionine, $1.65/lb; Tryptosine (70:15, Lys:Tryp) $4.70/lb.
Source: NCSU, 1998b

Phase Feeding and Split-Sex Feeding. Dividing the growth period into more phases with less spread in weight allows producers to more closely meet the pig's protein requirements. Also, since gilts (females) require more protein than barrows (males), penning barrows separately from gilts allows lower protein levels to be fed to barrows without compromising leanness and performance efficiency in gilts. Feeding three or four diets, compared with only two diets, during the grow-finish period would reduce nitrogen excretion by at least 5 to 8 percent (NCSU, 1998b).

Formulating Diets on an Available Phosphorus Basis. A high proportion (56 to 81 percent) of the phosphorus in cereal grains and oilseed meals occurs as phytate. Pigs do not use phosphorus in this form well because they lack significant amounts of intestinal phytase, the enzyme needed to remove the phosphate groups from the phytate molecule. Therefore, supplemental phosphorus is added to the diet to meet the pig's growth requirements.

Because some feedstuffs are high in phytate and because there is some endogenous phytase in certain small grains (wheat, rye, triticale, and barley), there is wide variation in the bioavailability of phosphorus in feed ingredients. For example, only 12 percent of the total phosphorus in corn is available, whereas 50 percent of the total phosphorus in wheat is available. The phosphorus in dehulled soybean meal is more available than the phosphorus in cottonseed meal (23 percent vs. 1 percent), but neither source of phosphorus is as highly available as the phosphorus in meat and bone meal (66 percent), fish meal (93 percent), or dicalcium phosphate (100 percent) (NCSU, 1998b).

Supplementing Diets with Phytase Enzyme. Supplementing the diet with the enzyme phytase is an effective means of increasing the breakdown of phytate phosphorus in the digestive tract and reducing the phosphorus excretion in the feces. Using phytase allows one to feed a lower phosphorus diet because the unavailable phytate phosphorus in the grain and soybean meal is made available by the phytase enzyme to help meet the pig's phosphorus needs. Studies at Purdue University, at the University of Kentucky, and in Denmark indicate that the inclusion of phytase increased the availability of phosphorus in a corn-soy diet threefold, from 15 percent up to 45 percent.

A theoretical example of using phytase is presented in Table 4-31. If a finishing pig is fed a diet with 0.4 percent phosphorus (the requirement estimated by NRC, 1988, cited in NCSU, 1998b), 12 grams of phosphorus would be consumed daily (3,000 grams times 0.4 percent), 4.5 grams of phosphorus would be retained, and 7.5 grams of phosphorus would be excreted. Feeding a higher level of phosphorus (0.5, 0.6, or 0.7 percent) results in a slight increase in phosphorus retention but causes considerably greater excretion of phosphorus (10.3, 13.2, and 16.2 g/d, respectively). Being able to reduce the phosphorus to 0.3 percent in a diet supplemented with phytase would reduce the intake to 9 grams of phosphorus per day and would potentially reduce the excreted phosphorus to 4.5 g/day (a 37 percent reduction in phosphorus excretion versus NRC's estimate). The percent reduction in excreted phosphorus is even more dramatic (56 percent) when one compares the 4.5 grams with the 10.3 grams of phosphorus excreted daily by finishing pigs fed at the 0.5 percent phosphorus level typically recommended by universities and feed companies. Bone strength can be completely recovered by supplementing a low-P diet with 1,000 phytase units per kilograms of feed, while most of the grain and feed efficiency is returned to NRC levels. In addition to returning bone strength and growth performance to control levels, there is a 32 percent reduction in phosphorus excretion. A summary of 11 experiments (Table 4-32) indicates that all the growth rate and feed efficiency can be recovered with the dietary supplementation of 500 phytase units and reduced-phosphorus diets. Some analyses have suggested that a 50 percent reduction in excreted phosphorus by pigs would mean that land requirements for manure applications based on phosphorus crop uptake would be comparable to manure applications based on nitrogen.

Table 4-31. Theoretical Effects of Dietary Phosphorus Level and Phytase Supplementation (200-lb Pig)

Dietary P (%)	Phosphorus (g/d)			Change From Industry Average (%)
	Intake	Retained	Excreted	
0.70	21.0	4.8	16.2	+57
0.60	18.0	4.8	13.2	+32
0.50	15.0	4.7	10.3	0
0.40 (NRC, 1988)	12.0	4.5	7.5	-27
0.30	9.0	2.5	6.5	-37
0.30 + Phytase	9.0	4.5	4.5	-56

Source: Cromwell and Coffey, 1995, cited in NCSU, 1998b.

Previously, phytase was too expensive to use as a feed additive. However, this enzyme can now be effectively produced by recombinant DNA techniques and the cost has decreased. A cost evaluation indicates that under certain conditions replacing dietary phosphorus of an inorganic phosphorus source (e.g., dicalcium phosphate) with the phytase enzyme would be cost neutral. Swine require that phytase supplements be fed at different levels based on the age of the pig (Table 4-33). The different levels are based on phase of production and are likely related to the digestive enzymes and cecum of the younger pig being less developed.

Table 4-32. Effect of Microbial Phytase on Relative Performance of Pigs[a]

Growth Response	Negative Control	Positive Control	Effect of 500+ Phytase Units/kg
ADG	100	115 (+/- 6.5)	116.7 (+/ -10.6)
ADFI	100	105 (+/- 5.2)	107.6 (+/- 7.8)
Feed Conversion Ratio	100	93 (+/- 4.9)	93.2 (+/- 5.0)

[a] Eleven experiments with the negative control diets set at 100 percent and the relative change in pig growth performance to the control diets.
Source: Jongbloed et al., 1996, cited in NCSU, 1998b

Table 4-33. Effect of Microbial Phytase on Increase in Phosphorus Digestibility by Age of Pigs and the Recommended Rates for Inclusion of Phytase in Each Phase

	Nursery	Grower	Finisher	Gestation	Lactation
Approximate Increase (%)	13	17	17	7	20
Inclusion Level (Phytase Unit/lb)	454-385	385-227	27-113	227	227

Source: Jonbloed et al., 1996, cited in NCSU, 1998b

4.1.5.2 *Waste and Waste Water Reductions*

Methods to reduce the quantity of waste water generated at swine operations include advanced swine watering systems to reduce water spillage and recycling water in waste flush systems. The feeding strategies discussed in the previous section will also reduce the quantity of waste generated by ensuring that animals do not receive more feed than required for optimal growth. Additional information on feeding strategies for swine can be found in Chapter 8. Advanced swine breeding has resulted in animals that produce less waste per pound of meat produced.

Nipple water delivery systems reduce the amount of waste water and are more healthy for the animals. Trough or cup waters are typically placed close to the floor of the pen. This allows the animal to spill water and add contaminates to the standing water. Nipple water delivery systems are placed higher in the pen and only deliver water to the animal when the animal is sucking on the nipple. Watering systems may also use water pressure sensors and automatic shutoff valves to reduce water spillage. The sensor will detect a sustained drop in water pressure resulting from a break in the water line. The sensor will then stop the water flow to the broken line and an alarm will sound. The operator can then fix the broken line and restore water to the animals with minimal water spillage. There is little information about the relative use of the various water delivery systems or the relative use of water pressure sensors and shutoff valves within the swine industry.

The use of recycled water in swine flush and pull plug waste management systems will also reduce the amount of waste water generated at an operation. To obtain recycled water of appropriate quality an operation can use a variety of methods to remove pollutants from the waste stream. Such methods include solid-liquid separation, digesters, and multiple-stage lagoon systems. Multiple-stage lagoon systems or the use of an initial settling basin will allow settling of solids and biological processes to occur that can result in high quality water. One large operation in Utah claims to have a completely closed system in which all waste water is treated in a multiple-stage lagoon system and them recycled back to the manure flush system.

4.1.6 Waste Disposal

Waste is disposed in either a liquid or solid form. Handling and disposal in a solid form has several advantages the more concentrated the waste. Hauling costs are reduced as the water content is reduced; however, most operations prefer to handle and dispose of waste in a liquid form because of the reduced labor cost of handling the waste in this manner. Table 4-34 shows the percentage of operations that use or dispose of manure and wastes as unseparated liquids and solids. Tables 4-35 and 4-36 show the percentage of operations that are using the most common disposal methods by USDA APHIS region.

Table 4-34. Percentage of Operations in 1995 That Used or Disposed of Manure and Wastes as Unseparated Liquids and Solids

Operation Size	USDA APHIS Region[a]		
	Midwest	North	Southeast
Operations marketing fewer than 5,000 hogs in 12 months	92.3	99.1	97.7
Operations marketing 5,000 or more hogs in 12 months	100	19.6[b]	98.5

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
[b] The standard error on this measurement is 16.0, resulting in questions of its accuracy
Source: USDA NAHMS, 1999

Table 4-35. Percentage of Operations in 1995 That Marketed Fewer Than 5,000 Hogs in a 12–Month Period and That Used the Following Methods of Use/Disposal by Region

Waste Disposal Method	USDA APHIS Region[a]		
	Midwest	North	Southeast
Placed on own land	97.9	98.5	96.8
Given away	NA	11.0	2.6

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
Source: USDA NAHMS, 1999

Table 4-36. Percentage of Operations in 1995 That Marketed 5,000 or More Hogs in a 12–Month Period and That used the Following Methods of Use/Disposal by Region

Waste Disposal Method	USDA APHIS Region[a]		
	Midwest	North	Southeast
Placed on own land	100	100	97.5
Sold	NA	NA	7.3
Given away	NA	NA	11.3

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA
Source: USDA NAHMS, 1999

Transport and land application of manure nutrients are necessary to realize the fertilizer benefit of such nutrients. Surface application and injection are common means of land application for slurry. Depending on the consistency of the manure, several types of equipment are available to apply the nutrients to the land. The common manure spreader is a low-maintenance, relatively inexpensive piece of equipment. The spreader is designed for solids and thick slurries; however, because of the characteristics of the equipment, the manure is hard to apply uniformly. This type of spreader requires loading equipment and usually takes longer to empty small loads. A flexible drag hose can be used on relatively flat landscapes. This system unloads the manure quickly, although it normally requires two tractors and a power unit on the pump. A flexible drag hose system is effective on regularly shaped fields, but the equipment is expensive. Tank wagon applications are used for liquid manure. The wagon is adaptable to either surface broadcast or injection, depending on the situation. Tank wagons apply liquid manure uniformly and are self-loading; however, the pump to discharge the manure requires a large amount of horsepower, which can be taxing on the tractor. Soil compaction is normally associated with tank wagons, and it usually takes longer to empty the storage facility. Tables 4-37 and 4-38 show the percentage of operations that disposed of manure and waste on owned or rented land using various methods. Operations may use more than one method, therefore columns do not add up to 100 percent.

Table 4-37. Method of Manure Application in 1995 on Land by Operations That Marketed Fewer Than 5,000 Hogs in a 12–Month Period

Variable	**USDA APHIS Region[a]**		
	Midwest	**North**	**Southeast**
Irrigation	47.6	11.2	2.9
Broadcast	18.4	57.8	69.0
Slurry–surface	33.0	55.7	46.6
Slurry–sSubsurface	X	26.6	22.9

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA
Source: USDA NAHMS, 1999

Table 4-38. Method of Manure Application in 1995 on Land by Operations That Marketed 5,000 or More Hogs in 12–Month Period

Variable	**Region[a]**		
	Midwest	**North**	**Southeast**
Irrigation	100	74.8	16.4
Broadcast	X[b]	X	39.4
Slurry–surface	X[b]	6.3	68.1
Slurry–subsurface	X	23.6	72.1

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA
[b] Operations in this region also use broadcast and slurry-surface methods, but NAHMS determined the standard error was too high to report statistically valid values.
Source: USDA NAHMS, 1999

Most manure and waste is disposed of on land owned or rented by the operator, thus the amount of land available for land application of wastes is critical. Applying too much manure and waste to the same land year after year can result in a steady increase in the soil phosphorus content. Tables 4-39 through 4-41 present the percentage of swine operations with and without adequate crop and pasture land for manure application on a nitrogen- and phosphorus-basis at plant removal rates and operations that own no land. The operations that have "no land" were determined by running queries of the USDA 1997 Census of Agriculture data to identify facilities that did not grow any of the 24 major crops grown in the U.S. Operations with no land available are assumed to haul their waste to land that can use the waste as a fertilizer resource.

Table 4-39. Percentage of Swine Grow-Finish Operations With Sufficient, Insufficient, and No Land for Agronomic Application of Generated Manure

Size (head)[a]	Sufficient Land		Insufficient Land		No Land
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	
1-749	76.4	67.38	7.2	14.54	18.7
750-1,874	84.4	68.19	8.98	23.55	15.5
1,875-2,499	80.2	56.56	13.81	34.66	16.46
2,500-4,999	73.8	44.15	19.45	49.27	17.79
> 5,000	48.31	15.53	42.04	69.48	21.97
Total	76.3	60.78	13.54	28.11	18.1

Source: USDA NASS, 1999c.
[a] Estimated by adding head sold in the last year to inventory and dividing the sum by 2.8 turns per year.

Table 4-40. Percentage of Swine Farrowing Operations With Sufficient, Insufficient, and No Land for Agronomic Application of Generated Manure

Size (head)	Sufficient Land		Insufficient Land		No Land
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	
1-749	70.7	57.77	8.44	21.33	20.9
750-2,499	13.33	0	33.33	46.7	53.33
> 2,500	20	0	60	80	20
Total	66.1	53.1	11	24.1	22.9

Source: USDA NASS, 1999c.

Table 4-41. Percentage of Swine Farrow-Finish Operations With Sufficient, Insufficient, and No Land for Agronomic Application of Generated Manure

Size (head)[a]	Sufficient Land		Insufficient Land		No Land
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	
1-749	0	67.4	6.6	15.6	17
750-1,874	84.4	68.2	6	22.2	9.6
1,875-2,499	80.2	56.6	7.9	31.5	12
2,500-4,999	73.8	44.2	12.4	42	13.9
> 5,000	48.3	15.5	23.1	55.8	28.6
Total	76.3	60.8	8.3	23.8	15.4

[a] Estimated by adding head sold in the last year to inventory and dividing the sum by 2.1 turns per year. Inventory includes the number of head in the breeding herd.
Source: USDA NASS, 1999c

Another waste product of swine farms is animal mortality. Mortalities are usually handled in an environmentally sound and responsible manner, but improper disposal may cause problems with odors, pathogens, biosecurity, and soil and water contamination. The 1995 USDA APHIS *Swine 95* study assessed the frequency of mortality disposal methods based on whether operations marketed more or fewer than 2,500 head in the prior 6-month period. (An operation that sold 2,500 head in the last 6–months corresponds roughly to an operation with 1,000 to 1,500 animal unit capacity.) Tables 4-42 and 4-43 show the percentage of operations by method of disposal for those operations which specified at least one pig had died in the 6–month period.

Table 4-42. Method of Mortality Disposal on Operations That Marketed Fewer Than 2,500 Hogs in a 6–Month Period in 1995

Method of disposal	USDA APHIS Region[a]		
	Midwest	North	Southeast
Burial on operation	73.2	71.6	46.6
Burn on operation	9.1	7.2	15.2
Renderer entering operation	2.1	14.1	38.7
Renderer at perimeter of operation	2.7	4.2	8.7
Composting	10.3	6.4	13.0
Other	7.0	9.8	6.8

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
Source: USDA NAHMS, 1999

Table 4-43. Method of Mortality Disposal on Operations That Marketed 2,500 or More Hogs in a 6–Month Period in 1995

Method of Disposal	USDA APHIS Region[a]		
	Midwest	North	Southeast
Burial on operation	23.0	21.0	20.8
Burn on operation	9.9	10.2	17.1
Renderer entering operation	39.9	50.1	37.5
Renderer at perimeter of operation	27.9	23.2	31.4
Composting	X	X	11.1
Other	3.4	X	1.8

[a] Midwest=SD, NE, MN, IA, IL; North=WI, MI, IN, OH, PA; Southeast=MO, KY, TN, NC, GA; Only the 16 major pork states that accounted for nearly 91 percent of U.S. hog inventory were surveyed.
Source: USDA NAHMS, 1999

4.2 Poultry Industry

Poultry feeding operations include facilities that confine chickens or turkeys for feeding or maintenance for at least 45 days in any 12-month period. These facilities do not have significant vegetation in the confinement area during the normal growing season, thus pasture and grazing operations are generally not included. Facilities at which poultry are raised may also include other animal and agricultural operations such as grazing, egg processing, and crop farming.

The specific poultry sectors are discussed in the following sections:

- 4.2.1: Broilers, roasters, and other meat-type chickens
- 4.2.2: Layers and pullets
- 4.2.3: Turkeys

Up until the 1950s most of the nation's poultry production was conducted on small family farms in the Midwest. Midwestern states provided favorable climatic conditions for seasonal production of poultry and close proximity to major sources of grain feed. Eventually, with the improvement of the transportation and distribution systems, the poultry industry expanded from the Midwest to other regions. With the advent of climate-controlled systems, poultry production evolved to a year-round production cycle. By 1997, the value of poultry production exceeded $21.6 billion, and much of the poultry output was generated by corporate producers on large facilities producing more than 100,000 birds (USDA NASS, 1998a).

The poultry industry encompasses several subsectors, including broilers, layers, turkeys, ducks, geese, and several other game fowl. This section focuses only on broilers, layers, and turkeys, which account for more than 99 percent of the annual farm receipts from the sale of poultry (USDA NASS, 1998a).

Together the annual sales of broilers, chicken eggs, and turkeys generate almost 10 percent of the value of all farm commodities. Although each of the poultry subsectors has experienced significant growth in output over the past two decades, broilers remain the dominant subsector, accounting for approximately 65 percent ($14.2 billion) of the $21.6 billion in poultry farm sales during 1997. Sales of eggs and turkeys accounted for 21 percent ($4.5 billion) and 13 percent ($2.9 billion), respectively. More than 15 million metric tons of poultry meat were produced in the U.S. during that year (USDA NASS, 1998c).

Poultry production (especially broiler production) is a highly integrated industry, and as a result, management strategies at the facility level tend to be more similar than in other sectors of animal feeding operations. Contract growing began in the South during the 1930s, and by the 1950s the contracts had evolved to their current form. Thus, the integrated structure seen today was in place by the 1960s (Sawyer, 1971, cited in Aust, 1997). For example, more than 90 percent of all chickens raised for human consumption in the U.S. are produced by independent farmers working under contract with integrated chicken production and processing companies. The company provides some inputs such as the birds themselves, feed, medication, and monitoring of flock health by company service personnel. The farmer provides the grow-out buildings, electricity, water, fuel, bedding material (“litter”), and his or her own labor and management skill. The company provides the newly hatched chicks that the farmer raises to market age and weight, giving them the feed provided by the company. The farmer is paid largely on the basis of weight gained by the flock as compared with other flocks produced during the same span of time. When the birds reach market weight, the company picks them up and takes them to processing plants, where they are processed into food products. Most integrated companies are stand-alone chicken operations, although some also produce turkeys.

The poultry industry has continued to evolve in terms of the type and number of birds it produces. Genetically designed birds have been developed with the ability to mature quickly and reach market weight or lay eggs more rapidly. This has resulted in increased efficiency and overall poultry production. Facilities that grow the birds have incorporated the latest automated technology for the feed and watering systems as well as ventilation systems. The technological advances have transformed poultry raising into a modern, mechanized industry.

