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

Addendum

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1	EPA-821-R-03-001	December 2002	Initial Release	PHS
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This document is an addendum to the *Development Document for the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations* (EPA-821-R-03-001), which was prepared in support of effluent limitations guidelines and standards for Concentrated Animal Feeding Operations (CAFOs), published February 12, 2003 (68 FR 7176). Please note that the section and page numbers in this document are numbered to be consistent with the original document. The section numbers either correspond to section numbers in the existing document, or are additions to the original document. The page numbers continue from the existing pages in the original document.

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Chapter 1

INTRODUCTION

This document is an addendum to the *Development Document for the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations* (EPA-821-R-03-001), referred to as the Technical Development Document or TDD, which was prepared in support of effluent limitations guidelines and standards for Concentrated Animal Feeding Operations (CAFOs), published February 12, 2003 (68 FR 7176). On February 28, 2005, the Second Circuit Court of Appeal issued its decision to remand several elements of the 2003 CAFO rule related to new sources and Best Conventional Pollutant Control Technology (BCT) and directed EPA to further review and clarify these rules. This addendum summarizes EPA's findings.

The final regulations in the 2003 Effluent Limitations Guidelines and Standards include revisions of two regulations that ensure manure, litter, and other process wastewaters for CAFOs do not impair water quality. These two regulations are the National Pollutant Discharge Elimination System (NPDES) and the Effluent Limitations Guidelines and Standards (ELGs) for feedlots (beef, dairy, swine, poultry, and veal), which establish the technology-based standards that are applied to CAFOs. Both regulations were originally promulgated in the 1970s. EPA revised these regulations in 2003 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 by ensuring effective management of manure by primarily the largest CAFOs. EPA did not revise the ELG for the horse, sheep and lamb, or duck subcategories. In establishing these regulations, EPA evaluated several different technology options for implementation at CAFOs, which are summarized in Table 1-1.

This document presents the methodology and calculations used to evaluate the court remanded issues of NSPS requirements and BCT standards for pathogens. The chapter, section, and page numbers of this TDD Addendum are designed to fold into and continue from the original TDD document. Section 2.3 is a continuation of Chapter 2 in the original TDD, which discusses the court decision and EPA's proposed regulation for NSPS and BCT. Section 8.6 is a continuation of Chapter 8 in the original TDD, which discusses treatment technologies that were evaluated for pathogen control. Chapter 15 is a new chapter that describes the additional analyses that EPA conducted in response to the 2005 Second Circuit Court decision.

Table 1-1. Regulatory Options for CAFOs that EPA Considered for the 2003 Rule

Option Number	Description
1	Zero discharge from a facility designed, maintained, and operated to hold manure, litter, and other process wastewater, including direct precipitation and runoff from a 25-year, 24-hour rainfall event. This option includes implementation of feedlot best management practices, including stormwater diversions; lagoon and pond depth markers; periodic inspections; nitrogen-based agronomic application rates; elimination of manure application within 100 feet of any surface water, tile drain inlet, or sinkhole; mortality handling, nutrient management planning, and recordkeeping guidelines.
1A	The same elements as Option 1, with the addition of storage capacity for the chronic storm event (10-year, 10-day storm) above any capacity necessary to hold manure, litter, and other process wastewater, including direct participation and runoff from a 25-year, 24-hour rainfall event.
2	The same elements as Option 1, except nitrogen-based agronomic application rates are replaced by phosphorus-based agronomic application rates when dictated by site-specific conditions.
3A/3B	The same elements as Option 2, plus Option 3A facility costs include an assessment of the ground water's hydrologic link to surface water; Option 3B facility costs include ground water monitoring, concrete pads, synthetically lined lagoons and/or synthetically lined storage ponds.
3C/3D	The same elements as Option 2, plus permeability standards for lagoons and storage ponds, which may include costs for synthetically lined lagoons and ponds.
4	The same elements as Option 2, plus costs for additional surface water monitoring.
5	For swine, poultry, and veal operations only, the same elements as Option 2, but is based on zero discharge with no overflow under any circumstances (i.e., total confinement and covered storage).
5A	For beef, dairy, and heifer operations only, the same elements as Option 2, plus implementation of a drier manure management system (i.e., composting).
6	For the Large swine and dairy operations only, the same elements as Option 2, plus implementation of anaerobic digestion with energy recovery.
7	The same elements as Option 2, plus timing restrictions on land application of animal waste to frozen, snow-covered, or saturated ground.

Chapter 2

SUMMARY AND SCOPE OF PROPOSED REGULATION

The proposed regulations described in this document include revisions to the ELGs promulgated for CAFOs on February 12, 2003 (68 FR 7176). Section 2.3.1 describes the proposal related to NSPS and Section 2.3.2 describes the proposal related to BCT for the control of pathogens.

2.3 Summary of the Second Circuit Court Decision Concerning Remanded Issues

The Second Circuit Court of Appeals remanded several elements of the 2003 CAFO rule related to new sources. Specifically, the court directed EPA to clarify the basis for allowing subpart D CAFOs to comply with the NSPS requirements by either the 100-year storm standard or the alternative performance standards. With respect to the 100-year storm standard, the Court noted that while certain studies showed that the production area Best Management Practices (BMPs) adopted by the 2003 CAFO rule would have substantially prevented the production area discharges documented in the record, the court explicitly stated that *substantially preventing* discharges is not the same as prohibiting them outright. With respect to the alternative performance standards, the court held that EPA had not justified its decision to allow compliance with the no discharge standard through an alternative standard permitting production area discharges so long as the aggregate pollution to all media is equivalent to or lower than the baseline standards. The court further held that EPA did not provide adequate notice for either of these provisions under the CWA's public participation requirements. See 33 U.S.C. § 1251(e) ("Public participation in the development, revision, and enforcement of any regulation, standard, effluent limitation, plan, or program established by the Administrator or any State under this Act shall be provided for, encouraged, and assisted by the Administrator and the States").