4.2.1 Broiler Sector

This section describes the following aspect of the broiler industry:

- 4.2.1.1: Distribution of the broiler industry by size and region
- 4.2.1.2: Production cycles of broilers
- 4.2.1.3: Broiler facility types and management
- 4.2.1.4: Broiler waste management practices
- 4.2.1.5: Pollution reduction
- 4.2.1.6: Waste disposal

National Overview

Domestic broiler production has followed the same trend as swine and other livestock industries. Production has shifted from geographically diverse, small, family-run operations to large industrial production facilities concentrated in a few states. The number of broiler operations was quite stable between 1992 and 1997, with operations decreasing slightly from 23,949 broiler operations in 1992 to 23,937 operations in 1997, down less than 1 percent (USDA NASS, 1999b); however, between 1982 and 1992, more than 6,000 broiler operations, or 20 percent of the industry's producers, went out of business. As shown in Table 4-44, although the number of operations decreased over the past 20 years, total broiler production increased, with new large operations more than compensating for the small producers who have left the industry.

Table 4-44. Broiler Operations and Production in the United States 1982-1997[a]

Year	Operations	Production
1982	30,100	3,516,095,408
1987	27,645	4,361,198,301
1992	23,949	5,427,532,921
1997	23,937	6,741,476,153

[a] Broilers are young chickens of the meat-type breeds, raised for the purpose of meat production. Estimates cover a 12-month period (Dec. 1 through Nov. 30) and exclude states with fewer than 500,000 broilers.
Source: USDA NASS, 1998a, 1998b

4.2.1.1 *Distribution of Broiler Operations by Size and Region*

EPA's 1974 CAFO Effluent Limitations Guidelines and Standards generally apply to broiler operations with more than 100,000 birds and with continuous overflow watering systems, and to broiler operations with 30,000 birds and with a liquid manure system. (See Chapter 2 for the definition of a CAFO, and Chapter 5 for a discussion of the basis for revisions to the poultry subcategories.) Where numbers of birds are presented, all birds regardless of age (e.g., poult, laying age, or pullet) or function (i.e., breeder, layer, meat-type chicken) are included unless otherwise indicated in the text.

Large operations dominate broiler production. Although large production operations are characteristic of other livestock industries, such as the swine sector, the consolidation of the broiler industry began earlier and was well entrenched by the 1970s. By 1982, farms that produced fewer than 2,000 birds per flock numbered only 2,811, or about 5 percent of the total. This number decreased by two-thirds to about 1,000 farms a decade later (Abt, 1998). Compared with other livestock industries, such as swine, the broiler industry has the smallest proportion of small operators. For example, the smallest hog operations still accounted for more than 60 percent of all hog producers in 1992.

Regional Variation in Broiler Operations

Table 4-45 presents the 1997 distribution of broiler operations by region and operation size, and Table 4-46 presents the average flock size for these operations. In addition to being dominated by large producers, the broiler industry is concentrated in several states. Georgia, Arkansas, and Alabama, all in the South Region are some of the largest broiler-producing states. Table 4-47 presents the distribution of total chickens by region and operation size. It is important to note that operations with more than 90,000 birds accounted for more than 48 percent of the broilers even though they represented only 11.3 percent of the broiler operations. Operations with fewer than 30,000 birds represented almost 60 percent of the operations but accounted for less than 7 percent of the total birds.

Table 4-45. Total Number of Broiler Operations by Region and Operation Size in 1997

Region [a]	Number of Chicken Broiler Operations by Size Group [b] (Operation Size Presented by Number of Birds Spot Capacity)					
	>0-30,000	>30,000-60,000	>60,000-90,000	>90,000-180,000	>180,000	Total
Central	3,046	412	325	274	78	4,135
Mid Atlantic	5,113	2,105	1,055	842	100	9,215
Midwest	7,910	207	96	141	43	8,397
Pacific	1,244	41	38	42	63	1,428
South	3,403	3,597	2,327	1,980	377	11,684
National	20,716	6,362	3,841	3,279	661	34,859

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Pacific=WA, OR, CA, AK, HI; South=AR, LA, MS, AL, GA, SC, FL

[b] Broilers are young chickens of the meat-type breeds, raised for the purpose of meat production. Estimates cover a 12-month period (Dec. 1 through Nov. 30) and exclude states with fewer than 500,000 broilers.

Source: USDA NASS, 1999c

Table 4-46. Average Number of Chickens at Broiler Operations by Region and Operation Size in 1997

Region [a]	Average Chicken Broiler Animal Counts [b] (Operation Size Presented by Number of Birds Spot Capacity)					
	>0-30,000	>30,000-60,000	>60,000-90,000	>90,000-180,000	>180,000	All Operators
Central	1,494	44,224	73,084	119,026	332,030	25,402
Mid Atlantic	6,178	44,193	73,590	115,281	303,155	35,771
Midwest	830	47,357	75,821	118,611	414,945	6,933
Pacific	608	44,041	73,695	132,560	624,380	35,200
South	12,538	43,998	73,776	117,581	281,453	60,897
National	4,158	44,187	73,717	117,347	332,073	35,993

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Pacific=WA, OR, CA, AK, HI; South=AR, LA, MS, AL, GA, SC, FL

[b] Broilers are young chickens of the meat-type breeds, raised for the purpose of meat production. Estimates cover a 12-month period (Dec. 1 through Nov. 30) and exclude states with fewer than 500,000 broilers.

Source: USDA NASS, 1999c

Table 4-47. Distribution of Chickens by Region and Operation Size in 1997

Region [a]	Percentage of Total Chicken Broiler Counts [b] (Operation Size Presented by Number of Birds Spot Capacity)					
	>0-30,000	>30,000-60,000	>60,000-90,000	>90,000-180,000	>180,000	Total
Central	0.36	1.45	1.89	2.60	2.06	8.37
Mid Atlantic	2.52	7.41	6.19	7.74	2.42	26.27
Midwest	0.52	0.78	0.58	1.33	1.42	4.64
Pacific	0.06	0.14	0.22	0.44	3.14	4.01
South	3.40	12.61	13.68	18.56	8.46	56.71
National	6.86	22.41	22.57	30.67	17.49	100.00

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Pacific=WA, OR, CA, AK, HI; South=AR, LA, MS, AL, GA, SC, FL

[b] Broilers are young chickens of the meat-type breeds, raised for the purpose of meat production. Estimates cover a 12-month period (Dec. 1 through Nov. 30) and exclude states with fewer than 500,000 broilers.

Source: USDA NASS, 1999c

4.2.1.2 *Production Cycles of Broilers*

Broilers are usually grown for 42 to 56 days depending on the market weight desired. Female broilers can also be grown to lay eggs for replacement stock, and these females are called broiler breeders. Roasters are usually grown separated by sex, with the females being harvested at 42 days of age and the males given the space in the entire house until they are sent to market several weeks later (USEPA, 1998). Other meat-type chickens (capons, game hens) comprise less than 1 percent of chickens raised for meat. Since they are raised in a similar manner to broilers, albeit with different market weights and ages, they are not usually differentiated in the data.

Chickens are produced to meet specific requirements of the customer which can be a retail outlet, fast-food chain, or institutional buyer, among others. A broiler is considered any chicken raised for meat products, though the industry further classifies chickens primarily by the size, weight, and age of the bird when processed.

- **Poussin** - Less than 24 days of age and about 1 pound or less.
- **Cornish Game Hens** - Less than 30 days of age and about 2 pounds.
- **Fast-food Broiler** - 2 pounds 4 ounces to 3 pounds 2 ounces (mostly 2 pounds 6 ounces to 2 pounds 14 ounces) and less than 42 days of age.
- **3's and Up** - 3 to 4 3/4 pounds and 40 to 45 days of age.
- **Broiler Roaster** - 5 to 6 pounds, hens usually 55 days.
- **Broiler for De-boning** - 5 to 6 pounds, males usually 47 to 56 days.
- **Heavy Young Broiler Roaster** - The typical "roaster," 6 to 8 pounds, less than 10 weeks.
- **Capon** - 7 to 9 pounds, surgically de-sexed male broiler, 14 to 16 weeks.
- **Heavy Hens** - spent breeder hens, 5 to 5 ½ pounds, 15 months of age.

4.2.1.3 *Broiler Facility Types and Management*

The most common type of housing for broilers, roasters, pullets, and breeding stock is some type of enclosed housing with bedding derived from wood shavings, rice hulls, chopped straw, peanut hulls, or other products, depending on availability. The bedding absorbs moisture and dilutes the manure produced by the birds. Modern houses have an automatic feeding system to distribute the feed, a closed water system (automatic) to deliver the water for the birds, and a ventilation system to provide clean air. Some houses have side curtains that can be retracted to allow diffusion of air. Ventilation is typically provided using a negative-pressure system, with exhaust fans drawing air out of the house, and fresh air returning through ducts around the perimeter of the roof. The ventilation system uses exhaust fans to remove moisture and noxious gases during the winter season and excess heat during the summer. Advanced systems use thermostats and timers to control exhaust fans. These houses are also commonly integrated with an alarm signal to notify the operator of malfunctions and a back-up electric generator during power outages.

Broilers and Roasters. Houses for broilers and roasters are usually 40 feet wide and 400 to 500 feet long and typically designed for 25,000 to 30,000 broilers per flock. Older houses may be somewhat smaller, holding 20,000 to 25,000 birds. The houses contain an impermeable surface for the floor, typically clay. Wood shavings are initially added to the houses to a depth of approximately 4 inches. Between flocks, a small amount of litter referred to as cake (compacted and concentrated manure/litter mix) is removed and the remaining litter may be “top dressed” with an inch or so of new bedding material.

Pullets. Pullets are young chickens, usually less than 20 weeks of age, often raised for the purpose of egg production. Pullet houses are similar in construction to broiler houses. The houses are usually 40 to 45 feet in width and 300 to 500 feet in length. Most pullet houses are equipped with nipple, trough, or bell drinkers and often use mechanical feeders (drag chain, trough, or pan) to distribute feed to the birds. Pullets are usually raised on a floor covered with a bedding source, 1 to 4 inches deep. This litter mixture is either removed after each flock (20 to 21 weeks) or used for a second flock. If the litter is used for a second flock, a small amount of litter as cake is removed and the remaining litter is top dressed with an inch or so of new bedding material. When the house is totally cleaned out, the litter is pushed to the center of the house and a front loader places it in a litter spreader for land application or disposal. Regular and thorough house cleaning is required to minimize disease transmission.

Breeders. Houses are usually 40 to 45 feet in width and 300 to 600 feet in length. Most of the breeder houses contain two rows of slats for the birds to roost. The slats are panels of wood elevated 18 to 24 inches and laid across supports. The slats are spaced 1 inch apart to allow the feces material to fall to the floor. Equipment can access the center section of the house to aid in the clean-out between flocks. These slats cover two-thirds of the entire length of the house along the outside walls, with the center one-third of the building containing bedding litter.

The center third of the house is covered with 2 to 6 inches of a bedding source before young breeder layers are placed in the breeder house. Drinkers, mechanical feeders, and nests are placed over the slat section of the house, which allows most of the manure produced by the birds to fall beneath the slat area, keeping the area accessible to the birds cleaner.

4.2.1.4 *Broiler Waste Management Practices*

This section summarizes waste management practices for broiler, breeding stock, pullets, and roaster production facilities. Manure as excreted by the birds has a high water content, most of which evaporates. A typical broiler house with capacity for 22,000 birds at a time will produce 120 tons of litter per year. The litter consists mainly of wood chips or other organic plant matter even after it has been in place for a year (NCC, 1999).

Litter Clean-out Schedules. The litter (bedding and manure) of broiler, pullet, and roaster houses is typically cleaned out completely once a year, although there is a trend toward less frequent complete clean-outs. Between flocks, the feeders, waterers, and brooding equipment are winched to the ceiling. A machine is often used to clean out any clumps of litter (termed caking out) that may build up around waterers and feeders. When the broiler or roaster house is completely cleaned out, the litter is typically removed with a front-end loader or bobcat to a spreader truck or flail-type spreader. Spreader trucks are similar to lime-spreading trucks, with a moving bed that empties onto large, round metal plates that distribute the litter for use as fertilizer nutrients for pasture and crops. The rate of application is controlled by the rate at which the moving bed empties and the speed of the truck (NCSU, 1998).

The common clean-out frequency in broiler breeder houses is once a year. When the house is cleaned, all the equipment (including slats) is removed from the house to allow a front-end loader to push all of the manure to the center litter section of the house. Then a front-end loader places the mixture of manure and litter into a spreader for land application. A thorough cleaning after each flock (essentially once a year) removes pathogens that could be transferred to the next flock. After removal of all organic matter, the house is disinfected.

Litter Storage. Litter is removed from houses in large quantities during annual clean-out. Thus, operators that have land try to time the annual clean-out to coincide with the time land is available for litter application. If this approach is successful, the facility will need only enough storage for cake out during the rest of the year. Traditionally, operators stack litter outside, near the poultry houses or at the edge of fields for spreading in the spring.

However, an increasing number of states are imposing restrictions on the outdoor storage of waste, although the stringency of these requirements vary from state to state. For example, under Virginia's Poultry Waste Management Program, stockpiled poultry litter must be (1) covered, (2) located to prevent storm water runoff, and (3) separated a minimum of 3 feet from the seasonally high water table or by the use an impermeable barrier. Maryland's requirements for outdoor storage are less restrictive and require only that storage be conducted in manner to be protective from rainfall and runoff. The State of Delaware, which is also an important producer of poultry, is less restrictive than Maryland and allows for uncovered storage of poultry litter (Hansen, 2000).

There are several methods for storing poultry litter ranging from open stock piles to roofed-storage structures. The size and type of method employed varies with location and size of the operation as well as applicable regulations. Open stockpiles are the least expensive alternative, but pose the greatest risk of contaminating the surrounding environment. Contamination risk is reduced if these stockpiles are put on top of ground liners. Other storage structures include bunker-type storage structures, which are permanent aboveground concrete slabs with two parallel walls of concrete identical to those used for storing silage on livestock farms (Brodie et al., 2000). Storage structures with permanent roofs offer both advantages and disadvantages. These structures eliminate the need for plastic covers and reduce the risk of runoff contamination; however, they require a higher level of investment and higher maintenance costs than the other types of structures. Also if these roof structures are not high enough, compacting becomes more difficult and reduces the operator's ability to use the full capacity of the structure (Goan, 2000).

4.2.1.5 *Pollution Reduction*

New technologies in drinking water systems result in less spillage and are equipped with automatic shutoff valves that help ensure that broiler litter stays drier. Feeding strategies reduce the quantity of waste generated by ensuring that broilers do not receive more feed than required for optimal growth. State regulations have also driven many broiler operations to handle mortalities in ways other than burials such as rendering and composting, which are increasing (see Section 4.2.1.6).

Nipple water delivery systems reduce the amount of wasted water and are healthier for the animals. Trough or bell type watering devices allow the animal to spill water and add contaminants to the standing water. Nipple water systems deliver water only when the animal is sucking on the nipple. Watering systems may also use water pressure sensors with automatic shutoff valves to reduce water spillage. The sensor will detect a sustained drop in water pressure resulting from a break in the water line. The sensor will then stop the water flow to the broken line and an alarm will sound. The operator can then fix the broken line and restore water to the animals with minimal water spillage.

Feeding strategies that reduce nitrogen and phosphorus can reduce the quantity of nutrients in the excreta. Dietary strategies designed to reduce nitrogen and phosphorus include enhancing the digestibility of feed ingredients, genetic enhancement of cereal grains and other ingredients resulting in increased feed digestibility, more precise diet formulation, and improved quality control. Although nitrogen and phosphorus are currently the focus of attention, these strategies also have the potential to decrease other nutrients. Phytase is commonly added to broiler feed. Phytase additions are expected to achieve a reduction in phosphorus excretion of 20 to 60 percent depending on the phosphorus form and concentration in the diet (NCSU, 1998b). Protein content, calcium, other mineral content, vitamin B, as well as other factors identified in the literature influence the effectiveness of phytase use in feed. Additional information on feeding strategies for broilers can be found in Chapter 8.

Feeding Strategies. Phosphorus excretion can be reduced by improving the utilization of feed nutrients through genetic improvements in poultry or by improving the availability of nutrients in the feed ingredients through processing or genetics. Absorption of some minerals is relatively poor and is dependent on the chemical form in the feed or supplement.

4.2.1.6 *Waste Disposal*

This section summarizes waste disposal practices for poultry production facilities. The two major categories of poultry waste are manure or litter (manure mixed with bedding) and dead animals. There is little variation in manure characteristics, but the litter composition varies by storage, composting management, and other practices. Poultry litter can be disposed of in several ways including land application, animal feed, and incineration. Waste may be pelletized before its applied to the land. Pelletizing produces a more uniform product that is lighter, easily transported in bulk, and spread more uniformly. Additional information on pelletizing poultry wastes and other waste disposal methods can be found in Chapter 8.

Land Application of Poultry Litter. Land application of poultry litter recovers nutrients that otherwise would be lost and improves crop yields. Poultry manure slowly releases its nutrients, so annual applications are possible. Composting and bagging a pelleted poultry manure fertilizer produces a marketable product for the commercial horticulture industry. One main obstacle to greater commercialization of poultry manure as a fertilizer product has been the inconsistency in product quality from one facility to another.

Where land application is employed, operators commonly use broadcast spreaders and flail-type spreaders for litter. Recommended application rates are based on the nutrient content of the litter, crop type and yield goals, and current soil conditions.

Many producers with cropland apply their litter to their own crops. However, as operations have increased in size and have become more specialized, this option is becoming more limited. In some cases, poultry production provides supplemental income to an otherwise small or non-agricultural household with little or no land. Further exacerbating the problem of poultry litter disposal is the fact that many areas of chicken production have a surplus of nutrient supply over crop needs (USDA NRCS, 1998). In these areas, the poultry producers face difficulties in selling litter, giving litter away, or even paying local farmers to take the litter. The percentage of broiler operations with enough land and without enough land for application of manure on a nitrogen- and phosphorus-basis and operations with no land are shown in Table 4-48. The facilities that have "no land" were determined by running queries of the USDA 1997 Census of Agriculture data to identify facilities that did not grow any of the 24 major crops grown in the U.S. More details on the national and county level nutrient balance are found in Chapter 6.

Table 4-48. Percentage of Broiler Dominated Poultry Operations With Sufficient, Insufficient, and No Land for Agronomic Application of Generated Manure

Capacity (Number of Birds)	Sufficient Land		Insufficient Land		No Land
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	
1-29,999	11.92	9.6	37.7	40.07	50.37
30,000-59,999	6.38	2.9	53.52	56.99	40.09
60,000-89,999	4.78	2.1	57.39	6.008	37.82
90000-179,999	4.42	1	64.16	67.62	31.41
> 180,000	3.63	0.7	68.93	7.19	27.43
Total	5.39	2.3	59.97	62.69	35.02

Source: USDA NASS, 1999c

Use of Poultry Litter as Animal Feed. Data on the use of poultry litter as animal feed is inadequate to determine how prevalent it is as a waste disposal method. Anecdotal information indicates that use of poultry litter as a food supplement for beef herds may be common in the Mid-Atlantic and Southeast regions.

Incineration of Poultry Wastes. Incineration of poultry wastes is not done on a large scale in the U.S. The practice is being successfully implemented in the United Kingdom and is actively being investigated in the U.S. Additional information on centralized incineration of poultry wastes is presented in Chapter 8.

Disposal of Dead Animals. Concerns about possible ground water pollution from the burial of dead birds have caused the poultry industry to search for alternatives for dealing safely with dead stock. The most common methods of disposal of dead birds are composting, incineration, burial in deep pits, rendering, and disposal in landfills. Anecdotal information indicates that some broiler integrators have begun to distribute freezers to grower operations to store dead birds prior to pick up for rendering. Technical information on practices for the disposal of dead animals is presented in Chapter 8. However, there is little information available on the relative use of these practices within the broiler industry.

4.2.2 Layer Sector

This section describes the following aspect of the layer industry:

- 4.2.2.1: Distribution of the layer industry by size and region
- 4.2.2.2: Production cycles of layers and pullets
- 4.2.2.3: Layer facility types and management
- 4.2.2.4: Layer waste management practices
- 4.2.2.5: Egg processing and wash water
- 4.2.2.6: Pollution reduction
- 4.2.2.7: Waste disposal

National Overview. Trends in the egg production subsector have paralleled those in other livestock industries—increasing overall production on fewer and larger farms. At the end of 1997, there were 69,761 operations with hens and pullets of laying age in the U.S. (layers 20 weeks and older). This number represents a 19 percent decrease from the estimated 86,245 operations with egg-producing birds in 1992 (USDA NASS, 1999c). In the ten–year period from 1982 to 1992, the number of operations with hens and pullets declined from more than 212,000, a 60 percent decrease (Abt, 1998). Table 4-49 shows the number of operations and bird inventory for 1982, 1987, 1992, and 1997. The number of operations in each category of operation has decreased substantially while total production has increased. Table 4-49 also provides data on operations and inventory with birds below laying age. As with other sectors, specialization of production has gained a foothold, with a small but increasing number of operations producing only pullets.

One major difference between the layer and egg production sector and the broiler production sector is geographical distribution. Layer production, although primarily performed in 10 states, is much less geographically concentrated than the broiler industry. Hence, the key regions identified for the broiler industry in the previous section are not applicable to the layer and egg production sector. Overall, layer production has not increased as rapidly as has broiler production has.

Table 4-49. Operations With Inventory of Layers or Pullets 1982-1997.

Total Number of Farms with	1997		1992		1987		1982	
	Ops	Production	Ops	Production	Ops	Production	Ops	Production
Layers 20 weeks and older	69,761	313,851,480	86,245	301,467,288	141,880	316,503,065	212,608	310,515,367
Layer and pullets 13 weeks and older	72,616	366,989,851	88,235	351,310,317	144,438	373,577,186	215,812	362,464,997
Pullets between 13 and 20 weeks old	13,180	53,138,371	14,818	49,843,029	19,639	57,074,121	28,109	51,949,630
Pullets less than 13 weeks	5,122	51,755,985	4,938	44,567,993	6,753	47,409,798	8,726	40,705,085

Source: USDA NASS, 1999b

4.2.2.1 *Distribution of Layer Operations by Size and Region*

Layers are defined as chickens maintained for the production of table eggs. Eggs may be produced for human consumption in the shell form (sold in cartons) or may be used in the production of liquid, frozen, or dehydrated eggs. Laying hen operations include facilities that confine chickens for feeding or maintenance for at least 45 days in any 12-month period. These facilities do not have significant vegetation in the confinement area during the normal growing season. Facilities that raise pullets are generally included. Egg washing and egg processing facilities located at the same site as the birds are generally included. Facilities that have laying hen or pullet feeding operations may also include animal and agricultural operations such as grazing and crop farming.

EPA's 1974 CAFO Effluent Limitations Guidelines and Standards generally apply to laying hen operations with more than 100,000 birds and with continuous overflow watering systems, and to laying hen operations with 30,000 birds and with a liquid manure system. (See Chapter 2 for the definition of a CAFO, and Chapter 5 for a discussion of the basis for revisions to the poultry subcategories.) Where numbers of birds are presented, all birds regardless of age (e.g., poult, laying age, or pullet) or function (i.e., breeder, layer, meat-type chicken) are included unless otherwise indicated in the text.

Table 4-50 presents the number of layer, pullet, and combined operations by size class as well as the average bird count at each type of operation. Table 4-51 presents the number of operations with laying hens by operation size and region, and Table 4-52 presents the average number of birds at these operations. Data on the three types of operations were obtained through special queries of the 1997 Census of Agriculture (USDA NASS, 1999c). Each operation is uniquely characterized, thus the sum of all three provides the total number of operations with layers or pullets or both (75,172 total operations). Pullet operations were assumed to be evenly distributed so as to support layer operations. Thus the percentage of operations in a region from Table 4-51 is used to estimate the percentages of all layer and pullet operations in that region. Table 4-53 presents the distribution of egg laying chickens by facility size and region. It is important to note that in 1997 the 326 largest operations with laying hens were less than one half of a percent of the total operations (70,857) but had over 55 percent of the laying hens.

Table 4-50. Number of Operations in 1997 and Average Number of Birds at Operations with Layers or Pullets or Both Layers and Pullets in 1997

<table>
<tr><th rowspan="2">National Item</th><th colspan="6">Number of Layer, Pullet, and combined Layer and Pullet Operations and Average Bird Counts
(Operation Size Presented by Number of Birds Spot Capacity)</th></tr>
<tr><th>>0-30,000</th><th>>30,000-62,500</th><th>>62,500-180,000</th><th>>180,000-600,000</th><th>>600,000</th><th>Total</th></tr>
<tr><td>Layer Ops</td><td>57,413</td><td>528</td><td>419</td><td>146</td><td>25</td><td>58,531</td></tr>
<tr><td>Layer Count</td><td>926</td><td>43,621</td><td>103,048</td><td>311,189</td><td>1,013,318</td><td></td></tr>
<tr><td>Pullet Ops [a]</td><td>3,694</td><td>516</td><td>61</td><td colspan="2">44</td><td>4,315</td></tr>
<tr><td>Pullet Count</td><td>5,010</td><td>51,162</td><td>133,303</td><td colspan="2">305,679</td><td></td></tr>
<tr><td>Layer and Pullet Ops</td><td>12,011</td><td>67</td><td>93</td><td>91</td><td>64</td><td>12,326</td></tr>
<tr><td>Layer and Pullet Count</td><td>218</td><td>45,963</td><td>112,377</td><td>358,580</td><td>1,367,476</td><td></td></tr>
</table>

[a] Pullet size ranges vary from the others: >0-30,000; >30,000-100,000; >100,000-180,000; and >180,000.
Source: USDA NASS, 1999c

Table 4-51. Number of Operations in 1997 With Laying Hens by Region and Operation Size in 1997

Region [a]	Number of Chicken Egg Laying Operations (Operation Size Presented by Number of Layers in Inventory)					
	>0-30,000	>30,000-62,500	>62,500-180,000	>180,000-600,000	>600,000	Total
Central	15,067	76	41	28	9	15,221
Mid Atlantic	17,445	150	133	48	15	17,791
Midwest	23,069	123	182	78	39	23,491
Pacific	6,509	38	66	39	17	6,669
South	7,334	208	90	44	9	7,685
National	69,424	595	512	237	89	70,857

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Pacific=WA, OR, CA, AK, HI; South=AR, LA, MS, AL, GA, SC, FL
Source: USDA NASS, 1999c

Table 4-52. Average Number of Chickens at Operations in 1997 With Laying Hens by Region and Facility Size

Region [a]	Average Chicken Egg Layer Counts (Operation Size Presented by Number of Layers in Inventory)					
	>0-30,000	>30,000-62,500	>62,500-180,000	>180,000-600,000	>600,000	All Operations
Central	311	42,360	89,688	317,725	733,354	1,779
Mid Atlantic	911	42,588	95,585	286,946	1,007,755	3,590
Midwest	281	45,244	97,848	279,202	1,229,095	4,236
Pacific	115	43,613	99,354	277,755	813,356	5,041
South	3,654	38,642	97,413	293,512	884,291	8,390
National	787	41,786	96,595	287,740	1,027,318	4,072

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Pacific=WA, OR, CA, AK, HI; South=AR, LA, MS, AL, GA, SC, FL
Source: USDA NASS, 1999c

Table 4-53. Distribution of Chickens at Operations in 1997 With Laying Hens by Region and Facility Size

Region [a]	Percentage of Total Chicken Egg Layer Counts (Operation Size Presented by Number of Layers in Inventory)					
	>0-30,000	>30,000-62,500	>62,500-180,000	>180,000-600,000	>600,000	Total
Central	1.62	1.12	1.27	3.08	2.29	9.38
Mid Atlantic	5.51	2.21	4.41	4.77	5.24	22.14
Midwest	2.25	1.93	6.15	7.55	16.61	34.49
Pacific	0.26	0.57	2.27	3.75	4.79	11.65
South	9.29	2.79	3.04	4.48	2.79	22.34
National	18.92	8.62	17.14	23.63	31.69	100.00

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Pacific=WA, OR, CA, AK, HI; South=AR, LA, MS, AL, GA, SC, FL
Source: USDA NASS, 1999c

4.2.2.2 *Production Cycles of Layers and Pullets*

A layer is a sexually mature female chicken capable of producing eggs. Egg production can be divided into two types, table and hatching. Table eggs are used for consumption, and hatching eggs are used to supply broiler or layer production operations.

Traditionally, layers are kept through 1 year of egg production and sold for meat at 18 to 20 months of age. Depending on market conditions (relative price of eggs to hens), it has become increasingly common to recycle layers through more than 1 year of production (Bradley et al., 1998). Producers will recycle their flocks into a second or even a third cycle of lay. Flock recycling involves stopping the flock's egg production, allowing a suitable rest period, and then bringing the flock back into production. The entire process (called "force molting") of recycling layers takes approximately 4 to 5 weeks. Producers stop egg production by reducing the length of day (lighting) and feed supply. This period typically takes 2 to 4 weeks and involves a 7–day fast followed by a period during which the flock is fed a low calcium diet. After this "rest period," the flock is returned to normal lighting conditions and a nutritionally balanced diet to support egg production (UCD, 1998). Once the flock is brought back into production, most layers will meet or exceed original levels of egg production. Under this regime, the flock's life is extended for 6 to 12 additional months.

4.2.2.3 *Layer Facility Types and Management*

Litter-based Housing. A few litter and slat/litter houses are used to produce table eggs. These same housing systems are used for the breeders that produce fertile eggs for the production of hatching eggs, which eventually replace the current flock of egg layers.

Non-litter Based Housing. Layers are often raised in cages arranged in two or four decks. Cages have been the preferred way of housing table egg layers since the mid-1940s (Bradley et al., 1998). They are popular because they provide good sanitation. When the birds are caged, flock nutrition can be better managed and products (eggs) kept cleaner. Cages are designed to separate the layers from their own feces and thereby eliminate many of the feces-related parasite and health problems. Most commercial layer facilities employ one of the following designs.

High-rise Cage Systems. Cage systems are two-story poultry houses with cages for the laying hens in the top story suspended over the bottom story, where the manure is deposited and stored. The house structure itself is usually 40 to 60 feet wide and from 400 to 500 feet long. The watering system is a closed (noncontinuous flow) nipple or cup system. The ventilation system is designed so that the external air is brought into the top story, through the cages where the birds are located, and then over the manure in the bottom story, exiting through fans in the bottom story side wall. The ventilation system is designed to dry manure as it is stored. With proper management of waterers to prevent water leaking to the bottom story, layer waste commonly has a moisture content of 30 to 50 percent.

Scrape-out and Belt Systems. Housing facilities for scrape-out and belt manure removal cage systems are the same dimensions as high-rise units except they have only one story. Watering systems in these operations are also closed, using nipple or cup waterers. Ventilation varies from fan-controlled to adjustable curtains in the side wall.

Cages in the scrape-out system are suspended over a shallow pit, which is scraped out to the end of the house by a small tractor or a pit scraper. Belt systems have a continuous belt under the different tiers of cages that moves the manure to the end of the house, where it is placed into a field spreader or some other suitable storage device. Some of the newer belt systems move air over the manure on the belt in an attempt to dry the manure before it is removed.

The manure from scrape-out and belt systems usually has a moisture content of between 70 and 85 percent. Therefore, the manure can be handled as a slurry, which is either injected or land applied to the land with a spreader that can handle the high-moisture manure.

Flush-Cage Housing. Housing, equipment, and ventilation in flush-cage housing are similar to the scrape-out system with the exception of how the manure is handled. Cages are suspended over a shallow pit as in the scrape-out system, but water is used to move the manure from under the cages to the end of the house, where the water and manure mixture is placed in an anaerobic lagoon. The water used to flush the manure pits is recycled from the lagoon. A variation of this system consists of solids separation by means of a primary lagoon and a secondary lagoon. (NCSU, 1998a).

Although storage, management, and disposal practices are quite similar for broiler and layer operations, with the exception of layer operations using lagoon systems, there are regional differences in how operations manage waste. A survey conducted by the United Egg Producers during 1998 indicated significant regional differences in the way layer wastes are managed. These differences are shown in Table 4-54. This data was used with the data in Table 4-51 to estimate that the total number of layer operations that use water to move the wastes to a lagoon (referred to as wet layer systems) was approximately 3,100 operations.

Table 4-54. Summary of Manure Storage, Management, and Disposal

Practice	Percentage of Region With Practice				
	Pacific	Central	Midwest	Mid-Atlantic	South
Storage sheds in addition to high-rise housing	0	0	10	0	0
Housing with 6-month or longer storage of dry manure	75	40	90	90	40
Export or sale of some or all of litter	100	40	100	75	50
Litter use other than land application (incineration, pelletization)	0	0	5	5	0
Farms with wet storage systems, such as lagoon	0	60	2	5	60

Source: UEP, 1998

4.2.2.4 *Layer Waste Management Practices*

Manure handling systems vary by region. In 1999 the USDA's Animal and Plant Health Inspection Service completed the Layers '99 Study (USDA APHIS, 2000b), which looked at a 15-state target population to develop information on the nation's table egg layer population. The 15 states accounted for over 75 percent of the table egg layers in the U.S. on December 1, 1998. The information collected was summarized by four regions. The data collected on the manure handling methods of layer facilities are presented in Table 4-55.

Table 4-55. Frequency of Primary Manure Handling Method by Region

Primary Manure Handling Method	Great Lakes		Southeast		Central		West		All Farms	
	%	SE	%	SE	%	SE	%	SE	%	SE
High-rise (pit at ground level with house above	63.0	12.3	31.4	6.0	48.1	6.0	7.8	2.1	39.7	4.4
Deep pit below ground	0.0	--	0.0	--	6.4	3.9	7.3	2.5	2.9	1.0
Shallow pit (pit at ground level with raised cages)	23.4	9.6	19.9	7.3	1.6	1.2	24.1	7.2	18.9	4.4
Flush system to lagoon	0.0	--	41.0	5.9	0.0	--	12.0	3.6	12.5	2.5
Manure belt	13.6	6.7	4.3	2.1	20.2	4.9	5.2	1.5	10.6	2.7
Scraper system (not flush)	0.0	--	2.5	2.1	23.7	8.7	43.6	6.4	15.4	2.6
Total	100		100		100		100		100	

Regions: Great Lakes: IN, OH, and PA; Southeast: AL, FL, GA, and NC; Central: AR, IA, MN, MO, and NE; West: CA, TX, WA.
SE = Standard Error
Source: USDA APHIS, 2000b

4.2.2.5 *Layer Egg Wash Water*

The majority of eggs marketed commercially in the U.S. are washed using automatic washers. Cleaning compounds such as sodium carbonate, sodium metasilicate, or trisodium phosphate, together with small amounts of other additives, are commonly used in these systems. In addition, plants operating under the Federal Grading Service are required to rinse eggs with a sanitizer following washing (Moats, 1981). Wash water is contaminated with shell, egg solids, dirt, manure, and bacteria washed from the egg surface into the recycled water.

A study by Hamm et al. (1974), performed to characterize the wastewater from shell egg washers, calculated the pollutant load from 11 egg grading and egg breaking plants. Median waste concentrations in the wash waters at the grading plants were found to be 7,300 mg/L for chemical oxygen demand, 9,300 mg/L for total solids, and 4,600 mg/L for volatile solids; median concentrations at the breaking plants were found to be 22,500 mg/L for chemical oxygen demand, 27,000 mg/L for total solids, and 16,600 mg/L for volatile soilds.

Eggs may be washed either on farm or off farm. Operations that wash their eggs on farm may do so in-line or off-line. The frequency of the egg processing location is presented in Table 4-56. The frequency of egg processing location by operation size is presented in Table 4-57. The eggs from over 80 percent of the operations are processed off site. Operations with fewer than 100,000 layers are more likely to have their eggs processed off site. Smaller poultry operations primarily haul their wash water to treatment centers or sell their eggs to larger operations for washing and processing (Thorne, 1999). On the other hand, larger egg production operations collect and store egg wash water on site in large tanks or lagoons for treatment and storage. This lagoon water may then be applied to fields using spray irrigation. These anaerobic lagoons are earthen structures designed to provide biological treatment and long-term storage of poultry layer waste. Treatment of waste occurs anaerobically, a process in which organic material is decomposed to carbon dioxide and water, while stabilized products, primarily humic substances, are synthesized. Where space is available, two-stage lagoons may be constructed for better wastewater treatment and greater management flexibility. The first stage thus contains only the treatment (permanent) volume and sludge volume while the second stage lagoon stores treated wastewater for irrigation and provides additional treatment that produces a higher quality effluent for recycling as flush water (Tyson, 1996).

Table 4-56. Percentage of Operations by Egg Processing Location and Region

Primary Egg Processing Location	Great Lakes		Southeast		Central		West		All	
	%	SE	%	SE	%	SE	%	SE	%	SE
On farm in-line	17.8	8.4	13.1	4.3	9.0	3.2	10.9	2.4	13.5	3.0
On farm off-line	6.7	5.4	0.6	0.6	3.3	3.3	9.3	2.4	5.3	2.1
Off farm	75.5	8.1	86.3	4.4	87.7	4.5	79.8	3.6	81.2	3.2
Total	100	--	100	--	100	--	100	--	100	--

Regions: Great Lakes: IN, OH, and PA; Southeast: AL, FL, GA, and NC; Central: AR, IA, MN, MO, and NE; West: CA, TX, WA.
SE = Standard Error
Source: USDA APHIS, 2000b

Table 4-57. Percentage of Operations by Egg Processing Location and Operation Size

Primary Egg Processing Location	Egg Laying Operations with <100,000 Layers		Egg Laying Operations with 100,000+ Layers	
	%	SE	%	SE
On farm in-line	4.3	2.8	28.9	5.6
On farm off-line	5.2	3.1	5.5	1.9
Off farm	90.5	4.1	65.6	6.0
Total	100	--	100	--

Regions: Great Lakes: IN, OH, and PA; Southeast: AL, FL, GA, and NC; Central: AR, IO, MN, MO, and NE; West: CA, TX, WA.
SE = Standard Error
Source: USDA NAHMS, 2000

4.2.2.6 *Waste and Wastewater Reductions*

Methods to reduce the quantity of wastewater generated at layer operations include advanced watering systems to reduce water spillage and feeding strategies. The use of feeding strategies will reduce the quantity of waste generated by ensuring that animals do not receive more feed than required for optimal growth. Dietary strategies to reduce nitrogen and phosphorus content include developing more precise diets and improving the digestibility of feed ingredients through the use of enzyme additives and genetic enhancement of cereal grains. Information on feeding strategies for layer operations can be found in Chapter 8.