The Second Circuit Court of Appeal also remanded the 2003 CAFO rule's BCT standard for pathogens. In the court's view, the 2003 CAFO rule violated the CWA because EPA did not make an affirmative finding that the BCT-based ELGs adopted in the CAFO rule do in fact represent the best conventional pollutant control technology for reducing pathogens – specifically, fecal coliform bacteria (FC). The court noted that EPA may well determine that the ELGs otherwise adopted by the CAFO rule do in fact represent the best conventional pollutant control technology for reducing pathogens. The court further noted that EPA may determine, after considering all the relevant factors, that the ELGs otherwise adopted by the 2003 CAFO rule will directly – not just incidentally – reduce pathogens and do so better than any other pollutant control technology.

2.3.1 Proposed Regulation of NSPS

The CWA requires EPA to promulgate NSPS for new, as opposed to already existing, sources of pollution. See 33 U.S.C. § 1316. The Act provides that these standards must "reflect the greatest degree of effluent reduction which the Administrator determines to be achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants." 33 U.S.C. § 1316(a)(1). The Act further requires that the EPA "take into consideration the cost of achieving such effluent reduction, and any non-water quality, environmental impact and energy requirements." 33 U.S.C. § 1316(b)(1)(B). EPA is given considerable discretion to weigh and balance the various factors required by statute to set NSPS. *Waterrkeeper Alliance, Inc., et al. v. EPA*, 358 F. 3d 174, 195 (2d Cir. 2004).

EPA proposed that the NSPS for the production areas of swine, poultry, and veal CAFOs include a total prohibition on production area discharges. In the Final Rule, however, the EPA changed course in several respects: (1) The NSPS still barred all production area discharges, but provided that a CAFO could comply with this requirement by designing, constructing, operating and maintaining production areas that could "contain all manure, litter, and process wastewater including the runoff and the direct precipitation from a 100-year, 24-hour rainfall event;" and (2) the NSPS empowered permitting authorities to establish alternative performance standards that allow production area discharges, so long as such discharges were accompanied by "an equivalent or greater reduction in the quantity of pollutants released to other media" by the CAFO. The court determined that there was not adequate support in the record for either of these decisions. This section discusses EPA's analysis for the proposed changes to NSPS.

2.3.1.1 100-Year Storm Containment Structure

EPA proposes to delete 40 CFR 412.46(a)(1), the provision allowing CAFOs to meet the no discharge standard through the use of the 100-year, 24-hour rain event containment structure. By doing so, the production area requirements for new source swine, poultry, and veal calf operations sources would be no discharge of manure, litter, and process wastewater. The land application requirements would remain unchanged. EPA recognizes that a depth marker can be an excellent means of displaying how much storage a CAFO has, and whether it is time to pump down levels in the lagoon. Depth markers are a useful tool to help with the management of any facility.

EPA proposes a compliance alternative for facilities with open manure storage structures to meet the no discharge requirements. Specifically, EPA is proposing a modeling approach by which facilities could demonstrate that their proposed system would comply with the no discharge requirements. If a facility complied with the specified site-specific design, construction, operation, and maintenance components of the modeled manure storage structure, it would be deemed to be in compliance with the no discharge requirement.

2.3.1.2 Superior Alternative Performance Standards

EPA proposes to delete 40 CFR 412.46(d) and remove the voluntary superior performance standards provision for new swine, poultry, and veal sources. The court ruling states that EPA cannot establish production area standards that substantially prevent discharges as equivalent to standards that prohibit discharges outright. In accordance with this ruling, EPA is proposing to withdraw this provision.

2.3.2 Proposed Regulation of BCT for Pathogen Control

EPA evaluated various candidate technologies to assess whether they are technologically feasible for all facilities in a subcategory and would achieve greater reductions of FC than the technologies selected as the basis for BPT in the 2003 rule. Specifically, EPA estimated pathogen reductions associated with technology Options 3, 5, 6 and 7, described in Table 1-1 and discussed in the 2003 docket. These regulatory options were evaluated despite EPA's previous determinations of technical infeasibility, disproportionately high costs, and low affordability because these options may provide more reductions of pathogens than the option selected for the final 2003 CAFO ELGs. EPA did not consider Options 1 and 4 because they do not provide any further conventional pollutant reductions than the final selected Option 2. EPA also evaluated additional candidate technologies for pathogen reductions: fluidized bed incinerators; composting for poultry; chemical addition for disinfection; and additional storage to comply with national prohibitions of land application to frozen, saturated, or snow-covered ground (Option 7) for the swine industry (Option 7 for the beef and dairy industries was already presented in 2003). See Chapter 5 for a description and discussion of the evaluated technologies.

EPA conducted the BCT cost-reasonableness test for those technology options determined to be feasible. EPA found that none of these candidate technologies would pass either part of the BCT cost test, noting the BCT cost test explicitly addresses the conventional pollutants TSS and BOD. See Chapter 4 for a description of the BCT cost test analysis. Therefore, EPA believes that any combination of these technologies developed into a regulatory option for a subcategory would also not pass the BCT cost test. For example, suppose technology A is practical for dry poultry facilities, but is not practical for wet poultry facilities. Technology B is practical for wet poultry facilities, but is not practical for dry poultry facilities. Both technologies are necessary to create a technology basis for the entire poultry category. If both technology A and technology B fail the BCT cost test, then a technology option developed for the poultry category comprised of technology A for dry facilities and technology B for wet facilities would also fail the BCT cost test.