There are several types of water delivery systems used in layer operations. Nipple water delivery systems reduce the amount of wastewater and result in healthier birds. Trough or cup drinkers allow the bird to spill water and add contaminates to the standing water. Continual overflow watering systems reduce the health risk to the birds but produce a greater quantity of wastewater.

Nipple water delivery systems are placed in the cage and deliver water only when the bird is sucking on the nipple. Approximately 62 percent of all layer operations use nipple drinker systems (USDA APHIS, 2000b). However, for layer operations with more than 100,000 birds this number increases to approximately 81.5 percent (USDA NAHMS, 2000). Watering systems may also use water pressure sensors and automatic shutoff valves to reduce water spillage. The sensor will detect a sustained drop in water pressure resulting from a break in the water line. The sensor will then stop the water flow to the broken line and an alarm will sound. The operator can then fix the broken line and restore water to the animals with minimal water spillage. There is little information about the relative use of water pressure sensors within the layer industry.

4.2.2.7 *Waste Disposal*

Practices for the disposal of layer wastes are similar to those for other poultry litter. After removal from the housing facilities, waste can be directly applied to the land (if available), stored prior to final disposal, or pelletized and bagged for use as commercial fertilizer. Waste storage, application of litter, and other poultry waste disposal practices are discussed in detail in Section 4.2.1.6. The percentage of layer and pullet operations with and without enough land for application of manure on a nitrogen- and phosphorus-basis and operations with no land are shown in Tables 4-58 and 4-59. The facilities that have "no land" were determined by running queries of the USDA 1997 Census of Agriculture data to identify facilities that did not grow any of the 24 major crops grown in the U.S.

Table 4-58. Percentage of Layer Dominated Operations With Sufficient, Insufficient, and No Land for Agronomic Application of Generated Manure

Capacity (Number of Birds)	Sufficient Land		Insufficient Land		No Land
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	
1-29,999	12.2	9.2	49.1	53	41.1
30,000-59,999	6.8	1	60.3	65	33.2
60,000-179,999	6.2	0	52	62.2	36.8
> 180,000	1.1	0	46.6	47.1	52.9
Total	10.5	6.9	49.5	57.5	38.8

Source: USDA NASS, 1999c

Table 4-59. Percentage of Pullet Dominated Operations With Sufficient, Insufficient, and No Land for Agronomic Application of Generated Manure

Capacity (Number of Birds)	Sufficient Land		Insufficient Land		No Land
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	
1-29,999	11.6	5.9	47.3	53	41.1
30,000-59,999	11.9	1.7	54.9	65	33.2
60,000-179,999	14.1	1.1	49.2	62.2	36.8
> 180,000	2	0	45.1	47.1	52.9
Total	11.6	3.7	49.5	57.5	38.8

Source: USDA NASS, 1999c

Mortality and the disposal of dead hens is a potentially significant source of contamination at laying operations. A total of 6.5 percent of hens placed in the last completed flock (one flock per farm site) died by 60 weeks of age and overall the average cumulative mortality was 14.6 percent (USDA APHIS, 2000b). The common methods of disposing of dead hens and frequency of use are presented in Table 4-60. Tables 4-61 and 4-62 present this information for operations with fewer than and more than 100,000 laying hens. Larger facilities are much more likely than smaller facilities to send dead birds to rendering plants (50.2 percent versus 21.1 percent). While smaller facilities are more likely than larger facilities to bury their dead birds (45.6 percent versus 9.1 percent).

Table 4-60. Frequency of Disposal Methods for Dead Layers for All Facilities

Method of Disposal	Farm Sites		Dead Hens	
	Percent	Std Error	Percent	Std Error
Composting	15.0	(3.5)	11.7	(4.1)
Incineration	9.0	(2.9)	10.4	(4.5)
Covered deep pit	32.0	(5.8)	17.9	(4.3)
Rendering	32.0	(4.9)	41.4	(8.6)
Other	16.1	(3.6)	18.6	(5.4)
Total	--		100.0	

Source: USDA APHIS, 2000b

Table 4-61. Frequency of Disposal Methods for Dead Layers for Facilities With <100,000 Birds

Method of Disposal	Farm Sites		Dead Hens	
	Percent	Std Error	Percent	Std Error
Composting	13.9	4.7	13.4	7.5
Incineration	9.3	4.2	19.8	9.8
Covered deep pit	45.6	7.2	36.4	8.3
Rendering	21.1	4.5	19.7	6.0
Other	14.0	4.7	10.7	3.8
Total	--	--	100.0	--

Source: USDA NAHMS, 2000

Table 4-62. Frequency of Disposal Methods for Dead Layers for Facilities With >100,000 Birds

Method of Disposal	Farm Sites		Dead Hens	
	Percent	Std Error	Percent	Std Error
Composting	16.8	4.6	10.6	4.4
Incineration	8.7	3.3	4.6	2.5
Covered deep pit	9.1	2.2	6.5	2.5
Rendering	50.2	7.2	54.8	10.9
Other	19.7	5.8	23.5	8.7
Total	--	--	100.0	--

Source: USDA NAHMS, 2000

4.2.3 Turkey Sector

This section describes the following aspects of the turkey industry:

- 4.2.3.1: Distribution of the turkey industry by size and region
- 4.2.3.2: Production cycles of turkeys
- 4.2.3.3: Turkey facility types and management
- 4.2.3.4: Turkey waste management practices
- 4.2.3.5: Pollution reduction
- 4.2.3.6: Waste disposal

National Overview

Turkey production has increased steadily over the past 2 decades, and as in the other poultry sectors, there has been a shift in production to fewer but larger operations. Between 1982 and 1997, almost 21 percent of the turkey operations went out of business (USDA NASS, 1998b). As shown in Table 4-63, the number of turkey operations decreased from 12,708 operations in 1992 to 12,207 operations in 1997, a 4 percent decrease. The number of turkeys produced rose approximately 10 percent between 1992 and 1997. The number of hens held for breeding, however, decreased by almost 6 percent during the same period.

As in the broiler industry, most turkeys are produced under contract production arrangements. For each contract arrangement, an integrator company provides the birds, feed, medicines, bird transport, and technical help. The contract producer provides the production facilities and labor to grow the birds from hatchlings to market-age birds. In return, the contract producer receives a guaranteed price, which may be adjusted up or down based on the performance of the birds compared with that of other flocks produced or processed by the company during the same span of time. Some turkeys are raised by independent turkey producers. Even under this type of production, however, the independent producer may arrange for feed, poults, medical care, and possibly processing, through contracts. Finally, some turkeys are produced on farms owned by the integrator company. The integrator company may also be the company that processes the birds; however, some turkey integrators provide all services except the processing, which the integrator arranges with a processing company.

Table 4-63. Turkey Operations (Ops) in 1997, 1992, 1987, and 1982 With Inventories of Turkeys for Slaughter and Hens for Breeding

Total Farms With	1997		1992		1987		1982	
	Ops	Production	Ops	Production	Ops	Production	Ops	Production
Turkeys	6,031	307,586,680	6,257	279,230,136	7,347	243,336,202	7,498	172,034,935
Turkeys sold for slaughter	5,429	299,488,350	5,658	272,831,801	6,813	238,176,199	6,838	167,540,306
Turkey hens kept for breeding	747	8,098,330	793	6,398,335	761	5,160,003	1,040	4,494,629

Source: USDA NASS, 1998b

4.2.3.1 *Distribution of Turkey Operations by Size and Region*

EPA's 1974 CAFO Effluent Limitations Guidelines and Standards generally apply to turkey operations with more than 55,000 birds. (See Chapter 2 for the definition of a CAFO, and Chapter 5 for a discussion of the basis for revisions to the poultry subcategories.) Where numbers of birds are presented, all birds regardless of age (e.g., poult, laying age, or pullet) or function (i.e. breeder, layer, meat-type birds) are included unless otherwise indicated in the text.

The consolidation of the turkey industry has mirrored that of other livestock industries. The number of turkey farms with fewer than 30,000 birds decreased from 5,113 in 1987 to only 3,378 in 1997 (USDA NASS, 1999b). Concurrently, the number of operations with more than 60,000 birds increased 26 percent from 1232 in 1987 to 1671 in 1997. Although these changes are not as dramatic as those for the swine or broiler industry, they are indicative of an industry that is undergoing a steady transformation into one dominated by large integrated operations.

Table 4-64 presents the number of turkey operations in 1997 by size and region. Table 4-65 presents the average number of birds at these operations, and Table 4-66 presents the distribution of turkey production by size of operation and region. It is important to note that the 369 largest operations (2.7 percent) had 43.6 percent of the total turkey count. These tables reflect the use of 2.5 turns (flocks) per year. USDA NASS performed an analysis for EPA to estimate how variations in the estimated of number of turns per year would change the number of potential CAFOs (operations with more than 55,000 birds). This analysis showed that there would be only minor changes to the estimated number of CAFOs if the estimated number of turns was adjusted to two or three turns.

State-level data from the 1997 Census of Agriculture (USDA NASS, 1999b) indicate that states in the Midwest and Mid-Atlantic regions account for more than 70 percent of all turkeys produced. Key production states (determined by number of turkeys produced) are North Carolina, Minnesota, Virginia, Arkansas, California, and Missouri. Other states with significant production include Indiana, South Carolina, Texas, Pennsylvania, and Iowa.

Table 4-64. Number of Turkey Operations in 1997 by Region and Operation Size

Region [a]	Number of Turkey Operations by Size (Operation Size Presented by Number of Birds Spot Capacity)				
	>0-16,500	>16,500-38,500	>38,500-55,000	>55,000	Total
Central	2,301	54	19	34	2,408
Mid-Atlantic	3,265	597	143	83	4,088
Midwest	4,016	493	121	142	4,772
Other	2,035	222	83	110	2,450
National	11,617	1,366	366	369	13,718

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Other=WA, OR, CA, AK, HI, AR, LA, MS, AL, GA, SC, FL
Source: USDA NASS, 1999c

Table 4-65. Average Number of Birds at Turkey Operations in 1997 by Region and Operation Size

Region [a]	Average Turkey Counts by Operation Size (Operation Size Presented by Number of Birds Spot Capacity)				
	>0-16,500	>16,500-38,500	>38,500-55,000	>55,000	All Operations
Central	311	25,420	47,310	172,416	3,675
Mid-Atlantic	1,705	24,903	45,193	97,111	8,551
Midwest	1,231	24,303	45,469	158,365	9,413
Other	818	26,310	45,520	116,295	9,827
National	1,110	24,936	45,486	133,340	8,223

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Other=WA, OR, CA, AK, HI, AR, LA, MS, AL, GA, SC, FL
Source: USDA NASS, 1999c

Table 4-66. Distribution of Turkeys in 1997 by Region and Operation Size

Region [a]	Percentage of Total Turkey Counts by Operation Size (Operation Size Presented by Number of Birds Spot Capacity)				
	>0-16,500	>16,500-38,500	>38,500-55,000	>55,000	Total
Central	0.64	1.22	0.80	5.20	7.85
Mid-Atlantic	4.93	13.18	5.73	7.15	30.99
Midwest	4.38	10.62	4.88	19.94	39.82
Other	1.48	5.18	3.35	11.34	21.34
National	11.43	30.20	14.75	43.62	100.00

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Other=WA, OR, CA, AK, HI, AR, LA, MS, AL, GA, SC, FL
Source: USDA NASS 1999c

4.2.3.2 *Production Cycles of Turkeys*

The growth of a turkey is commonly divided into two phases: brooding and grow out. The brooding phase is the period of the poult's life extending from 1 day to about 6-8 weeks. During this time, the poults are unable to maintain a constant body temperature and need supplemental heat. Brooder stoves are used to keep the ambient temperature at 90 to 95 °F when the poults arrive; thereafter, the producer decreases the temperature by 5 °F for the next 3 weeks until the temperature reaches 75 °F. Poults are extremely susceptible to disease and are typically administered special starter feeds containing antibiotics and a high percentage of protein. A difference between turkeys and broilers is that feeding strategies such as the use of phytase to reduce phosphorus content in waste is not employed with turkeys through the entire life cycle because phytase is thought be some to inhibit bone development in poults. As with the broiler industry, further research in diet, nutrition, and the complex relationships between calcium, vitamins, and phosphorus may overcome this limitation.

The grow-out phase is the period in a turkey's life between the brooding phase and the market or breeding phase. Depending on the sex of the birds, the grow-out phase typically lasts up to 14 weeks. Modern turkeys grow rapidly. A tom (male turkey) poult weighs about ¼ pound at birth; at 22 weeks it weighs almost 37 pounds. Hens (female turkey) are usually grown for 14 to 16 weeks and toms from 17 to 21 weeks before being marketed. Most operators start fewer toms than hens in a given house to allow more space for the larger birds.

4.2.3.3 *Turkey Facility Types and Management*

Market and breeder turkeys are raised in similar housing systems. Typically, young turkey poults are delivered to the operation on the day of or the day after hatching. The poults are placed in barns called brooder houses. The brooder houses for turkeys are usually as wide as broiler and pullet houses but are usually only 300 to 400 feet long. The houses have an impermeable floor surface made of either clay or cement. The floors are then covered with 3 to 4 inches of bedding.

As with broilers, ventilation is usually provided by a negative-pressure system, with exhaust fans drawing air out of the house and fresh air returning through ventilation ducts around the perimeter of the roof. Some turkey houses have side curtains that can be retracted to allow diffusion of air. More advanced ventilation systems use exhaust fans controlled by a thermostat and timer. Brooding heaters are normally present in one-third to one-half of the house, for the early stages of development. As the poults get older, they are usually released into the other two-thirds or half of the house and remain there until they are of market age. In some operations the poults are moved to a specially designed grower house, where they stay until they are of market age. Some operations will move poults to range.

The construction of the housing facilities varies by region and depends on climatic conditions and production practices. Generally, in the southern and southeastern U.S. the houses are more open. The side walls of the houses are 6 to 8 feet high, with a 4- to 5- foot-wide opening covered by wires and curtains. Since moderate winters are normal in the South and Southeast, the curtains can contain the heat necessary to maintain a reasonable temperature within the commercial poultry houses. In the northern and central states, most houses have solid side walls and contain considerable insulation to combat the colder temperatures. These houses rely on exhaust fans or moveable solid side walls during the hot summer days to diminish the effects of heat stress on the birds.

These traditional systems are called two-age farms because two ages of birds can be on the farm at one time. Once the poults have been moved to the grower barn, the brooder house is totally cleaned out for another group of poults. This cleanup includes removal of all litter used during the brooding phase. The second group of poults occupies the brooder house while the first group of birds is still in the grower barn. Operations in the Shenandoah Valley area of Virginia and

West Virginia are known to use a modification of the typical two-age management system. Under this system the houses are longer. Poults may occupy one end of the house, while an older group is being grown out at the other end. The birds do not have to be moved as often under this system.

The two-age farm system has served the turkey industry for more than 20 years. Currently, however, there are efforts to modify this system because of morbidity and mortality. The modifications are directed at raising older birds in facilities removed from the poults. This approach provides an opportunity to break any disease cycle that might put the birds, especially the younger ones, at increased risk for disease (USEPA, 1998).

4.2.3.4 *Turkey Waste Management Practices*

For brooder facilities, the litter is removed after every flock of brooded poults. This practice is necessary to provide the next group of poults with clean bedding to achieve the lowest possible risk of disease exposure. Poult litter many be composted between flocks to control pathogens and then reused in the grow out houses. For grower systems, the litter is removed once a year. In between flocks, cake is removed and the old litter may be top-dressed with a thin layer of new bedding. For single-age farms, the bedding in the brooding section is moved to the grower section. New bedding is put in the brooder section, and the facilities are prepared for the next group of poults.

4.2.3.5 *Pollution Reduction*

New technologies in drinking water systems result in less spillage and ensure that turkey litter stays drier. Feeding strategies will also reduce the quantity of waste generated by ensuring that turkeys do not receive more feed than required for optimal growth. State regulations have also driven many turkey operations to handle mortalities in ways other than burial such as rendering and composting, which are on the rise (see Section 4.2.3.6).

Nipple water delivery systems reduce the amount of wasted water and are healthier for the animals. Trough or bell type watering devices allow the animal to spill water and add contaminants to the standing water. Nipple water systems deliver water only when the animal is sucking on the nipple. Watering systems may also use water pressure sensors and automatic shutoff valves to reduce water spillage. The sensor will detect a sustained drop in water pressure resulting from a break in the water line. The sensor will then stop the water flow to the broken line and an alarm will sound. The operator can then fix the broken line and restore water to the animals with minimal water spillage.

Feeding strategies can be used to reduce the quantity of nutrients in the excreta. Dietary strategies designed to reduce nitrogen and phosphorus include enhancing the digestibility of feed ingredients, genetic enhancement of cereal grains and other ingredients resulting in increased feed digestibility, more precise diet formulation, and improved quality control. Although nitrogen and phosphorus are currently the focus of attention, these strategies also have the potential to decrease other nutrients. There is debate on the impacts of phytase feed supplements for turkey poults concerning bone growth and bone development. Phytase additions are expected to achieve a reduction in phosphorus excretion of 20 to 60 percent depending on the phosphorus form and concentration in the diet (NCSU, 1999b). Protein content, calcium, other mineral content, vitamin B, as well as other factors identified in the literature influence the effectiveness of phytase use in feed. Additional information on feeding strategies for turkeys can be found in Chapter 8.

4.2.3.6 *Waste Disposal*

Practices for the disposal of turkey litter are similar to those for other poultry litter. After removal from the housing facilities, waste can be directly applied to the land (if available), stored prior to final disposal, or pelletized and bagged for use as commercial fertilizer. Waste storage, application of litter, and other poultry waste management practices are discussed in detail in Section 4.2.1.4. The percentage of turkey operations with and without enough land for application of manure on a nitrogen- and phosphorus-basis and operations with no land are shown in Table 4-67. The facilities that have no land were determined by running queries of the USDA 1997 Census of Agriculture data to identify facilities that did not grow any of the 24 major crops grown in the U.S.

Table 4-67. Percentage of Turkey Dominated Operations With Sufficient, Insufficient, and No Land for Agronomic Application of Generated Manure

Capacity (Number of Birds)	Sufficient Land:		Insufficient Land:		No Land
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	
1-16,499	15.6	5.9	52.5	62.2	31.8
16,500-38,499	6.8	0.3	65.4	71.9	27.9
38,500-54,999	4.1	0	65.5	69.9	30.4
> 55,000	3	0	58.1	61.1	38.9
Total	9.4	2.4	59.5	66.5	31.1

Source: USDA NASS, 1999c

Disposal of dead birds can be handled through composting, incineration, burial in deep pits, rendering, and disposal in landfills. Technical information on practices for the disposal of dead animals is presented in Chapter 8; however, there is little information available on the relative use of these practices within the turkey industry.

4.3 Dairy Industry

Dairy animal feeding operations include facilities that confine dairy cattle for feeding or maintenance for at least 45 days in any 12-month period, and do not have significant vegetation in the area of confinement. Dairies may also perform other animal and agricultural operations that are not covered by the existing dairy effluent guidelines, including grazing, milk processing, and crop farming.