EPA also evaluated an alternative approach to conducting the two-part cost test that explicitly addresses FC. Section 15.2.3 presents the results of applying this alternative cost test to the candidate BCT technology options considered. None of the candidate technology options pass the alternative BCT cost test.

2.4 References

Waterkeeper Alliance, Inc. et al. v. EPA, 358 F. 3d 174, 195 (2d Cir. 2004).
Waterkeeper Alliance, Inc. et al. v. EPA, 399 F. 3d 486 (2d Cir. 2005).

Chapter 8

TREATMENT TECHNOLOGIES AND BEST MANAGEMENT PRACTICES

8.6 Treatment Technologies and Practices Evaluated for Pathogen Control

This chapter provides a description of additional treatment technologies and best management practices (BMPs) specifically identified by EPA for the reduction of FC and other pathogens. These technologies, including digesters, fluidized bed incinerators, chemical addition for disinfection, composting, and deep stacking of poultry litter, were considered by EPA as the bases for BCT options in addition to the technology options evaluated for the 2003 CAFO rule (described in Table 1-1 of this document).

Section 8.6.1 provides a description of each of the new technologies considered. Section 8.6.2 presents the estimated engineering compliance costs associated with implementing the BCT regulatory options. More detailed information on the cost methodology used for options identified in the 2003 rule is contained in the Cost Report.

Section 8.6.3 presents an estimation of the pollutant load reductions associated with the implementation of each option. EPA's assessment incorporated pollutant loadings from feedlots and manure storage structures, representing discharges from AFO production areas. These discharges generally include runoff from the feedlot or manure storage areas due to precipitation events, but also include, where actual discharge data was available, a limited number of discharges attributed to storage system failures and improper management. The loadings also include edge-of-field pollutant loadings from cropland where animal manure, litter, and process wastewater is applied. More detailed information on the loads methodology used for options identified in the 2003 rule is contained in the *Pollutant Loading Reductions for the Revised Effluent Limitations Guidelines for Concentrated Animal Feeding Operations* (2002) (i.e., "Loads Report").

8.6.1 Descriptions of Technology Options

This section provides a description of the new technology options EPA considered for BCT as part of this proposed rule. EPA also evaluated Options 3, 5, 5A, 6, and 7 for the control of conventional pollutants. These options, identified in the 2003 rule and described in Table 1-1, potentially provide pathogen reduction beyond that of the BPT option (Option 2).

In support of this proposed rule, EPA reevaluated Option 6 (anaerobic digestion) to focus on a technology basis and design that would optimize pathogen removal, specifically mesophilic digestion. EPA identified the design basis for this technology, and estimated the cost to implement the technology, and the expected load reductions.

EPA also evaluated two new technology options not previously considered as BPT candidate technologies, but considered here because of their potential in reducing pathogens: lime addition to dairy manure, and composting of poultry litter. To be thorough, EPA evaluated the costs and load reductions associated with these technologies, despite EPA's previous determinations of their technical infeasibility, disproportionately high costs, and low affordability.

Finally, EPA reviewed several other technologies that were determined to not be viable technology options: fluidized bed incinerators, chemical addition for disinfection (including chlorine, calcium hypochlorite, sodium hypochlorite, and ozone), and deep stacking of poultry litter. These technologies are described in this section, but were not included in the cost or loads calculations because they are not technically feasible for this industry.

8.6.1.1 Anaerobic Digestion

EPA included a digester option in the BCT cost test for those species where the technology is most likely to be feasible - Large dairy and swine facilities (see the AgSTAR handbook for more information, EPA Docket OW-2005-0037, DCN 1-01215). Sections 8.6.2.1 and 8.6.2.2 present the cost calculation methodologies used to represent this option. The option includes construction of a mesophilic digester (either a heated covered-lagoon digester, plug flow, or complete mix digester, with biogas recovery) prior to manure storage. Treated manure is stored in the CAFO's existing manure storage facility. Treated manure is assumed to be land applied consistent with the BPT requirements of 40 CFR 412.

There are three basic temperature regimes for anaerobic digestion: psychrophilic, mesophilic, and thermophilic. Psychrophilic, or low-temperature, digestion is a natural decomposition process at temperatures typically found in lagoons. The hydraulic retention time for stable operation varies from 30 days to 90 days depending on temperature. Mesophilic digestion reduces the retention period to 12 to 20 days. In some limited cases digesters were shown to reduce FC by as much as 99 percent, particularly by thermophilic (higher temperatures in the range of 135 to 155 degrees Fahrenheit) digestion, but regrowth of both FC and other pathogens was shown to occur during effluent storage. (68 FR 7217) EPA did not receive any public comments or data during the 2003 rulemaking process that provided a reliable means of quantifying this regrowth. Most importantly, a digester does not eliminate the need for the CAFO to have liquid impoundments for process wastewater, treated wastewater, and storm water runoff.

EPA assumes a mesophilic (heated) digester system will reduce FC of the stored manure by 99 percent (a 2 log-order reduction). EPA's digester option costs include cost-offsets due to biogas recovery and energy recovery, and a new storage pond for effluent storage if the CAFO did not already utilize liquid storage structures. The resources for a mesophilic digester designed to target pathogen reduction are expected to be higher than a digester designed to stabilize manure and produce biogas. In particular, CAFO operators are highly unlikely to have the experience and technical expertise for start-up, troubleshooting, and routine diagnostics to ensure the digester is operating as intended. Therefore EPA's costs also include annual technical consultation and services necessary to assure effective digester system operation, optimal biogas generation, and energy recovery. The total incremental costs and pollutant reductions of this option are presented in Tables 15-8 and 15-12.

Digesters do not reduce the total nutrients in animal wastes. Most of the phosphorus removed from the effluent is concentrated in the digested solids, which are still subject to land application requirements. Other data show that changes in pollutant composition, particularly the soluble forms of nitrogen, could result in increased discharges of pollutants following land application of digested manure, specifically ammonia releases and other emissions. Similarly, metals are not reduced and remain in the digester effluent and solids.

Digestion may also be conducted aerobically, but this variation is rarely seen at CAFOs due to process problems, design challenges, high energy requirements, and disproportionately high costs (See Table 8-14 of the TDD for a list of aerobic digestion and activated sludge processes).

8.6.1.2 Lime Addition

Lime addition may be used as a disinfectant for barn and milking parlors and other animal wastes. Lime addition is a proven treatment technology for Class A and Class B biosolids standards. To meet Class B requirements using lime stabilization, the pH of the biosolids must be elevated to more than 12 for 2 hours and subsequently maintained at more than 11.5 for 22 hours. The material also needs to be kept at high temperature (70 Celsius) for at least 30 minutes, which would require outside heating of the material to be treated.

Section 8.6.2.3 presents a cost estimate for lime treatment of dairy manure. Data presented in Section 8.6.2.3 demonstrate that the capital costs for holding tanks, dosage tanks, mixing equipment, and neutralization tanks necessary for retrofitting this technology at CAFOs are high. The addition of lime results in an increase in sludge volume, although lime stabilization generally requires less space than treatment alternatives such as composting. Most high-moisture CAFO wastes would require some sort of digestion and/or dewatering prior to stabilization. EPA believes additional costs for operator training, safety controls, chemical purchases, and increased volume of materials that must be hauled and land applied may be another reason the technology has not been adopted by CAFOs given the successful application of lime addition to biosolids. The addition of lime to organic wastes in general has been shown to accelerate ammonia emissions.

8.6.1.3 Composting of Poultry Manure or Litter

Composting is used at animal feeding operations to biologically stabilize and dry waste for use as a fertilizer or soil amendment. Composting is an aerobic process in which microorganisms decompose organic matter into heat, water, carbon dioxide, and a more stable form of organic matter—resulting in a relatively uniform, dry, odorless end product that can be used as a soil amendment. The elevated temperature in the interior of a properly operated compost pile kills weed seeds, pathogens, and fly larvae. Because composting is an aerobic process, a continuous supply of oxygen must be available for the microorganisms to break down the organic matter. Composting time and efficiency are affected by the amount of oxygen, the balance of carbon and nitrogen in the raw materials, the moisture content, and the particle size and the porosity of the materials. Five basic approaches to composting are (1) the passive pile approach, (2) windrow composting using a loader for turning, (3) windrow composting using specialized windrow turners, (4) aerated static pile systems, and (5) in-vessel systems.

The effectiveness of the technology is weather dependent, and for Large CAFOs generating substantial quantities of manure, the technology requires a large amount of land, requires additional runoff controls and wastewater storage, and imposes a much operating higher cost on CAFOs. (TDD, p. 8-102 to 8-110; Cost Report, Section 5.12) However, windrow composting is applicable at a much wider range of CAFOs, and was included in technology Option 5A for beef and dairy operations in the 2003 rule. Composting is also a practical technology for incremental pathogen removals at most poultry operations.

EPA evaluated a windrow composting option for poultry manure/litter in the BCT cost test. Similar to the digesters option, EPA conservatively estimates that composting reduces FC by 99 percent. Costs for the poultry composting option include:

- Planning;
- Compost amendments (including water);
- Land rental for the composting area;
- Equipment for windrow turning (capital and operation & maintenance) and compost monitoring;
- Labor for windrow turning and monitoring (temperature and moisture content);
- Solids separation equipment for wet layer operations; and
- Storage pond installation and irrigation costs for dry layer, broiler, and turkey operations.

Section 8.6.2.4 provides a detailed explanation of the windrow composting option and methodology used to calculate costs for applying composting technology to poultry operations.

8.6.1.4 Fluidized Bed Incineration

Fluidized bed incineration is a proven technology for reducing waste volume and for converting the waste to useful products (e.g., energy, nutrient enriched ash), and is being used at municipal waste disposal facilities. However, even at municipal operations, incineration can be a costly method of disposal and frequently requires co-combustion with other feedstocks.

In addition, incinerators are not widely used in the United States to manage animal manure because it is generally not affordable to individual CAFOs. Application of this technology has been attempted by a beef feedlot in the U.S., but failed because the incinerator thermal output could not be sustained (TDD, page 8-93 to 8-95). Fluidized bed incinerators are also sensitive to moisture content and fuel particle size, limiting incinerator effectiveness to those wastes that have a more consistent composition and contain no more than 15-20 percent moisture.

EPA has not been able to identify cattle or swine CAFOs that have successfully implemented the technology. Individual poultry CAFOs in the U.S. do not currently use incineration as a method of handling excess poultry litter, although centralized incinerator projects have been successfully developed in the European Union in selected geographic areas with a high density of poultry operations, and several similar systems have been proposed in the U.S. These centralized incinerators reduce pathogens in the litter. However, large-scale, centralized incineration plants have not yet successfully translated into feasible, smaller-scale units for individual CAFO use. (See Chapter 8 of the TDD.)

It is also possible to gasify manure solids on-farm, but this technology is still in the pilot stage. EPA is aware of a demonstration project that heats the manure in a refractory oven, and where the gasses are used to replace propane in a mortality handling system. EPA is not aware of any individual CAFOs using incineration due to fuel costs, the high capital costs of the incineration unit, and the inability to sustain the technology for most animal manures. EPA therefore rejects this technology as practical for individual CAFOs.