This section discusses the following about dairy operations:

- Section 4.3.1: The distribution of dairy operations by size of operation and region in 1997
- Section 4.3.2: Dairy production cycles
- Section 4.3.3: Stand-alone heifer raising operations
- Section 4.3.4: Dairy facility management practices
- Section 4.3.5: Dairy waste management practices
- Section 4.3.6 lists the references used in this section

4.3.1 Distribution of Dairy Operations by Size and Region

Current effluent limitations guidelines and standards apply to dairy operations with a capacity of 700 or more mature dairy cattle (both lactating and dry cows), where the animals are fed at the place of confinement and crop or forage growth or production is not sustained in the confinement area.

Information presented in this section comes from USDA's National Agricultural Statistics Service (NASS), 1997 Census of Agriculture data, and from site visits and trade associations. The 1993 to 1997 NASS reports on dairy operations present the number of dairies by size class; however, dairy operations with more than 200 mature dairy cattle are grouped in one size class; therefore, an analysis of dairy operations that fall under the current effluent guidelines regulations (i.e., those with more than 700 milking cows) cannot be completed with NASS data alone. Data from the 1997 Census of Agriculture provide some additional information on medium and large (more than 200 milking cows) dairy operations. Although the NASS and Census data do not match exactly, EPA has found that there is generally a good correlation between the two data sets. EPA used the Census data to estimate farm counts.

From 1988 to 1997, the number of dairies and milking cows in the U.S. decreased while total milk production increased. Improved feeding, animal health, and dairy management practices have allowed the dairy industry to continue to produce more milk year with fewer milking cattle. Since 1988, the total number of milking cows has decreased by 10 percent and the total number of dairy operations has decreased by 43 percent, indicating a general trend toward consolidation (USDA NASS, 1995b; 1999d).

Between 1993 and 1997, the number of operations with fewer than 200 milking cows decreased, while the number of operations with 200 milking cows or more increased. Both NASS and the 1997 Census of Agriculture have collected data that quantify the changes by size class. Based on the NASS data, the number of operations with 200 milking cows or more increased by almost 7 percent between 1993 and 1997, while all smaller size classes decreased in numbers of operations. Table 4-68 shows the estimated distribution of dairy operations by size and region in 1997, and Table 4-69 shows the total number of milk cows and average cow herd size by size class in 1997. EPA derived the data in these tables from the Census data (ERG, 2000b).

According to Census of Agriculture data, of the 116,874 dairy operations across all size groups in 1997, Wisconsin had the most with 22,576 (19 percent), followed by Pennsylvania with 10,920 (9 percent), Minnesota with 9,603 (8 percent), and New York with 8,732 (7 percent). Table 4-70 presents the number of dairies by top-producing states for the following size groups:

- 1 to 199 milk cows;
- 200 to 349 milk cows;
- 350 to 700 milk cows; and
- more than 700 milk cows.

Of the large dairies (more than 700 milking cows), California has the most operations (46 percent), and of the medium dairies (200 to 700 milking cows), California, New York, Wisconsin, and Texas have the most operations.

Table 4-71 shows the annual milk production in 1997 for the top-producing states. Although California has only 2,650 dairy farms in all, it is the largest milk-producing state in the U.S., according to NASS data and data received from the National Milk Producers Federation (National Milk Producers, 1999; USDA NASS, 1999d).

Table 4-68. Distribution of Dairy Operations by Region and Operation Size in 1997

Region[a]	Number of Operations				
	0-199 Milk Cows	200-349 Milk Cows	350-700 Milk Cows	> 700 Milk Cows	Total
Central	9,685	593	433	404	11,115
Mid-Atlantic	32,490	870	487	81	33,928
Midwest	59,685	943	497	90	61,215
Pacific	2,875	722	725	786	5,108
South	5,001	253	170	84	5,508
National	109,736	3,381	2,312	1,445	116,874

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Pacific=WA, OR, CA, AK, HI; South=AR, LA, MS, AL, GA, SC, FL

Table 4-69. Total Milk Cows by Size of Operation in 1997

Size Class	Number of Operations	Total Number of Milk Cows	Average Milk Cow Herd Size
0-199 Milk Cows	109,736	5,186,000	47
200-349 Milk Cows	3,381[a]	795,000	235
350-700 Milk Cows	2,312[a,b]	1,064,000	460
> 700 Milk Cows	1,445[b]	2,050,455	1,419
Total United States	116,874	9,095,455	78

[a] Estimated value. Published Census of Agriculture data show 4,881 dairies with 200-499 milk cows. Assumes approximately 70 percent have 200-349 milk cows and 30 percent have 350-500 milk cows.
[b] Estimated value. Published Census of Agriculture data show 1,379 dairies with 500-999 milk cows. Assumes approximately 60 percent have 500-699 milk cows and the remainder have 700-1,000 milk cows.

Table 4-70. Number of Dairies by Size and State in 1997

Location	Size Class				Total
	1-199 Milk Cows	200-349 Milk Cows	350-700 Milk Cows	>700 Milk Cows	
California	969	471	547	663	2,650
Florida	495	51	58	62	666
Idaho	1,105	119	90	90	1,404
Michigan	3,743	144	81	22	3,990
Minnesota	9,379	135	75	14	9,603
New York	8,162	319	194	57	8,732
Pennsylvania	10,693	148	71	8	10,920
Texas	3,562	266	188	97	4,113
Washington	925	175	130	72	1,302
Wisconsin	22,041	333	171	31	22,576
Total United States	109,736	3,381	2,312	1,445	116,874

Table Table 4-71. Milk Production by State in 1997

Location	Total Milk Production (million pounds)	Milk Produced Per Cow (pounds)
California	27,582	19,829
Florida	2,476	15,475
Idaho	5,193	19,092
Michigan	5,410	17,680
Minnesota	9,210	16,186
New York	11,530	16,495
Pennsylvania	10,662	16,951
Texas	5,768	15,259
Washington	5,305	20,968
Wisconsin	22,368	16,057
Total United States	156,091	16,871

4.3.2 Dairy Production Cycles

The primary function of a dairy is the production of milk, which requires a herd of mature dairy cows that are lactating. In order to produce milk, the cows must be bred and give birth. Therefore, a dairy operation may have several types of animal groups present, including:

- Calves (0 to 5 months)
- Heifers (6 to 24 months)
- Cows that are close to calving (close-up cows)
- Lactating dairy cows
- Dry cows
- Bulls

Most dairies operate by physically separating and handling their animals in groups according to age, size, milking status, or special management needs. This separation allows each group to be treated according to its needs. Section 4.3.2.1 presents a description of the typical mature dairy herd, and Section 4.3.2.2 discusses the immature animal groups that may also be present at the dairy.

4.3.2.1 *Milk Herd*

The dairy milk herd is made up of mature dairy cows that have calved at least once. These mature cows are either lactating or "dry" (not currently producing milk). After a cow has calved, the milk she initially produces (called "colostrum") contains higher amounts of protein, fat, minerals, and vitamins than normal milk. The colostrum is usually collected and fed to the calves. After about 4 days, the milk returns to normal and the cow rejoins the lactating cow herd.

After being milked for about 10 to 12 months after calving, the cows go through a dry period. These dry periods allow the cow to regain body condition and the milk secretory tissue in the udder to regenerate. The dairy industry has reported an average of 60.5 days of dry period per cow (USDA APHIS, 1996a).

Periodically, all dairies must cull certain cows that are no longer producing enough milk for that dairy. Cows are most often culled for the following reasons: reproductive problems; udder or mastitis problems; poor production for other reasons; lameness or injury; disease; or aggressiveness or belligerence. In 1995, an average of 24 percent of the herd was culled from all size operations (USDA APHIS, 1996a). Dairies in high milk-producing regions (e.g., California) have reported during site visits cull rates of up to 40 percent.

Some dairies decide when a cow is to be culled by determining a milk break-even level (pounds of milk per cow per day). Approximately 28 percent of dairies use this practice and reported an average milk break-even level of approximately 33 pounds per cow per day. The milk break-even levels ranged from 32.5 pounds per cow per day at small dairies (less than 100 head) up to 36.5 pounds per cow per day at larger dairies (200 or more head) (USDA APHIS, 1996a).

Nearly all culled cows (approximately 96 percent) are sent away for slaughter. Approximately 74 percent are sent to a market, auction, or the stockyards. Others (21 percent) are sold directly to a packer or slaughter plant, and the remaining 1 percent are sent elsewhere. Cows that are not sold for slaughter (approximately 4 percent) are usually sent to another dairy operation (USDA APHIS, 1996a).

4.3.2.2 *Calves, Heifers, and Bulls*

The immature animals at a dairy are heifers and calves. Typically, according to Census of Agriculture data, for dairies greater than 200 milking cows, the number of calves and heifers on site equals approximately 60 percent of the mature dairy (milking) cows. EPA assumes that there are an equal number of calves and heifers on site (30 percent each). Calves are considered to be heifers between the age of six months and the time of their first calving (between 25 and 28 months of age) (USDA APHIS, 1996a). Heifers tend to be handled in larger groups, and often they are divided for management purposes into a breeding group and a bred heifer group (Bickert et al., 1997). Heifers and cows are often bred artificially. They may be placed daily in stanchions for estrus (heat) detection with the aid of tail chalk or heatmount detectors. Heifers and cows in pastures or in pens without stanchions may be heat detected by observation and then bred in a restraining chute. Heifers that do not conceive after attempts with artificial insemination are often placed in groups with a breeding-age bull to allow natural service of those animals. Approximately 45 percent of dairy operations do not keep bulls on site, and approximately 35 percent of dairy operations keep one bull on site for breeding (USDA APHIS, 1996a).

Cows and heifers that are at the end of their pregnancy are considered to be “periparturient” or “close-up cows.” About 2 weeks before she is due, the heifer or cow is moved from her regular herd into a smaller pen or area where she can be observed and managed more closely. When the cow is very near to calving, she is often moved to an isolated maternity pen. Shortly after birth, the calves are separated from their mothers and are generally kept isolated from other calves or in small groups until they are about 2 months old. After the calves are weaned from milk (at about 3 months of age), they are usually moved from their individual pen or small group into larger groups of calves of similar age. Female calves are raised (as replacements) to be dairy cows at the dairy or sent to an off-site calf operation. Female calves (heifers) may also be raised as beef cattle. Male calves that are not used for breeding are either raised as beef cattle (see Section 4.4) or as veal calves (see Section 4.4.5).

4.3.3 Stand-Alone Heifer Raising Operations

Stand-alone heifer raising operations provide replacement heifer services to dairies. It has been estimated that 10 percent to 15 percent of all dairy heifers are raised by stand-alone heifer raisers (Personal communication: Larry Jordan and Dr. Don Gardner). These heifer raising operations often contract with specific dairies to raise those dairies' heifers for a specified period of time, and many also provide replacement heifers to any dairy needing additional cows. The age at which dairies send their animals to heifer raising operations varies significantly (USDA APHIS, 1996a). Table 4-72 shows the percentage of dairies that use heifer raising operations, the median age at which heifers are received by these facilities, and the amount of time that the heifers remain at these facilities.

Table 4-72. Characteristics of Heifer Raising Operations

Age of Heifer	Percentage of Dairies Using Heifer Raisers	Median Age of Heifer	Time That Heifers Remain on Site
0 - 4 months	41.2	1 week	12 months
4 months - breeding	47.1	6 months	15 months
Breeding - first calving	11.8	Breeding age	9 months

There are a number of advantages for dairies to use heifer raising operations. Specifically, dairies using heifer raising operations could expand their herd size by 25 percent or more within existing facilities, specialize in milking cows or raising crops, and obtain healthier and better producing milking cows. In addition, raising calves off the farm may reduce risks of transmission of diseases for which older cows are the main source of infection. Some disadvantages include an increased risk of introducing disease into the herd and a shortage of replacement heifers if the raiser's breeding results are less than adequate. Also, the costs associated with raising the heifers could run higher than what the dairies are paying if labor, feed, and other resources are not allocated profitably (USDA APHIS, 1993).

Custom raising of dairy heifers is becoming more common as dairy herds increase in size and dairy farmers do not have facilities to raise all their heifers (Noyes, 1999). Throughout the U.S., the level of specialization is increasing for dairy farms; in fact, some large dairy farms raise no crops, purchase all of their feedstuffs, or do not raise replacement heifers for the milking herd.

Herd owners for these dairies must use other strategies to obtain herd replacements. As a result, enterprises that specialize in raising dairy calves and heifers are found in many western U.S. states (Faust, 2000). It is also believed that the poor beef market in the last few years has caused some beef feedlots to add pens of dairy heifers or switch to heifers entirely (Personal Communication: Dr. Roger Cady).

Stand-alone heifer operations use two primary methods for raising their animals. One method is to raise heifers on pasture, usually in moderate to warm climates where grazing land is available. The second method is to raise heifers in confinement (on drylots, as for beef cattle). Confinement is commonly used at operations in colder climates or areas without sufficient grazing land (Personal Communication: Larry Jordan).

The actual number of stand-alone heifer raising operations, as well as the number of confined operations, is unknown. However, based on information supplied by industry representatives (e.g., Professional Dairy Heifer Growers Association), EPA estimates that there may be 5,000 heifer raising operations in the U.S.: 300 to 400 operations with more than 1,000 head; 750 to 1,000 operations with more than 500 head; and 4,000 heifer operations with fewer than 500 head (most of them with around 50 head) (Personal Communication: Dr. Roger Cady). Most large dairy heifer raising operations (those with more than 1,000 head) are confinement-based while smaller operations are often pasture-based (Personal Communication: Dr. Roger Cady). Table 4-73 shows EPA's estimate of confined heifer raising operations by size and region (ERG, 2000a; 2000b).

Table 4-73. Distribution of Confined Heifer Raising Operations by Size and Region in 1997

	Number of Operations			
Region[a]	**300-499 Heifers**	**500-1,000 Heifers**	**> 1,000 Heifers**	**Total**
Central	25	250	180	455
Mid-Atlantic	0	0	0	0
Midwest	200	100	0	300
Pacific	25	150	120	295
South	0	0	0	0
National	250	500	300	1,050

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Pacific=WA, OR, CA, AK, HI; South=AR, LA, MS, AL, GA, SC, FL

The sizes of heifer raising operations range from 50 head (typical "mom and pop" operations) to 25,000 head and tend to vary geographically. The average size of a heifer operation located west of the Mississippi River is 1,000 to 5,000 head, while the average size in the upper Midwest, Northeast, and South is 50 to 200 head. Nationally, the median size of a dairy heifer raising operation is approximately 200 head (Personal Communication: Dr. Roger Cady).

Stand-alone heifer raising operations are found nationwide with more heifer raisers located where cows are concentrated and in areas where the dairy industry is evolving toward more specialization (Bocher, 2000). EPA estimates that, of the number of heifers raised at stand-alone heifer operations, approximately 70 percent are managed in the West, 20 percent are managed in the South/Southeast, 7 percent are managed in the Northeast, and approximately 3 percent are managed in the upper Midwest. The upper Midwest is also believed to be the single largest growing region with respect to small heifer operations (Personal Communication: Dr. Roger Cady).

4.3.4 Dairy Facility Management

This section describes factors that affect the facility management of a dairy operation, including housing by type of animal, as well as use of housing in the industry, flooring and bedding type, feeding and watering practices, milking operations, and rotational grazing.

4.3.4.1 *Housing Practices*

The purpose of dairy housing is to provide the animals with a dry and comfortable shelter, while providing the workers with a safe and efficient working environment. Optimal housing facilities accommodate flexibility in management styles and routines, enhance the quality of milk production, and allow for the protection of the environment, yet remain cost-effective (Adams, 1995). The following subsections describes housing for each type of animal group according to age, from milking cows to calves.

Milking Cows

The primary goal in housing lactating dairy cows is to provide an optimum environment for the comfort, proper nutrition, and health of the lactating cow for maximum milk productivity. It is also designed to allow for efficient milking processes. The most common types of lactating cow housing include freestalls, drylots, tie stalls/stanchions, pastures, and combinations of these. The types of housing used for dry cows include loose housing and freestalls (Stull et al., 1998). These housing types are described in detail below.

- <u>Freestalls</u> - This type of housing provides individual resting areas for cows in freestalls or cubicles, which helps to orient the cow for manure handling. Freestalls provide the cows with a dry and comfortable place to rest and feed. The cows are not restrained in the freestalls and are allowed to roam on concrete alleys to feeding and watering areas. Manure collects in the travel alleys and is typically removed with a tractor or mechanical alley-scraper, by flushing with water, or through slotted openings in the floor (refer to Section 4.3.5 for a more detailed description of waste handling) (Adams, 1995). Recently, there has been a trend toward using freestalls to house dairy cows and many loose housing units have been converted to freestalls (Bickert, 1997).

- <u>Drylots</u> - Drylots are outside pens that allow the animals some exercise, but do not generally allow them to graze. The use of drylots depends upon the farm layout, availability of land, and weather conditions. Also, milking cows are not likely to spend their entire time on a drylot, as they need to be milked at least twice a day at a tiestall or in a milking parlor.

- Tie Stalls/Stanchions - Tie stalls or stanchions confine the cow to a single stall where she rests, feeds, and is often milked. The tie stall prevents the cow from moving out of her stall with a chained collar, but allows her enough freedom to get up and lie down without interfering with her neighbors. Tie stalls are also designed to allow the cows access to feed and fresh water in a natural grazing position (Adams, 1995). Cows that are housed in tie stalls may be let out at certain times each day (e.g., between milkings) to graze in a pasture. Tie stalls are the most predominant type of dairy cow housing for lactating cows (USDA APHIS, 1996a); however, this is true of older, smaller dairies. The current preference, particularly for medium and large dairies, is freestalls.

- Loose Housing - Barns, shades, and corrals are considered loose housing. The design of these facilities depends upon the number of cows, climate, and waste-handling techniques. Overcrowding in this type of housing can lead to health problems and may reduce access to feed, water, or resting areas for some subordinate animals. Loose housing that is hard-surfaced typically has at least a 4 percent slope, depending on soil type and rainfall (Stull et al., 1998).

- Pastures - Depending on the farm layout, availability of pastureland, and weather conditions, heifers or cows may spend part or most of their day in a pasture. Milking cows do not spend all of their day outside, since they are milked at least twice per day in a parlor or from a tie stall. On some farms, the cows may be contained outdoors during the day, but are housed in a tie stall or freestall overnight.

Close-Up Cows

The primary objective in housing for cows that are close to calving is to minimize disease and stress to both the cow and calf. Sod pastures are often used in warmer climates or during the summer; however, the pastures can become too muddy in the winter in some climates, requiring additional worker time to keep watch over the cows. Alternatively, the cows may be housed in multiple-animal or individual pens prior to calving. About 2 weeks before the cow is due (i.e., 2 weeks prior to freshening), she is moved to a “close-up” pen. The cow density in close-up pens is about one-half the density in lactating cow pens to allow the calving cows some space to segregate themselves from other cows if they go into labor, although calving in close-up pens is usually avoided.

When birth is very near, cows are moved to a maternity area for calving. If the climate is sufficiently mild, pastures can be used for a maternity area; otherwise, small individual pens are used. Pens are usually designed to allow at least 100 square feet per cow and to provide a well-ventilated area that is not drafty (Stull et al., 1998).

Approximately 45 percent of all dairy farms have maternity housing apart from the housing used for the lactating cows. This feature is more prevalent in larger farms than in smaller farms. Approximately 87 percent of farms with 200 or more cows have separate maternity housing (USDA APHIS, 1996a).