8.6.1.5 Other Chemical Addition Technologies

Methods of disinfection include chemical addition, heat, mechanical methods, and radiation. Various types of chemical addition for the purpose of disinfection were reviewed but not selected as part of a technology option in the 2003 CAFO rule. (See Chapter 8 of the TDD for more information). Commonly used disinfection technologies in the U.S. include the addition of chemicals such as chlorine, calcium hypochlorite, sodium hypochlorite, lime, and ozone. Chlorination has a history of select pathogen destruction effectiveness and is relatively inexpensive when used as a polishing step for final incremental removal of pathogens. However, organic compounds present in typical CAFO wastewater can combine with chlorine to form chloroform (a documented animal carcinogen), monochloramines, and other toxic chloro-organic compounds. Accordingly, the Occupational Safety and Health Administration (OSHA) established intensive training and safety measures for chlorine use (EPA Docket OW-2005-0037, DCN 1-01198). Chlorine dioxide is widely used as an alternative bactericide, but requires expensive generating equipment, and produces chlorate and chlorite as potentially undesirable by-products. Chemical addition is not commonly practiced in the United States for treatment of animal wastes. In order for chlorination to be optimally effective and to minimize the generation of chlorinated by-products, the treated wastewater should have low levels of suspended solids-generally 30 to 50 mg/l or less. Therefore, to implement chlorine-based disinfection, animal wastewater would require primary and/or biological treatment prior to disinfection. Storage tanks, dosage control equipment, and mixing equipment would need to be retrofitted. The capital investment to modify a typical CAFO's existing manure management system will be costly and clearly requires higher levels of maintenance and operator skill.

Ozone is a highly effective germicide against a wide range of pathogenic organisms, including bacteria, protozoa, and viruses. Ozone use in U.S. wastewater treatment is limited due to high capital and operating costs and intensive energy requirements. Ozonation, like chlorination, requires a wastewater that has relatively low levels of solids to avoid regrowth of microorganisms after disinfection and reduce added cost associated with oxidizing oxygen demanding solids. Ozone disinfection technology is not commonly practiced in the United States for treatment of animal wastes. The processes are costly and require higher levels of maintenance and operator skill. Ozone disinfection efficiency depends on a pH 6-10 and temperature of at least 36 degrees Fahrenheit. (TDD, p. 8-117) To implement this technology, animal wastewater would require primary and/or biological treatment prior to disinfection (EPA Docket OW-2005-0037, DCN 1-01198). Therefore, EPA rejected ozonation as practical due to undesirable disinfection by-products, high operation and maintenance requirements, high operator skill, considerable worker safety concerns, and overall high costs. For the above reasons, EPA finds that all of these chemical addition technologies are not practical for individual CAFOs.

8.6.1.6 Deep Stacking of Poultry Litter

Deep stacking consists simply of piling litter in a conical pile or stack after it is removed from a poultry house and raising the temperature to a maximum of 140 Fahrenheit (60 Celsius) by microbes. As with anaerobic digestion, incineration, and in some cases chemical addition, the heat (high temperature) reduces pathogens. Although the practice of deep stacking poultry litter enhances its potential value as a feedstuff for ruminants by reducing concern about possible pathogen transmission, the poultry litter cannot be considered pathogen free. The stacked litter is not mixed out of concern that re-aeration will create the potential for excessive heating. Thus, outer regions of the deep stacked litter do not reach the temperatures necessary for pathogen destruction.

In practice, deep stacking may be considered a specialized approach to composting in which oxygen availability limits the overall temperature and the degree to which dry matter ("volatile solids" or "VS") are destroyed. (TDD, p. 8-131 to 8-132) Due to the lack of reliable data on the overall effectiveness of the technology in reducing FC, the operational similarities to windrow composting (an option already evaluated; see Section 8.6.1.3), and limited applications to limited types of poultry CAFOs, EPA rejects deep stacking as practical for consideration as a BCT candidate.

8.6.2 Technology Cost Calculations

EPA estimated industry costs for Options 2, 3, 5, 5A, and 7, based on costs developed for the 2003 CAFO rule using the methodology presented in the Cost Report. Estimation of these costs began by identifying the practices and technologies that could be used to meet a particular set of regulatory requirements. The Agency then developed a cost model to estimate costs for their implementation.

EPA used the following approach to estimate compliance costs for the CAFOs industry:

EPA collected data from published research, meetings with industry organizations, discussions with USDA cooperative extension agencies, review of USDA's Census of Agriculture data, and site visits to swine, poultry, beef, veal, and dairy CAFOs. These data were used to define model farms and to determine waste generation and nutrient concentration, current waste and nutrient practices, and the viability of waste management technologies for the model farms.

EPA identified candidate waste and nutrient management practices and grouped appropriate technologies into regulatory options. These regulatory options serve as the bases of compliance cost and pollutant loading calculations.

EPA developed technology frequency factors to estimate the percentage of the industry that already implements certain operations or practices required by the regulatory options (i.e., baseline conditions).

EPA differentiated between the top 25 percent and bottom 25 percent of performers. This is identified as "Performance Needs" and receives a value of low, medium, or high (L, M, or H). This part of the costing methodology addresses the concern that all CAFOs are average performers and all incur an average cost. This methodology, when combined with frequency factors, results in some CAFOs having little or no costs, some CAFOs having high or full costs, and some CAFOs incurring moderate costs.

EPA developed cost equations for estimating capital costs, initial fixed costs, and 3-year recurring costs, 5-year recurring costs, and annual O&M costs for the implementation and use of the different waste and nutrient practices targeted under the regulatory options. Cost equations were developed from information collected during the site visits, published information, vendor contacts, and engineering judgment.

EPA developed and used computer cost models to estimate compliance costs and nutrient loads for each regulatory option.

EPA used output from the cost model to estimate total annualized costs and the economic impact of each regulatory option on the CAFOs industry (presented in the Economic Analysis).

Table 8-28 presents the regulatory options and the waste and nutrient management components that make up each option.

Table 8-28. Summary of Regulatory Options for CAFOs

Technology or Practice	Options									
	1	1A	2	3A/ 3B	3C/ 3D	4	5	5A	6	7(d)
Feedlot best management practices (BMPs), including storm water diversions, lagoon/pond depth markers, periodic inspections, and records	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mortality handling requirements (e.g., rendering, composting) (a)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Nutrient management planning and recordkeeping (sample soils once every 3 years, sample manure twice per year)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Land application limited to nitrogen-based agronomic application rates	✓	✓								
Land application limited to phosphorus-based agronomic application rates where dictated by site-specific conditions, and nitrogen-based application elsewhere			✓	✓	✓	✓	✓	✓	✓	✓
No manure application within 100 feet of any surface water, tile drain inlet, or sinkhole	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ground water requirements, including assessment of hydrologic link, monitoring wells (four per facility), impermeable pads under storage, impermeable lagoon/pond liners, and temporary/modified storage during upgrade				✓						
Ground water requirements including performance based standards for lagoons					✓					
Additional capacity for 10-year, 10-day chronic storm event		✓								
Surface water monitoring requirement, including four total grab samples upstream and downstream of both feedlot and land application areas, 12 times per year. One composite sample collected once per year at stockpile and surface impoundments. Samples are analyzed for nitrogen, phosphorus, and total suspended solids.						✓				
Drier manure technology basis (b)(c)							✓	✓		
Anaerobic digestion									✓	
Timing requirements for land application (resulting in regional variation in storage periods)										✓

(a) There are no additional compliance costs expected for beef and dairy operations related to mortality handling requirements.
(b) Option 5 mandates "drier waste management." For beef feedlots and dairies, this technology basis is composting. For swine, poultry and veal operations, drier systems include covered lagoons.
(c) Option 5A mandates "no overflow" systems. For swine operations, the technology basis is high-rise housing for hogs, and for poultry operations the technology basis is dry systems.
(d) EPA modified the cost estimations for Option 7 costs to 12 month storage for northern facilities

EPA additionally estimated industry costs for lime disinfection at Large dairy operations, anaerobic digestion optimized for pathogen reduction at Large swine and dairy operations (i.e. recalculated Option 6), and windrow composting at Large poultry operations (Option 5A for poultry). Section 8.6.2 describes the cost estimating methodology EPA used for each of these technology options.

8.6.2.1 Anaerobic Digestion for Pathogen Reduction at Large Dairy Operations

EPA investigated the technical applicability, costs, and FC reductions associated with anaerobic digestion with a focus on pathogen reduction at Large dairy operations. Some anaerobic digester systems are capable of treating CAFO wastes at elevated temperatures, resulting in a decrease in pathogenic microorganism numbers, while converting the volatile solids into reusable energy. Section 8.6.2.1 provides a description of two model dairy CAFOs with different manure removal methods (flush and scrape) and the associated wastes (manure, wash water, flush water, runoff, etc) used to size and cost an anaerobic digester system, the cost calculation methodology and total costs to the industry, and FC loads associated with this technology.

Model Farms

EPA developed two model farms to represent Large dairy operations in the United States: a flush dairy and a scrape dairy. Scrape and flush dairies were previously costed for anaerobic digestion for the final CAFO regulation as described in EPA's Cost Report. EPA's previous costing efforts assumed that flush dairies use a covered lagoon system following a settling basin, and scrape dairies use a complete mix digester following a settling basin. However, these assumptions were based on the optimal influent solids content of each digester rather than their pathogen reduction capability. A covered lagoon system is not heated and is therefore not considered a technology that adequately reduces pathogen levels. The complete mix and plug flow digester systems are heated and are best suited for pathogen reduction. To account for pathogen reduction, EPA assumed that flush dairies use a complete mix digester and scrape dairies use a plug flow digester.

For costing purposes, the representative location used for the Large dairy farms is Tulare County, California. The costs of digester systems for scrape and flush dairies were calculated for a range of farms containing 850, 1500 and 2500 dairy cows. Each farm is assumed to have both calves and heifers. Based on data and assumptions previously presented in the Cost Report:

- The number of calves and heifers on site was assumed to equal 60 percent of the dairy cows, with each animal accounting for 30 percent;

- The dairy cows spend 4 hours in the milking parlor and 20 hours in the free stall barn; and

- The heifers and calves spend the entire time in a dry lot.

Cost Methodology

During the development of the CAFOs effluent guidelines, several regulatory options were considered. Regulatory Option 6 stated that "for Large swine and dairy operations only, the same elements as Option 2, plus implementation of anaerobic digestion with energy recovery" should be evaluated. Therefore, Option 6 costs will be evaluated as the cost of the digester systems plus the costs to implement Option 2. The cost of implementation of anaerobic digestion without energy recovery will also be evaluated for comparison. There is no concern of double counting lagoon costs because lagoons costs are not included in Option 2 costs for Large Dairy farms as described in the Cost Report.

To estimate the total industry cost of dairy anaerobic digestion, EPA performed the following steps:

1. EPA estimated the anaerobic digestion costs for scrape and flush dairies with 850, 1500, and 2500 head using FarmWare Version 2. This is the same version of FarmWare that was used for EPA's previous costing efforts. The anaerobic digestion costs were estimated for two different scenarios: with energy recovery and without energy recovery. The costs were estimated on an annual basis.

2. Operation and maintenance costs were estimated for anaerobic digestion for both scrape and flush dairies by calculating a weighted average of the different size operations.