Bulls

When bulls are housed on site at a dairy operation, they are typically kept in a pen or on pasture. If possible, bulls are penned individually with sufficient space for special care and to reduce fighting. When a bull is grazed on pasture, an electric fence is typically used to prevent the bull from escaping and causing danger (Bodman et al., 1987).

Heifers

According to information collected during site visits, the majority of heifers are kept on drylots either on or off site. Heifers may also be kept in a pasture, in which the herd is allowed to move about freely and to graze. Pastures may be provided with an appropriate shelter. Heifer housing is typically designed for ease in:

- Animal handling for treatment (e.g., vaccinations, dehorning, pregnancy checks)
- Animal breeding
- Animal observation
- Convenient feeding, bedding, and manure handling (Bickert et al., 1997)

Weaned Calves (Transition Housing)

After calves are weaned, they are usually moved from individual pens or small group pens into housing for a larger numbers of calves. This change causes a number of stresses due to the new social interactions with other calves, competition for feed and water, and the new housing. Therefore, the housing is designed such that the workers can monitor each calf's adjustment into the social group. Transition housing is used for calves from weaning to about 5 months of age. The most common types of housing used for weaned calves are calf shelters or superhutches, transition barns, and calf barns (Bickert et al., 1997). These types of housing are described below.

- <u>Superhutches</u> - Superhutches are open-front, portable pens that provide a feeder, water trough, and shelter for 5 to 12 calves. Superhutches typically provide 25 to 30 square feet per calf and can be moved in a field, drylot, or pasture as needed to provide calves with a clean surface.

- <u>Transition Barns</u> - A transition barn is composed of a series of pens for groups of six to eight calves of up to 6 months old. Some transition barns are designed such that the back and end walls may be open or covered, depending on the weather conditions.

- <u>Calf Barns</u> - A calf barn combines both individual calf pens and transition barns within one building. The pens can be designed to be easily dismantled for waste removal, to minimize calf contact, or to provide draft protection (Bickert et al., 1997).

Calves

Sickness and mortality rates are highest among calves under 2 months of age; therefore, the housing for this group typically minimizes environmental stress by protecting the calves against heat, wind, and rain. Common calf housing types include individual animal pens and hutches, which are described below.

- Individual Pens - Pens are sized to house animals individually and separate them from others. Individual pens make it easier to observe changes in behavior, feed consumption, and waste production, which can indicate sickness. Calves may be raised in 2-foot by 4-foot expanded metal or slatted wood, elevated pens; however, these pens provide little shelter from drafts and cold in the winter (Stull, et al., 1998). Individual pens can be used inside a barn to provide isolation for each calf. Pens are typically 4-feet by 7-feet and removable. Solid partitions between pens and beyond the front of the pen prevent nose-to-nose contact between the calves. A cover over the back half of the pen gives the calf additional protection, especially in drafty locations. Pens can be placed on a crushed rock base or a concrete floor to provide a base for bedding (Bickert et al., 1997).

- Hutches - Hutches are portable shelters typically made of wood, fiberglass, or polyethylene and are placed in outdoor areas. Hutches allow for complete separation of unweaned calves since one calf occupies each hutch. One end of the hutch is open and a wire fence may be provided around the hutch to allow the calf to move outside. Lightweight construction materials improve hutch mobility and also allow for easier cleaning. Hutches are typically 4 feet by 8 feet by 4 feet and may be placed inside a shed or structure to provide protection from cold weather and direct sunlight (Bickert et al., 1997).

Use of Housing in Industry

Table 4-74 summarizes the relative percentages of U.S. dairies reporting various types of housing for their animals (USDA APHIS, 1996a). These data were collected in 1996 for activities in 1995 by USDA's NAHMS. Note that some operations may have reported more than one type of housing being used for a particular group. The NAHMS data did not include housing type for dry cows. It is expected that dry cows are typically housed similarly to lactating cows (Stull et al., 1998).

Multiple age groups may be housed within a single building that allows for each group to be managed separately. Larger farms tend to place their animals in more than one building (Bickert et al., 1997). Superhutches, transition barns, calf barns, and loose housing were not specifically addressed in the NAHMS study, but may be considered specific types of multiple animal pens. Dairies predominantly use some sort of multiple animal area for unweaned calves, weaned calves, and heifers.

Table 4-74. Percentage of U.S. Dairies by Housing Type and Animal Group in 1995

Housing Type	Unweaned Calves	Weaned Calves and Heifers	Lactating Cows	Periparturient Cows
Drylot	9.1	38.1	47.2	28.9
Freestall	2.5	9.7	24.4	5.6
Hutch	32.5	NA	NA	NA
Individual animal area	29.7	6.6	2.3	38.3
Multiple animal area	40.0	73.9	17.9	26.3
Pasture	7.4	51.4	59.6	41.9
Tie stall/stanchion	10.5	11.5	61.4	26.3

NA - Not applicable.

4.3.4.2 *Flooring and Bedding*

The flooring and bedding used in housing provide physical comfort for the cow, as well as a clean, dry surface to reduce the incidence of mastitis and other diseases. Tables 4-75 and 4-76 summarize the various types of flooring and bedding, respectively, that are used for lactating cows, as reported by U.S. dairies in the NAHMS study (USDA APHIS, 1996b).

The most predominantly used flooring is smooth concrete, reported by over 40 percent of the dairies. Other fairly common flooring types include grooved and textured concrete. The less common flooring types that were reported include slatted concrete, dirt, and pastures (USDA APHIS, 1996b). The flooring design is important in loose housing to maintain secure footing for the animals, as well as facilitate waste removal. The surfaces typically contain scarified concrete areas around water troughs, feed bunks, and entrances. Both hard-surface and dirt lots are sloped to allow proper drainage of waste and rainfall (Stull et al., 1998).

Table 4-75. Types of Flooring for Lactating Cows

Type of Flooring	Percentage of Dairies Reporting
Smooth concrete	41.6
Grooved concrete	27.2
Textured concrete	16.2
Pasture	6.9
Dirt	5.8
Other	1.5
Slatted concrete	0.8

Table 4-76. Types of Bedding for Lactating Cows

Type of Bedding	Percentage of Dairies Reporting
Straw and/or hay	66.9
Wood products	27.9
Rubber mats	27.0
Corn cobs or stalks	12.8
Sand	11.2
Shredded newspaper	6.7
Mattresses	4.7
Other	3.7
Composted manure	2.4
Rubber tires	1.0

More than one bedding type may be reported by a single dairy. The most commonly used bedding is straw or hay, or a combination of the two, while other common bedding includes wood products and rubber mats. Less frequently used are rubber tires, composted manure, mattresses, shredded newspaper, sand, and corn cobs and stalks (each reported by less than 13 percent of the dairies) (USDA APHIS, 1996b).

4.3.4.3 *Feeding and Watering Practices*

Feeding and watering practices vary for each type of animal group at the dairy. Most dairies deliver feed several times each day to the cows, and provide a continuous water supply. The type of feed provided varies with the age of the animal and the level of milk production to be achieved.

Milking cows - At dairies, mature cows are fed several times a day. Lactating cows are provided a balanced ration of nutrients, including energy, protein, fiber, vitamins, and minerals (NRC, 1989). Dairies with greater than 200 milking cows typically feed a total mixed ration. In addition, most dairies in the U.S. feed grains and/or roughages (e.g., hay) that were grown and raised on the farm. Over half of all U.S. dairies reported that they pastured their dairy cows for at least 3 months in the year. Almost half of these dairies reported that grazing provided at least 90 percent of the total roughage for the cows while they were pastured (USDA APHIS, 1996a).

A lactating dairy cow consumes about 5 gallons of water per gallon of milk produced daily (Stull et al., 1998). Temperature can affect water consumption; therefore, actual consumption may vary. The predominant method for providing water to cows is from a water trough where more than one cow can drink at a time. Other watering methods frequently reported by small dairies (less than 200 cows) include automatic waterers for use by either individual cows or by a group of cows, at which only one cow drinks at a time (USDA APHIS, 1996b).

Heifers - Rations are balanced so heifers raised on site reach a breeding weight of 750 to 800 pounds by 13 to 15 months of age. Heifers are fed high-forage rations between breeding and calving, and usually are given enough manger space for all heifers to eat simultaneously (Stull et al., 1998).

Cows within 10 to 16 days of calving are normally fed as a separate group. They may be fed a few pounds of a grain concentrate mix in addition to forages. This practice avoids a sudden shift from an all-forage ration to a ration with a high proportion of concentrates, which is typical of that fed to cows in early lactation. If a postpartum cow is fed a total mixed ration, she may be fed about 5 pounds of long-stemmed hay in the ration for at least 10 days after calving to stimulate feed intake.

Calves - Calves are initially fed colostrum, the milk that is produced by the cow just prior to and during the first few days after calving. Colostrum contains more protein (especially immunoglobulins), fat, minerals, and vitamins than the milk normally produced, and less lactose (USDA BAMN, 1997). When calves are about 5 days old, their feed is switched to fresh whole milk or a milk replacer. Milk replacers are powdered products that contain predominantly dry milk ingredients. These are mixed with water to provide the optimum nutrition for the calf (Stull et al., 1998).

Calves are then weaned from a milk replacer or milk-based diet to a forage and/or concentrate diet. Calves are offered a starter ration in addition to milk or milk replacer when they are approximately 1 week old. Calves will consume 1 to 1.5 pounds of starter ration per day at weaning time, usually when they are 2 to 3 months old (Stull et al., 1998).

Because calves require more water than they receive from milk or milk replacer, water is typically available to them at all times.

4.3.4.4 *Milking Operations*

Lactating cows require milking at least twice a day and are either milked in their tie stalls or are led into a separate milking parlor. The milking parlors are often used in the freestall type of housing. The milking center typically includes other types of auxiliary facilities, such as a holding area, milk room, and treatment area (Bickert, 1997).

Milking Parlor - Milking parlors are separate facilities, apart from the lactating cow housing, where the cows are milked. Usually, groups of cows at similar stages of lactation are milked at a time. The parlor is designed to facilitate changing the groups of cows milked and the workers' access to the cows during milking. Often, the milking parlors are designed with a worker "pit" in the center of a room with the cows to be milked arranged around the pit at a height that allows the workers convenient access to the cows' udders.

The milking parlor is most often equipped with a pipeline system. The milk is collected from the cow through a device called a "milking claw" that attaches to each of her four teats. Each milking claw is connected to the pipeline and the milk is drawn from the cow, through the claw, and into the pipeline by a common vacuum pump. The pipeline is usually constructed of glass or steel and flows into a milk receiver. From the receiver, the milk is pumped through a filter and into a bulk tank where it is stored until collection.

The milking parlor is typically cleaned several times each day to remove manure and dirt. Large dairies tend to use automatic flush systems, while smaller dairies simply hose down the area. Water use can vary from 1 to 3 gallons per day per cow milked (for scrape systems) to 30 to 50 gallons per day per cow milked (for flush systems) in the dairy parlor and holding area (Loudon et al., 1985).

Milking at Tie Stalls - Cows that are kept in tie stalls may be milked from their stalls. The housing is equipped with a pipeline system that flows around the barn and contains ports where the milking claws may be "plugged in" at each stall. The workers carry the necessary udder and teat cleaning equipment as well as the milking claws from one cow to the next.

Approximately 70 percent of dairy operations reported that they milk the cows from their tie stalls, while only 29 percent reported that they used a milking parlor; however, more than half of the lactating cow population (approximately 55 percent) is milked in a milking parlor (USDA APHIS, 1996a; 1996b). Therefore, it can be interpreted that many of the large dairies are using milking parlors, while the smaller dairies are typically using tie stalls.

Holding Area - The holding area confines cows that are ready for milking. Usually, the area is enclosed and is part of the milking center, which in turn, may be connected to the barn or located in the immediate vicinity of the cow housing. The holding area is typically sized such that each cow is provided 15 square feet and is not held for more than 1 hour prior to milking (Bickert et al., 1997). The cows' udders may sometimes be washed in this area using ground-level sprinklers.

Milk Room - The milk room often contains the milk bulk tank, a milk receiver group, a filtration device, in-line cooling equipment, and a place to wash and store the milking equipment (Bickert et al., 1997). To enhance and maintain milk quality and to meet federal milk quality standards, it is cooled from the first milking to 40°F or less within 30 minutes. Some commonly used milk cooling devices include precoolers, heat exchangers, bulk tank coolers, and combinations of these. The cooling fluid used is typically fresh or chilled service water. This water is still clean and may then be used to water the animals (Bickert et al., 1997), or more commonly as milk parlor flush water.

Milking equipment cleaning and sterilizing processes are often controlled from the milk room. Typically, the milking equipment is washed in hot water (95 to 160 °F) in a prerinse, detergent wash, and acid rinse cycles. The amount of water used by an automatic washing system, including milking parlor floor washes, can vary from 450 to 850 gallons per day (Bickert et al., 1997).

Treatment Area - Treatment areas are used on farms to confine cows for artificial insemination, postpartum examination, pregnancy diagnosis, sick cow examination, and surgery. A single stall or a separate barn can be used as a treatment area.

Other Areas of the Milking Center - Milking and processing equipment is typically stored in a utility room. This equipment may include:

- Milk vacuum pump
- Compressor
- Water heater
- Furnace
- Storage

A separate room may also be used to store cleaning compounds, medical supplies, bulk materials, replacement milking system rubber components, and similar products. The storage room is often separated from the utility room to reduce the deterioration of rubber products, and is typically designed to minimize high temperatures, light, and ozone associated with motor operation (Bickert et al., 1997).

4.3.4.5 *Rotational Grazing*

Intensive rotational grazing is known by many terms, including intensive grazing management, short duration grazing, savory grazing, controlled grazing management, and voisin grazing management (Murphy, 1988). This practice involves rotating grazing cows among several pasture subunits or paddocks to obtain maximum efficiency of the pastureland. Dairy cows managed under this system spend all of their time, except time spent milking, out on the paddocks during the grazing season.

During intensive rotational grazing, each paddock is grazed quickly (1 or 2 days) and then allowed to regrow, ungrazed, until ready for another grazing. The recovery period depends on the forage type, the forage growth rate, and the climate, and may vary from 10 to 60 days (USDA, 1997). This practice is labor- and land-intensive as cows must be moved daily to new paddocks. All paddocks used in this system require fencing and a sufficient water supply. Many operations using intensive rotational grazing move their fencing from one paddock to another and have a water system (i.e., pump and tank) installed in each predefined paddock area.

The number of required paddocks is determined by the grazing and recovery periods for the forage. For example, if a pasture-type paddock is grazed for 1 day and recovers for 21 days, 22 paddocks are needed (USDA, 1997). The total amount of required land depends on a number of factors including the dry matter content of the pasture forage, use of supplemental feed, and the number of head requiring grazing. Generally, this averages out to one or two head per acre of pastureland (Personal Communication: Jim Hannawald). Successful intensive rotational grazing, however, requires thorough planning and constant monitoring. All paddocks are typically monitored once a week. High-producing milk cows (e.g., more than 80 pounds of milk per day) need a large forage allowance to maintain a high level of intake. Therefore, they need to graze in pastures that have sufficient available forage or be fed stored feed (USDA, 1997).

Due to the labor, fencing, water, and land requirements for intensive rotational grazing, typically only small dairy operations (those with less than 100 head) use this practice (Personal Communication: Jim Hannawald; USDA NRCS, 1996; CIAS, 2000a). Climate and associated growing seasons, however, make it very difficult for operations to use an intensive rotational grazing system throughout the entire year. These operations, therefore, must maintain barns and/or drylots for the cows when they are not being grazed or outwinter their milk cows. Outwintering is the practice of managing cows outside during the winter months. This is not a common practice as it requires farmers to provide additional feed (as cows expend more energy outside in the winter), provide windbreaks for cattle, conduct more frequent and diligent health checks on the cows, and keep the cows clean and dry so that they can stay warm (CIAS, 2000b).

There are two basic management approaches to outwintering: rotation through paddocks and "sacrifice paddocks." Some farms use a combination of these practices to manage their cows during the winter. During winter months, farmers may rotate cattle, hay, and round bale feeders throughout the paddocks. The main differences between this approach and standard rotational grazing practices are that the cows are not rotated as often and supplemental feed is provided to the animals. Deep snow, however, can cause problems for farmers rotating their animals in the winter because it limits the mobility of round bale feeders. The outwintering practice of sacrifice paddocks consists of managing animals in one pasture during the entire winter. There are several disadvantages and advantages associated with this practice. If the paddock surface is not frozen during the entire winter, compaction, plugging (tearing up of the soil), and puddling can occur. Due to the large amounts of manure deposited in these paddocks during the winter, the sacrifical paddocks must be renovated in the spring. This spring renovation may consist of dragging or scraping the paddocks to remove excess manure and then seeding to reestablish a vegetative cover. Some farmers place sacrifice paddocks strategically in areas where an undesirable plant grows or where they plan to reseed the pasture or cultivate for a crop (CIAS, 2000c).

Advantages of rotational grazing compared to conventional grazing include:

- Higher live weight gain per acre. Intensive rotational grazing systems result in high stocking density, which increases competition for feed between animals, forcing them to spend more time eating and less time wandering (AAFC, 1999).

- Higher net economic return. Dairy farmers using pasture as a feed source will produce more feed value with intensive rotational grazing than with continuous grazing (USDA NRCS 1996). Competition also forces animals to be less selective when grazing. They will eat species of plants that they would ignore in other grazing systems. This reduces less desirable plant species in the pasture and produces a better economic return (AAFC, 1999).

- Better land. Pastureland used in rotational grazing is often better maintained than typical pastureland. Intensive rotational grazing encourages grass growth and development of healthy sod, which in turn reduces erosion. Intensive rotational grazing in shoreline areas may help stabilize stream banks and could be used to maintain and improve riparian habitats (PPRC, 1996).

- Less manure handling. In continuous grazing systems, pastures require frequent maintenance to break up large clumps of manure. In a good rotational system, however, manure is more evenly distributed and will break up and disappear faster. Rotational grazing systems may still require manure maintenance near watering areas and paths to and from the paddock areas (Emmicx, 2000).

Grazing systems are not directly comparable to confined feeding operations, as one system can not readily switch to the other; however, assuming all things are equal, intensive rotational grazing systems have a number of advantages over confined feeding operations:

- Reduced cost. Pasture stocking systems are typically less expensive to invest in than livestock facilities and farm equipment required to harvest crops. Feeding costs may also be lowered.

- Improved cow health. Farmers practicing intensive rotational grazing typically have a lower cull rate than confined dairy farmers, because the cows have less hoof damage, and they are more closely observed as they are moved from one paddock to another (USDA, 1997).

- Less manure handling. Intensive rotational grazing operations have less recoverable solid manure to manage than confined operations.

- Better rate of return. Research indicates that grazing systems are more economically flexible than the confinement systems. For example, farmers investing in a well-planned grazing operation will likely be able to recover most of their investment in assets if they leave farming in a few years. But farmers investing from scratch in a confinement operation would at best recover half their investments if they decide to leave farming (CIAS, 2000d).

There are a number of disadvantages associated with intensive rotational grazing compared with either conventional grazing or confined dairy operations. The major disadvantages are:

- Limited applicability. Implementation of intensive rotational grazing systems depends upon available acreage, herd size, land resources (i.e., tillable versus steep or rocky), water availability, proximity of pasture area to milking center, and feed storage capabilities. Several sources indicate that this system is used by dairy farms with less than 100 cows. Typical confined dairy systems are often not designed to allow cows easy access to the available cropland or pastureland. Large distances between the milking center and pastureland will increase the cows expended energy and, therefore, increase forage demands.