3. The weighted average FarmWare costs were then annualized.

4. EPA then added the annualized anaerobic digestion costs to the Option 2 annualized costs, which were calculated during the original rule development.

The following sections describe the steps taken by EPA to calculate the total cost to industry for the implementation of anaerobic digester systems for Large dairy operations with and without energy recovery under regulatory Option 6.

FarmWare

EPA input data into FarmWare Version 2 to model three different sizes of scrape and flush dairies. The FarmWare program was developed by the AgSTAR Program (www.epa.gov/agstar) as a screening-level model to support decision making on whether a methane recovery facility could be integrated into an existing facility. FarmWare Version 2 is available publicly at: http://www.epa.gov/agstar/resources/handbook.html (and is also in EPA Docket OW-2005-0037, DCN 1-01203). The following list is a screen-by-screen summary of the inputs used to calculate the capital costs of anaerobic digestion using FarmWare.

Site Location and Climate: FarmWare contains a database of the average monthly temperature and rainfall for every county in the US. Tulare County, California was selected from this database. This region of the country represents more large dairies than any other region in the country. The actual farm level costs may be lower or higher depending on average temperature and rainfall, but this approach is intended to provide an average national cost, not a facility specific cost.

Farm Design: All farms were assumed to be freestall dairy farms. This assumption is consistent with the data presented in the Cost Report for Large CAFOs, as opposed to the farm design for AFOs or small farms. The manure collection method pick list was used to specify whether the farm was a flush or scrape barn. To specify a flush barn the "Flush Everything" option was selected and to specify a scrape barn the "Flush Parlor and Scrape Rest" option was selected. In order to select a digester system, the manure treatment/storage system must be specified as

"Methane Recovery Lagoon." A settling basin was specified for both complete mix and plug flow digester systems.

Livestock: Table 8-29lists the default animal weights used to calculate the manure and volatile solids (VS).

Table 8-29. Animal Weights

Animal Type	Animal Weight (lbs)
Lactating Cows	1,350
Heifers	550
Calf	350

Facilities: The amount of time each animal type spends in each housing type as discussed earlier was applied in this FarmWare screen.

Manure Management Train: For the flush dairy, process water is used for the parlor and the free stall barn. The amount of water used in each facility was calculated using the following equations and values from the Cost Report:

$$\text{Parlor Wastewater (gal/day)} = 477.5 \text{ gal/day} + (30 \text{ gal/cow-day} \times \text{Number of Dairy Cattle})$$

$$\text{Barn Wastewater (gal/day)} = 100 \text{ gal/day-cow} \times \text{Number of Dairy Cattle}$$

The calculated wastewater values were input into the model and a flush frequency of two was specified. A flush frequency of 2.5 was established as representative of the industry but FarmWare only recognizes whole numbers (EPA, 2002). This may result in underestimating the facility design (size), and may therefore understate capital costs. As the drylot is scraped, a mechanical scraper was specified for the manure collection.

For the scrape dairy, process water is only used for the parlor. The amount of water used to flush the parlor was calculated using the following equation:

$$\text{Parlor Wastewater (gal/day)} = 477.5 \text{ gal/day} + (0.625 \text{ gal/cow-day} \times \text{Number of Dairy Cattle})$$

The same flush frequency of 2 was specified for scrape barns. A mechanical separator was selected for the free stall barn and the drylot.

Both farms required an electric generator to recover the energy from the biogas produced. The unit was assumed to be running 90 percent of the time. This is the default value in FarmWare. EPA included additional O&M costs for a consultant who assists in maintaining the system at optimal levels throughout the system's life.

Energy Usage and Payments: To calculate the cost of electricity recovered each month, the national average unit price for electricity of 7.4 cents per kilowatt hour (kWh) and 90 cents per gallon of propane were used (USDOE, 1998). The maximum fraction of propane expenses that could be offset was assumed to be 90, which is the model default.

Anaerobic Digestion Costs for Large Dairy Operations

Tables 8-30 and 8-31 present the output of the FarmWare model for the flush and scrape model dairies using the inputs described above.

Table 8-30. FarmWare Flush Dairy Results

Dairy	Calf	Heifer	Capital Cost	Annual Energy Benefit
850	255	255	$746,585	$50,910
1,500	450	450	$1,204,852	$87,780
2,500	750	750	$1,896,021	$144,178

Table 8-31. FarmWare Scrape Dairy Results

Dairy	Calf	Heifer	Capital Cost	Annual Energy Benefit
850	255	255	$323,495	$53,072
1,500	450	450	$485,435	$89,939
2,500	750	750	$728,269	$146,657

Weighted Average of FarmWare Output

In order to calculate one cost for Large scrape dairies and one cost for Large flush dairies, EPA calculated a weighted average of the costs with and without the energy benefits calculated in FarmWare. First, EPA estimated total operating and maintenance costs. FarmWare calculates an annual O&M cost for operating the generator but not maintaining the digester system as a whole. Based on a memorandum from the CAFO docket (EPA Docket OW-2002-0037, DCN 00815), EPA assumed that the annual cost would equal 10 percent of the total capital cost. To account for the need for the farm operator to obtain on-going consulting support to operate the digester system at optimal levels, a special maintenance cost for technical consulting was added to the annual O&M cost. A 60-dollar per hour consulting fee was assessed for 6 hours per month (EPA Docket OW-2005-0037, DCN 1-02002). These operating and maintenance costs we used to calculate the total annual O&M costs with and without energy recovery using the following equations:

Annual O&M costs ($/yr) with Energy Recovery = Operating Costs + Consulting Fees – Energy Benefit

Annual O&M costs ($/yr) without Energy Recovery = Operating Costs + Consulting Fees

To calculate one set of costs for Large scrape dairies and one set of costs for Large flush dairies, EPA used statistics from the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) to calculate weighted average farm sizes and counts. These data are listed in Table 8-32.