  In most of the country, limited growing seasons prevent many operations from implementing a year-round intensive rotational grazing system. Southern states, such as Florida, can place cows on pasture 12 months of the year, but the extreme heat presents other problems for cows exposed to the elements. Grazing operations in southern states typically install shade structures and increase water availability to cows, which in turn increases the costs and labor associated with intensive rotational grazing systems. Because most dairy operations cannot provide year-round grazing, they still must maintain barns and drylot areas for their cows when they are not grazing, and dairy operations often prefer not to have to maintain two management systems.

- Reduced milk production levels. Studies indicate that dairy farmers using intensive rotational grazing have a lower milk production average than confined dairy farms (USDA NRCS, 1996). Lower milk production can offset the benefit of lower feed costs, especially if rations are not properly balanced once pasture becomes the primary feed source during warm months.

- Limited manure handling options. Dairies using intensive rotational grazing systems may not be able to apply the wastewater and solid manure collected during the non-grazing seasons to their available pastureland as crops may not be growing.

- Increased likelihood of infectious diseases. Some infectious diseases are more likely to occur in pastured animals by direct or indirect transmission from wild animals or presence of an infective organism in pasture soil or water (Hutchinson, 1988).

- Limited flexibility. Intensive rotational grazing systems have limited flexibility for planning how many animals can be pastured in any one paddock. Available forage in a paddock can vary from one cycle to another, because of weather and other conditions that affect forage growth rates. As a result, a paddock that was sized for a certain number of cows under adequate rainfall conditions will not be able to accommodate the same number of cows under drought conditions (USDA, 1997).

4.3.5 Dairy Waste Management Practices

Dairy waste management systems are generally designed based on the physical state of the waste being handled (e.g., solids, slurries, or liquids). Most dairies have both wet and dry waste management systems. Waste with 20 percent to 25 percent solids content can usually be handled as a solid while waste with less than 10 percent solids can be handled as a liquid (Loudon, 1985).

In a dry system, the manure is collected on a regular basis and stored where an appreciable amount of rainfall or runoff does not come in contact with it. Handling manure as a solid minimizes the volume of manure that is handled.

In a slurry or liquid system, manure is often diluted with water that typically comes from flushing system water, effluent from the solids separation system, and/or supernatant from lagoons. When dairy manure is handled and stored as a slurry or liquid, the milking center wastewater can be mixed in with the animal manure, serving as dilution water to ease pumping. If a gravity system is used to transfer manure to storage, milking center wastewater may be added at the collection point in the barn. Liquid systems are usually favored by large dairies for their lower labor cost and because the larger dairies tend to use automatic flushing systems.

4.3.5.1 *Waste Collection*

The collection methods for dairy manure vary depending on the management of the dairy operation. Dairy cows may be partially, totally, or seasonally confined. As previously mentioned, manure accumulates in confinement areas such as barns, drylots, and milking parlors and in other areas where the herd is fed and watered. In wet climates, it is difficult to collect and store manure from unroofed areas as a solid, but it can be done if the manure is collected daily, stored in a roofed structure, and mixed with bedding. In arid climates, manure from unroofed areas can be handled as a solid if collection time can be flexible.

The following methods are used at dairy operations to collect waste:

- <u>Mechanical/Tractor Scraper</u> - Manure and bedding from barns and shade structures are collected normally by tractor or mechanical chain-pulled scrapers. Eighty-five percent of operations with more than 200 milking cows use a mechanical or tractor scraper (USDA APHIS 1996b). Tractor scraping is more common since the same equipment can be used to clean outside lots as well as freestalls and loose housing. A mechanical alley scraper consists of one or more blades that are wide enough to scrape the entire alley in one pass. The blades are pulled by a cable or chain drive that is set into a groove in the center of the alley. A timer can be set so that the scraper runs two to four times a day, or continuously in colder conditions to prevent the blade from freezing to the floor. Scrapers reduce daily labor requirements, but have a higher maintenance cost due to corrosion and deterioration.

- <u>Flushing System</u> - Manure can be collected from areas with concrete flooring by using a flushing system. A large volume of water is introduced at the head of a paved area, and the cascading water removes the manure. Flush water can be introduced from storage tanks or high-volume pumps. The required volume of flush water varies with the size of the area to be flushed and slope of the area. The total amount of flush water introduced can be minimized by recycling; however, only fresh water can be used to clean the milking parlor area. Flushing systems are predominantly used by large dairies with 200 or more head (approximately 27 percent) that tend to house the animals in a freestall-designed barn. These systems are much less common in dairies with fewer than 200 head (fewer than 5 percent reported using this system) (USDA APHIS, 1996b). These systems are also more common at dairies located in warmer climates.

- <u>Gutter Cleaner/Gravity Gutters</u> - Gutter cleaners or gravity gutters are frequently used in confined stall dairy barns. The gutters are usually 16 to 24 inches wide, 12 to 16 inches deep, and flat on the bottom. Either shuttle-stroke or chain and flight gutter cleaners are typically used to clean the gutters. About three-fourths (74 percent) of U.S. dairy operations with fewer than 100 milking cows and approximately one-third of U.S. dairy operations with 100 to 199 milking cows use a gutter cleaner (USDA APHIS, 1996b).

- Slotted Floor - Concrete slotted floors allow manure to be quickly removed from the animal environment with minimal labor cost. Manure falls through the slotted floor or is worked though by animal traffic. The waste is then stored in a pit beneath the floor or removed with gravity flow channels, flushing systems, or mechanical scrapers. The storage of animal and milking center waste in a pit beneath slotted floors combines manure collection, transfer, and storage.

4.3.5.2 *Transport*

The method used to transport manure depends largely on the consistency of the manure. Liquids and slurries can be transferred through open channels, pipes, and in liquid tank wagons. Pumps can be used to transfer liquid and slurry wastes as needed; however, the greater the solids content of the manure, the more difficult it will be to pump.

Solid and semisolid manure can be transferred by mechanical conveyance or in solid manure spreaders. Slurries can be transferred in large pipes by using gravity, piston pumps, or air pressure. Gravity systems are preferred because of their low operating cost.

4.3.5.3 *Storage, Treatment, and Disposal*

Waste collected from the dairy operation is transported within the site to storage, treatment, and use or disposal areas. Typical storage areas for dairy waste include above- and belowground storage tanks and storage ponds. Handling and storage methods used at dairy operations are discussed in detail in Section 8.2.

One common practice for the treatment of waste at dairies is solids separation. Mechanical or gravity solids separators are used to remove bulk solids from a liquid waste stream; this separation reduces the volume of solids entering a storage facility, which increases its storage capacity. Separation facilitates reuse of liquid in a flushing system reduces clogging of irrigation sprinklers and reduces waste volume going to treatment or to land application sites. Manure slurry is often separated using mechanical separators, such as stationary screens, vibrating screens, presses, or centrifuges, all of which recover a relatively dry byproduct (Dougherty, 1998). Sedimentation by gravity settling is also used for solid/liquid separation.

Another common technology for the treatment of waste at dairies is an anaerobic lagoon. Anaerobic lagoons are biological treatment systems used to degrade animal wastes into stable end products. The advantage of anaerobic lagoons is their long storage times, which allow bacteria to break down solids. Disadvantages include odors produced during environmental or management changes and sensitivity to sudden changes in temperature and loading rates. Anaerobic lagoons are designed to hold the following volumes: a minimum treatment volume (based on volatile solids loading), the volume of accumulated sludge for the period between sludge removal events, the volume of manure and wastewater accumulated during the treatment period, the depth of normal precipitation minus evaporation, the depth of the 25-year, 24-hour storm event, and an additional 1 foot of freeboard.

Typical manure and waste treatment technologies used at dairy operations are discussed in detail in Section 8.2.

The majority (approximately 99 percent) of small and large dairy operations (fewer than and more than 200 milking cows) dispose of their waste through land application (USDA APHIS, 1996b). The amount of cropland and pastureland that is available for manure application varies at each dairy operation. Generally, dairy operations can be categorized into three groups with respect to available cropland and pastureland: (1) those with sufficient land so that all manure can be applied without exceeding agronomic application rates, (2) those without sufficient land to apply all of their manure at agronomic rates, and (3) those without any available cropland and pastureland. Operations without sufficient land, or any land, often have agreements with other farmers allowing them to apply manure on their land. Depending on the size of the dairy operation, 1997 Census of Agriculture data indicate that the average acres of cropland at dairies with at least 300 milking cows is approximately 350 acres and the average acres of pastureland is approximately 75 acres (Kellogg, 2000).

USDA conducted an analysis of the 1997 Census of Agriculture data to estimate the manure production at livestock farms (Kellogg, 2000). As part of this analysis, USDA estimated the number of confined livestock operations that produce more manure than they can apply on their available cropland and pastureland at agronomic rates for nitrogen and phosphorus and the number of confined livestock operations that do not have any available cropland or pastureland. The analysis assumed land application of manure would occur on one of 24 typical crops or pastureland. Using the percentage of these facilities estimated by USDA against the total number of livestock facilities, one can also estimate the number of facilities that have sufficient cropland and pastureland for agronomic manure application. Table 4-77 summarizes the percentage of dairy operations that have sufficient, insufficient, and no land for manure application at agronomic application rates for nitrogen and phosphorus. EPA assumes that confined heifer operations have similar percentages.

Table 4-77. Percentage of Dairy Operations With Sufficient, Insufficient, and No Land for Agronomic Application of Generated Manure

Size Class	Sufficient Land		Insufficient Land		No Land[a]
	Nitrogen Application	Phosphorus Application	Nitrogen Application	Phosphorus Application	
200-700 milking cows	50	25	36	61	14
> 700 milking cows	27	10	51	68	22

[a] No acres of cropland (24 crops) or pastureland.
Source: Kellogg, 2000

4.4 Beef Industry

Beef feeding operations include facilities that confine beef cattle for feeding or maintenance for at least 45 days in any 12-month period. These facilities do not have significant vegetation on the beef feedlot during the normal growing season (i.e., the feedlot area does not include grazing operations). Facilities that have beef feedlot operations may also include other animal and agricultural operations not considered part of the feedlots, such as grazing and crop farming.

This section discusses the following aspects of the beef industry:

- Section 4.4.1: Distribution of the beef industry by size of operation and region in 1997;
- Section 4.4.2: Beef production cycles
- Section 4.4.3: Beef feedlot facility management
- Section 4.4.4: Backgrounding operations
- Section 4.4.5: Veal operations
- Section 4.4.6: Cow-calf operations
- Section 4.4.7: Beef waste management practices

4.4.1 Distribution of the Beef Industry by Size and Region

EPA's current Effluent Limitations Guidelines and Standards apply to beef feedlot operations with a capacity of 1,000 or more slaughter steers and heifers, where the animals are fed at the place of confinement and crop or forage growth or production is not sustained in the confinement area.

Information presented in this section comes from USDA's National Agricultural Statistics Service (NASS), 1997 Census of Agriculture data, and from site visits and trade associations. The 1994 to 1998 NASS reports on beef feedlots present annual estimates of beef operations that have a capacity of 1,000 head of cattle or more grouped in the following categories:

- Cattle inventory and calf crop
- Number of operations
- Inventory by class and size groups
- Monthly cattle on feed numbers
- Annual estimates of cattle on feed

NASS publishes only limited data for operations that have a capacity of fewer than 1,000 head of cattle (USDA NASS, 1999e). The 1997 Census of Agriculture collects information on cattle inventory and the number of cattle fattened for slaughter.

The capacity of a beef feedlot is the maximum number of cattle that can be held on site at any one time and can usually be determined by the amount of feedbunk space available for the cattle. On average, most beef feedlots operate at 80 percent to 85 percent of capacity over the course of a year, depending on market conditions (NCBA, 1999). In addition, most feedlots have cattle on site for 150 to 270 days (see Section 4.4.2); therefore, on average, the feedlot can run one and one half to two and one half "turns" of cattle each year. However, a feedlot may have anywhere from one to three and one half turnovers of its herd per year. For example, some feedlots only have cattle on site during the winter months (one turnover) when crops cannot be grown, while other feedlots move cattle through the feedyard more quickly (three and one half turnovers).

EPA estimated the maximum capacity of beef feedlots reported in the 1997 Census of Agriculture using the reported sales of cattle combined with estimated turnovers and average feedlot capacity (ERG, 2000b).

Maximum Feedlot Capacity (Head) = Cattle Sales (Head) * Average Feedlot Capacity (%) / Turnovers

For example, a feedlot that sold 1,500 cattle in 1997 and is estimated to operate at 80 percent capacity with one and one half turnovers has an estimated maximum capacity of 800 head.

In 1997, there were approximately 2,075 beef feedlots with a capacity of more than 1,000 head in the U.S. (USDA NASS, 1999e). These operations represent only about 2 percent of all beef feedlots. EPA estimates that there were approximately 1,000 additional beef feedlots with a capacity of between 500 and 1,000 head (another 1 percent of beef feedlots), 1,000 beef feedlots with a capacity of between 300 and 500 head, and another 102,000 beef feedlots with a capacity of fewer than 300 head. Table 4-78 shows the estimated distribution of these operations by size and region. Table 4-79 shows the estimated number of cattle sold during 1997 by size class. EPA derived these data from the 1997 Census of Agriculture data and NASS data (ERG, 2000b).

Table 4-80 presents the number of beef feedlots by top producing states and nationally for the following eight size categories:

- up to 299 head
- 300 to 999 head
- 1,000 to 1,999 head
- 2,000 to 3,999 head
- 4,000 to 7,999 head
- 8,000 to 15,999 head
- 16,000 to 31,999 head
- 32,000 head and greater

The data in this table were obtained from NASS and were also derived from the 1997 Census of Agriculture data. Note that in some cases the feedlots from several size groups have been aggregated to avoid disclosing details on individual operations for some states.

As one would expect, the number of feedlots decreases as the capacity increases. For example, there are 842 feedlots in the 1,000 to 1,999 size category but only 93 in the greater than 32,000 size category. Of the 106,075 beef feedlots across all size groups in 1997, the Midwest region has the most with 71,183 (67 percent). Nebraska and Iowa have the most large beef feedlots (more than 1,000 head). Texas has the largest number of feedlots with a capacity of more than 32,000 head in the U.S. (41 percent).

Table 4-78. Distribution of Beef Feedlots by Size and Region in 1997

Region[a]	Feedlot Capacity					
	< 300 Head	300-500 Head	500-1,000 Head	1,000-8,000 Head	> 8000 Head	Total
Central	9,990	87	130	332	182	10,721
Mid-Atlantic	15,441	150	34	25	0	15,650
Midwest	68,235	685	810	1,236	217	71,183
Pacific	3,953	35	19	55	22	4,085
South	4,381	43	7	6	0	4,436
National	102,000[b]	1,000[b]	1,000	1,654	421	106,075

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Pacific=WA, OR, CA, AK, HI; South=AR, LA, MS, AL, GA, SC, FL

[b] Estimated value. Assumes 98 percent of feedlots with fewer than 1,000 head have a capacity of fewer than 300 head, and 99 percent of all feedlots with fewer than 1,000 head have a capacity of fewer than 500 head.

Table 4-79. Cattle Sold in 1997

Size Class	Number of Facilities	Cattle Sold	Average Cattle Sold
< 300 Head Capacity	102,000	2,362,000[a]	23
300-500 Head Capacity	1,000	600,000[b]	600
500-1,000 Head Capacity	1,000	1,088,000[b]	1,088
> 1,000 Head Capacity	2,075	22,789,000	10,983
All Operations	106,075	26,839,000	253

[a] Estimated value. Value presented is the difference between total sales for all feedlots with fewer than 1,000-head capacity, and the estimated sales for feedlots with 300-1,000 head capacity.

[b] Estimated value. Calculated from using the midpoint of the size range (e.g., 400 head for the 300-500 size class) and an average turnover rate of one and one half herds a year.

Table 4-80. Number of Beef Feedlots by Size of Feedlot and State in 1997[a]

Location	Feedlot Capacity							
	1 - 299 Head	300 - 999 Head	1,000-1,999 Head	2,000-3,999 Head	4,000-7,999 Head	8,000-15,999 Head	16,000-31,999 Head	32,000 + Head
Arizona	151	4	-	3[b]	-	-	3	3
California	885	25	4[b]	-	4	4	5	7
Colorado	1,374	70	54	46	32	23	11	8
Idaho	894	13	19	15	9	17[b]	-	-
Iowa	11,839	435	200	110[b]	-	-	-	-
Kansas	2,563	160	45	28	30	34	41	17
Nebraska	4,700	359	270	181	118	64	25	7
New Mexico	318	6	-	-	6[b]	-	4[b]	-
Oklahoma	1,840	21	3[b]	-	9	5	3	6
South Dakota	2,652	124	50	41	17	6[b]	-	-
Texas	3,556	49	8	13	28	25	35	38
Washington	1,166	8	7[b]	-	-	4	5[b]	-
Other States	70,062	726	191	85	36	8	5	-
United States	102,000	2,000	842	504	308	191	137	93

[a] The number of feedlots is the number of lots operating at any time during the year. The U.S. totals show the actual number of feedlots in each size group. The sum of the numbers shown by states under a specified size group may or may not add to the U.S. total for that size group because some states size groups are combined to avoid disclosing individual operations.
[b] Lots from other size groups are included to avoid disclosing individual operations.

Also included in the beef industry are veal operations, which are discussed in detail in Section 4.4.5. Veal operations are not specifically reported in the 1997 Census of Agriculture or NASS data. Therefore, EPA conducted site visits to veal operations and requested distribution data from the industry to ultimately estimate the number of veal operations in the U.S., as shown in Table 4-81 (ERG, 2000b).

Table 4-81. Distribution of Veal Operations by Size and Region in 1997

Region[a]	Capacity		Total
	300-500 Calves	> 500 Calves	
Central	5	3	8
Mid-Atlantic	1	1	2
Midwest	119	81	200
Pacific	0	0	0
South	0	0	0
Total United States	125	85	210

[a] Central=ID, MT, WY, NV, UT, CO, AZ, NM, TX, OK; Mid-Atlantic=ME, NH, VT, NY, MA, RI, CT, NJ, PA, DE, MD, VA, WV, KY, TN, NC; Midwest=ND, SD, MN, MI, WI, OH, IN, IL, IA, MO, NE, KS; Pacific=WA, OR, CA, AK, HI; South=AR, LA, MS, AL, GA, SC, FL

4.4.2 Beef Production Cycles

Beef feedlots conduct feeding operations in confined areas to increase beef weight gain, control feed rations, increase feeding efficiency, reduce feed costs, and manage animal health. Calves are often brought in from backgrounding operations to the feedlot (Section 4.4.4). Calves usually begin the "finishing" phase when they reach 6 months of age or a weight of at least 400 pounds. Cattle are typically held on the feedlot for 150 to 180 days. As stated previously in this section, a beef feedlot may run anywhere from one to three and one half turnovers of its herd per year. The annual average steer weight at slaughter ranges from 1,150 to 1,250 pounds, while the annual average heifer slaughter weight ranges from 1,050 to 1,150 pounds.

Some feedlots may bring in young calves at around 275 pounds and feed them on site for approximately 270 days. As a result, these feedlot operations have fewer turnovers of the herd per year. Based on site visits, this type of operation is typical at feedlots in southern California. Some operations may only bring in cattle during the winter months when no crops are being grown, also resulting in fewer turnovers of the herd per year. Other operations, the true "final finishing" operations, may bring cattle in at a heavier weight and require only approximately 100 days to feed cattle, resulting in more turnovers of the herd per year. These variations in turnovers often make it difficult to estimate farm counts if data only show cattle inventory.

4.4.3 Beef Feedlot Facility Management

This section describes factors that affect the facility management at a feedlot operation, including the layout of feedlot systems, feeding and watering practices, water use and wastewater generation, and climate.

4.4.3.1 *Feedlot Systems*

Cattle traffic flow is an important factor in the design of a feedlot. These operations use separate vehicle and cattle traffic lanes when possible to minimize congestion, reduce the spread of parasites and disease, and promote drainage to make pen cleaning easier and to promote animal comfort and welfare. Outdoor feedlot systems comprise the following units which can be organized in various ways.

- Office - This is usually located on or near the main access road and has truck scales and facilities for sampling incoming feed. All bulk feed delivered to the lot enters at this point. Cattle trucks also use these scales for in and out weights (Thompson et al., 1983).

- Feed Mill - Truck traffic around the feed mill is typically heavy. A good design allows feed ingredients to be received while finished rations are trucked to the pens without traffic conflict. Feeding pens are often near the feed mill to reduce travel (Thompson et al., 1983).

- Pens - Pens are designed for efficient movement of cattle, optimum drainage conditions, and easy feed truck access. A typical pen holds 150 to 300 head but the size can vary substantially. Required pen space may range from 75 to 300 square feet of pen space per head, depending on climate (see Section 4.4.3.4). Space needs vary with the amount of paved space, soil type, drainage, annual rainfall, and freezing and thawing cycles.

  Large feedlots use cattle alleys behind the pens to keep the flow of cattle separate from the feed trucks. Smaller feedlots often use feeding alleys to move the cattle. The pens should allow for proper drainage of runoff to provide comfortable conditions. A grade of at least 3 percent is necessary to allow proper drainage in most areas (Thompson et al., 1983).

- Cattle Loading and Unloading Facilities - Feedlots locate these facilities to ensure the smooth flow of trucks to bring cattle in and out of the lot. Larger feedlots typically use two shipping areas, with the receiving area having hospital or separate processing facilities where cattle can receive various identification markers, vaccinations, and treatment for internal and external parasites, and are held until they are healthy enough to go to regular feeding pens (Thompson et al., 1983).

- Hospital Areas - These are facilities where cattle can be medically treated. Each facility normally has a squeeze chute, refrigerator, water, and medicine and equipment storage (Thompson et al., 1983). Approximately 10 percent of the cattle in a feedlot will be treated in hospital areas during the feeding period (NCBA, 1999).

The majority of beef feedlots are open feedlots, which are usually unpaved. These types of operations may use mounds in the pens to improve drainage and provide areas that dry quickly, because dry resting areas improve cattle comfort, health, and feed utilization. In open feedlots, protection from the weather is often limited to a windbreak near the fence in the winter and sunshade in the summer; however, treatment facilities for the cattle and the hospital area are usually covered. A concrete apron is typically located along feedbunks and around waterers, because these are heavy traffic areas (Bodman et al., 1987).

Open-front barns and lots with mechanical conveyors or fenceline bunks are common for feedlots of up to 1,000 head, especially in areas with severe winter weather and high rainfall. Confinement feeding barns with concrete floors are also sometimes used at feedlots in cold or high rainfall areas. These barns require less land and solve feedlot problems caused by drifting snow, severe wind, mud, lot runoff, and mound maintenance. Feeding is typically mechanical bunk feeding or fenceline bunks. Manure is usually scraped and piled in a containment area. If the barn has slotted floors, the manure is collected beneath slotted floors, and is scraped and stored or flushed to the end of the barn where it is pumped to a storage area for later application (Bodman et al., 1987).

4.4.3.2 *Feeding and Watering Practices*

At feedyards, all cattle are fed two or three times a day and are normally fed for 120 to 180 days, depending on their initial weight and type. Some operations may feed as long as 270 days if they receive young calves. Feedlots consider the following factors when determining feeding methods: the number of animals being fed; the type and size of grain and roughage storage; the equipment necessary to unload, meter, mix, and process feed; and the location and condition of existing feed storage (Bodman et al., 1987).

Beef feedlots use the following types of feeding methods:

- <u>Fenceline feeding</u> - Bunks are located along the side of a lot or pen. This method requires twice as much bunk length as bunks that feed from both sides, but the advantage is that feed trucks do not have to enter the pens with the cattle. Fenceline feedbunks have 6 to 14 inches of bunk space per head, and are typically used for feedlots with more than 100 head. Feedbunks are cleaned routinely to remove uneaten feed, manure, and other foreign objects.

- <u>Mechanical bunk feeding</u> - Bunks typically allow cattle to eat from both sides and are also used as pen dividers. This feeding method is common with continuous feed processing systems and small operations. Mechanical feedbunks are useful for feedlots of up to 500 head.

- <u>Self-feeding</u> - Feedlots use haystacks, feed from horizontal silos or plastic bags, and grain and mixed rations in bunks or self feeders with this feeding method. Portable silage and grain bunks are useful for up to 200 head (Bodman et al., 1987).

Twenty-four hour access to the water trough is required for the health of the animals and maximum production efficiency. Cattle water consumption varies, depending on such factors as animal size and season, and may range from 9 gallons per day per 1,000 pounds during winter to 18 gallons per day per 1,000 pounds during hot weather (Bodman et al., 1987). Typically, one watering space for each 200 head and a minimum of one watering location per pen of animals is provided (USDA NASS, 1999e). Some water may be required to add to the feed processing or to clean equipment.

4.4.3.3 *Water Use and Wastewater Generation*

The main source of wastewater to be managed is the runoff from rainfall events and snow melt. Surface runoff from rain and snow melt can transport manure, soil, nutrients, other chemicals (e.g., pesticides), and debris off the feedlot; therefore, it is important to divert clean water away from contact with manure, animals, feed processing and storage, and manure storage areas to reduce the total volume of contaminated wastewater. Runoff is affected by rainfall amount and intensity, feedlot maintenance practices, and soil type and slope. Runoff can be controlled by using diversions, sediment basins, and storage ponds or lagoons. Feedlots can also reduce the volume of runoff by limiting the size of confinement areas.

Typically, pens are constructed such that runoff is removed as quickly as possible, transported from the lot through a settling basin, and diverted into storage ponds designed to retain, at a minimum, the 24-hour, 25-year storm. Feedlots can reduce the runoff volume by preventing all runon water from entering clean areas and by diverting all roof runoff.

Only specially constructed barns use water to flush or transport manure. These barns are used by a very small percentage of the industry and are typically used at smaller feedlots.

4.4.3.4 *Climate*

Climate plays a large role in the design and operation of a feedlot. The metabolic requirement for maintenance of an animal typically increases during cold weather, reducing weight gain and increasing feed consumption to provide more net energy. Feed consumption typically declines under abnormally high temperatures, therefore reducing weight gain. Investigations in California have shown that the effects of climate-related stress could increase feed requirements as much as 33 percent (Thompson et al., 1983). As a result, waste (manure) generation would also increase.

In cold areas, feedlots typically provide a roof of some sort for the cattle. Sheltered cattle gain weight faster and more efficiently during winter than unsheltered cattle. Areas that receive substantial rainfall require mud control and paved feeding areas, since higher precipitation results in greater runoff volumes. In hot, semiarid areas, sun shades are typically provided for the cattle. A dry climate requires generally 75 square feet of pen space per head whereas a wet climate may require up to 400 square feet of pen space per head (Thompson et al., 1983). Feedlots typically use misting sprinklers or watering trucks to control dust problems in dry climates.

4.4.4 Backgrounding Operations

Backgrounding operations feed calves, after weaning and before they enter a feedlot using pasture and other forages. These operations allow calves to grow and develop bone and muscle without becoming fleshy or gaining fat covering. Weaned calves are typically sent to backgrounding operations to allow producers to:

- Develop replacement heifers;
- Retain rather than sell at weaning when prices are typically low;
- Use inexpensive home-grown feeds, crop residues, pasture or a combination of these to put weight on calves economically;
- Put weight on small calves born late in the calving season before selling; and/or

- Put minimal weight on calves during winter before grazing on pasture the following spring and summer.

Calves are normally kept at the operation from 30 to 60 days but can be kept up to 6 months (approximately 400 pounds) (Rasby et al., 1996). Typical diets consist of equal proportions of roughage and grains that produce a moderate gain of 2 to 2.5 pounds per day. Backgrounding operations typically keep calves on pasture during their entire stay; however, these operations may operate similarly to a beef feedlot, using pens to confine calves, and feedbunks to feed.

4.4.5 Veal Operations

Veal operations raise calves, usually obtained from dairy operations, for slaughter. Dairy cows must give birth to continue producing milk. Female dairy calves are raised to become dairy cows; however, male dairy calves are of little or no value to the dairy operation. Therefore, these male dairy calves are typically sent to feedlots or veal operations. Calves are normally separated from the cows within 3 days after birth. Veal producers typically obtain calves through livestock auctions, although in some cases the calves may be taken directly from the dairy farm to the veal operation (Wilson et al., 2000).

The majority of veal calves are “special-fed” or raised on a low-fiber liquid diet until about 16 to 20 weeks of age, when they weigh about 450 pounds. Calves slated for “Bob” veal, which are marketed up to 3 weeks of age, when they weigh about 150 pounds; these constitute about 15 percent of the veal calves sold (USDA, 1998).

Calves are fed a milk-replacer diet composed of surplus dairy products, including skim milk powder and whey powder. Their diet also includes plant- and animal-derived fats, proteins, and other supplements such as minerals and vitamins (Wilson et al., 2000). Calves spend their entire growing-out period on a liquid diet.

Veal calves are generally grouped by age in an environmentally controlled building. The majority of veal operations utilize individual stalls or pens. Floors are constructed of either wood slats or plastic-coated expanded metal, while the fronts and sides are typically wood slats. The slotted floors allow for efficient removal of waste. The back of the stall is usually open, and calves may be tethered to the front of the stall with fiber or metal tethers. Individual stalls allow regulation of air temperature and humidity through heating and ventilation, effective management and handling of waste, limited cross-contamination of pathogens between calves, individual observation and feeding, and, if necessary, examination and medical treatment (Wilson et al., 2000). The stalls provide enough room for the calves to stand, stretch, groom themselves, and lie down in a natural position.

Veal waste is are very fluid, diluted by various volumes of wash water used to remove them from the building (see Section 6.4 for a discussion of veal manure characteristics). Therefore, manure is typically handled in a liquid waste management system. Manure, hair, and feed are regularly washed from under the stalls to reduce ammonia, odor, and flies in the room. Manure is typically washed out twice daily so that if the calf is having health problems, it is easily observed.

Approximately 10 percent to 30 percent of the wastewater generated at a veal operation comes from scrubbing rooms and stalls after calves have been shipped to market.

The most common method for handling manure and wash water is using a sloping gutter under the rear of the stalls, allowing manure to continuously drain into a manure storage system. Tanks, pits, and lagoons are used to store manure until it is spread on fields. Storage pits may also be built directly under buildings; however, this produces higher levels of ammonia and other pit gases that require increased ventilation and higher fuel costs in the winter (Meyer, 1987).

4.4.6 Cow-Calf Operations

Cow-calf operations breed mature cows and yearling heifers with bulls to produce calves and can be located in conjunction with a feedlot, but they are more often as stand-alone operations. A herd of mature cows, some replacement heifers, and a few bulls are typically maintained at cow-calf operations on a year-round basis. Offspring calves remain with the cows until weaned and then may be held in different pastures to grow until they weigh between 650 to 750 pounds when they are sold to feedlots as yearlings. These operations may also sell their calves to backgrounding operations or dairy operations. Artificial insemination is not commonly used at cow-calf operations. Bulls are typically used for breeding and are placed with cows at the proper time to ensure spring calves.

The number of bulls required at a cow-calf operation depends on the number of cows and heifers, size and age of bulls, crossbreeding program, available pasture, and length of breeding season. One bull is typically provided for each set of 25 cows or heifers. Bulls are usually pastured away from the cows, and they may be penned separately from each other to prevent fighting (Bodman, 1987).

Outdoor calving requires clean, well-drained, and wind-protected pastures. Separate feed areas are provided for mature cows, first calf heifers, bulls, and calves (Loudon, 1985). In cold climates, a calving barn may be needed to reduce the risk of death. These barns typically include a loose housing observation area, individual pens, and a chute for holding and treating cows. Typically, a barn is provided for 5 percent to 10 percent of the cow herd in mild climates, and for 15 percent to 20 percent of the herd in more severe weather or during artificial insemination (Bodman, 1987).

4.4.7 Waste Management Practices

Waste from a beef feedlot may be handled as a solid or liquid; both management methods have advantages and disadvantages. Waste from a veal operation is handled as a liquid. Solid waste is typically found in calving pens and in open lots with good drainage. Semisolid waste has little bedding and no extra liquid is added. Waste treated as a solid has a reduced total volume and weight because it contains less water; therefore, its management may cost less and require less power.

Slurry waste has enough water added to form a mixture that can be handled by solids handling pumps. Liquid waste is usually less than 8 percent solids, and large quantities of runoff and precipitation are added to dilute it. Wastes treated as a liquid are easier to automate and require less daily attention; however, the large volumes of added water increase the volume of waste. As a result, the initial cost of the liquid-handling equipment is greater (USDA NRCS, 1992).

4.4.7.1 *Waste Collection*

Beef cattle are confined on unpaved, partially paved, or totally paved lots, and much of their manure is deposited around feedbunks and water troughs. Feedlots typically collect these wastes from the feedlot surface after shipping each pen of cattle (Sweeten, n.d.).

The following methods are used in the beef industry to collect waste:

- Scraping - This is the most common method of collecting solid and semisolid manure from both barns and open lots. Solids can be moved with a tractor scraper and front-end loader. A tractor scraper may be used in irregularly shaped alleys and open areas. Mechanical scrapers are typically used in the pit under barns with slotted floors and propelled using electrical drives attached by cables or chains. Tractors have fewer problems and work better on frozen manure; however, mechanical scrapers reduce labor requirements. Removing manure regularly reduces odor in enclosed areas. Scraping is common for medium and large feedlots (Loudon, 1985).

- Slotted Flooring - This term refers to slats and perforated or mesh flooring and is a method of rapidly removing manure from an animal's space. Most slats are reinforced concrete, but can be wood, plastic, or aluminum, and are designed to support the weight of the slats plus live load, which includes animals, humans, and mobile equipment. Manure drops between slats, which keeps the floor surface relatively clean. Wide slats (between 4 and 8 inches) are commonly used with 1.5 to 1.75 inches between slats (Loudon, 1985).

- Flushing System - This type of system dilutes manure from beef feedlots with water to allow for automated handling. Diluting the manure increases its volume and therefore requires a larger capital investment for equipment and storage facilities. The system uses a large volume of water to flush manure down a sloped gutter to storage, where the liquid waste can be transferred to a storage lagoon or basin. The amount of water typically used for cleaning is 100 gallons per head at least twice a day. Grade is critical for the flush alleys as is amount of water used (Loudon, 1985). This system is not very common for large feedlots; however, this type of system is widely used at veal operations.

Waste collection is easiest on paved lots. On unpaved lots, cattle traffic tends to form a seal on the soil that reduces the downward movement of contaminated water; however, deep scraping can destroy the interface layer that forms between the manure and the soil and acts as a seal to decrease the chance of pollutants from entering the groundwater.

To reduce the production of unnecessary waste, clean water can be diverted away from the feedlot area. For example, uncontaminated water can be directed away from the waste and carried outside of the feedlot area. Roof runoff can be managed using gutters, downspouts, and underground outlets that discharge outside the feedlot area. Unroofed confinement areas can include a system for collecting and confining contaminated runoff. Paved lots generally will have more runoff per square foot than unpaved lots, but due to a smaller total area, they will have less total runoff per animal.

4.4.7.2 *Transport*

Waste collected from the feedlot may be transported within the site to storage, treatment, and use or disposal areas. Solids and semisolids are typically transported using mechanical conveyance equipment, pushing the waste down alleys, and transporting the waste in solid manure spreaders. Flail-type spreaders, dump trucks, or earth movers may also be used to transport these wastes. Liquids and slurries, typically found at veal operations, are transferred through open channels, pipes, or in a portable liquid tank. These wastes can be handled by relying on gravity or pumps as needed.

4.4.7.3 *Storage, Treatment, and Disposal*

Beef feedlot operations typically use a settling basin to remove bulk solids from the liquid waste stream, reducing the volume of solids before the stream enters a storage pond, thereby increasing storage capacity. A storage pond is typically designed to hold the volume of manure and wastewater accumulated during the storage period, the depth of normal precipitation minus evaporation, the depth of the 25-year, 24-hour storm event, and an additional 1 foot of freeboard. Solid manure storage can also range from simply constructed mounds to manure sheds that are designed to prevent runoff and leaching.

Beef feedlot operations may also use other types of technologies, such as composting or mechanical solids separation, when managing animal waste and runoff. Typical manure and waste handling, storage, and treatment technologies used at beef feedlots are discussed in detail in Section 8.2. The majority (approximately 83 percent) of beef feedlots dispose of their waste through land application (USDA APHIS, 2000a).

Veal operations typically use an underground storage pit or a lagoon for waste storage and treatment. Veal operations also typically dispose of their waste through land application.

The amount of cropland and pastureland that is available for manure application varies at each beef operation. Generally, operations in the beef industry can be categorized into three groups with respect to available cropland and pastureland: (1) those with sufficient land so that all manure can be applied without exceeding agronomic application rates, (2) those without sufficient land to apply all of their manure at agronomic rates, and (3) those without any available cropland and pastureland. Operations without sufficient land, or any land, often have agreements with other farmers allowing them to apply manure on their land. Depending on the size of the beef operation, 1997 Census of Agriculture data indicate that the average acreage of cropland at beef feedlots with at least 500 head is between 550 to 850 acres and the average acreage of pastureland is between 50 and 110 acres (Kellogg, 2000).

USDA conducted an analysis of the 1997 Census of Agriculture data to estimate the manure production at livestock farms. As part of this analysis, USDA estimated the number of confined livestock operations that produce more manure than they can apply on their available cropland and pastureland at agronomic rates for nitrogen and phosphorus and the number of confined livestock operations that do not have any available cropland or pastureland. The analysis assumed land application of manure would occur on 1 of 24 typical crops or pastureland (Kellogg, 2000). Using the percentage of these facilities estimated by USDA against the total number of livestock facilities, one can also estimate the number of facilities that have sufficient cropland and pastureland for agronomic manure application. Table 4-82 summarizes the percentage of beef feedlots that have sufficient, insufficient, and no land for manure application at agronomic application rates for nitrogen and phosphorus. EPA assumes that all veal operations have sufficient land to apply their manure.

Table Table 4-82. Percentage of Beef Feedlots With Sufficient, Insufficient, and No Land for AgronomicApplication of Manure

Size Class	Sufficient Land		Insufficient Land		No Land[a]
	Nitrogen Application	Phosphorus Application	Nitrogen Application	Phosphorus Application	
300 - 1,000 head	84	62	9	31	7
1,000 - 8,000 head	6	22	21	67	11
> 8,000 head	8	1	53	6	39

[a] No acreage of cropland (24 crops) or pastureland.
Source: Kellogg, 2000

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