Table 8-32. U.S. Total NASS Large Dairy Farm Statistics

Farm Size (# of head)	Representative Size	Number of Farms	Percent of Farms
700-999	850	1,020	48%
1000-1999	1,500	770	36%
2000+	2,500	325	15%
	Total	**2,115**	**100%**

By applying the percentage of representative farms to the costs calculated in FarmWare, the weighted average capital and O&M costs for flush and scrape dairy operations for the entire Large dairy category were calculated, as shown in Table 8-33.

Table 8-33. Weighted Average FarmWare Capital and O&M Costs

Farm Type	Capital	Annual O&M with Energy Recovery	Annual O&M without Energy Recovery
Flush	$ 1,090,052	$ 36,424	$ 111,089
Scrape	$ 444,651	$ (34,326)	$ 46,549

Annualized Anaerobic Digestion Costs

With the capital costs calculated in FarmWare and the O&M costs estimated as described above, the net present value (NPV) of the proposed project was calculated. The NPV was then used to calculate the total annualized cost of each model farm. The annualized costs for flush and scrape model farms are summarized in Table 8-34. The annualized costs were calculated based on the same annualization model used in the 2002 rule, which is documented in Section 2.2.4 of the *Economic Analysis of the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations* (EPA-821-R-03-002). The model uses a real discount/interest rate of 7 percent, as recommended by the Office of Management and Budget (OMB, 1992), which does not have to be adjusted for inflation. The life expectancy of the asset depends on the serviceable life of the structure as well as on the depreciable life, which affects what portion of a capital cost can be used each year to reduce taxable income. The Internal Revenue Service (IRS) rules govern the designation of depreciable life, which is assigned on the basis of serviceable life. Most of the types of capital investments required under these regulations are typically depreciated over 10 years (IRS, 1999c). The cost annualization model thus incorporates a 10-year annualization period to compute annual costs.

Table 8-34. Total Annualized Model Farm Costs for Flush and Scrape Operations

Farm	Annualized Cost w/ Energy Recovery	Annualized Cost w/o Energy Recovery
Flush	$ 271,154	$ 345,418
Scrape	$ 51,329	$ 102,624

Industry Total Costs

To obtain industry costs for Option 6, the annualized anaerobic digestion costs were added to the model farm costs for Option 2. (Option 2 costs totaled $128 million, as presented in Table 15-7.) The resulting model farms costs were multiplied by the number of facilities represented by each model farm and summed to obtain a total cost for Option 6 for the entire industry. EPA estimates that the total industry cost for the implementation of anaerobic digester systems at Large Dairy farms under Regulatory Option 6 will be $511 million with energy recovery and $619 million without energy recovery.

8.6.2.2 Anaerobic Digestion for Pathogen Reduction at Large Swine Operations

EPA calculated an anaerobic digester option for swine assuming no (zero) energy recovery or sales to represent a potential upper bound cost of this option. This scenario assumes the installation of a flare instead of the generator and therefore no energy recovery. (EPA Docket OW-2005-0037, DCN 1-02001)

EPA used FarmWare v.2 to calculate anaerobic digestion costs for model farm Large swine operations from the 2003 final CAFO rule (68 FR 7243). These model farms were run in FarmWare with the following assumptions and modifications:

- Used Sampson County, North Carolina as the representative MidAtlantic farm, Blue Earth, Minnesota as the Midwest farm, and Beaver County, Utah as the Central farm.

- Assumed "flush everything" as the existing manure management system for liquid manure and evaporative ponds and "Pull Plug or Cascade Dam" for pit.

- Reduced flush water to twice per day (33 percent reduction in flush water use)

- Precipitation is diverted away from the digester, no runoff from lot areas is generated, and direct precipitation into the open (uncovered) effluent storage lagoon is captured

- Used model default of $.06 per kWh (1999 U.S. average of 4.5 cents industrial use, 7.43 cents commercial, and 8.27 cents residential)

- Engineering costs of $25 thousand (FarmWare model default) was used for grow-finish facilities. Engineering costs for farrow-to-finish operations were increased to $40 thousand to account for the increased complexity of the site that could affect digester construction and design (such as multiple confinement buildings, different building designs for each stage of animal, different waste generation rates and manure composition at each site)

- Deep pit housing systems do not have a storage lagoon, so additional capital costs on the order of $30-50 thousand are incurred to construct an effluent holding structure, for an additional estimated $4,500 annual expense

- Digester Cover Material: High Durability was selected in the FarmWare pulldown menu

- Generator cost was oversized by 10 KW, for an additional cost of $10,500 per CAFO (Farmware cost of generator is $1,050/KW) (See Cost report for the basis for this design)

- Capital costs include a contingency factor of 5 percent to reflect site specific variations of the assumed digester design described above

See Table 5.13.3-1 of the Cost Report for additional information. The results are presented in Table 8-35.

Table 8-35. Digester Cost per Swine with Generator and Energy Recovery

Manure Type	Operation Type	Region	Total Cost ($ per head)	Annual Cost ($ per head)
Pit	GF	MA	47.99	(4.81)
Pit	GF	MW	55.10	(4.21)
Pit	FF	MA	47.79	(1.61)
Pit	FF	MW	53.36	(1.70)
Liquid	GF	MA	41.04	(4.77)
Liquid	GF	MW	51.77	(4.20)
Liquid	FF	MA	40.30	(1.62)
Liquid	FF	MW	48.63	(1.71)
Evaporative	GF	CE	40.20	(4.47)
Evaporative	FF	CE	39.18	(2.00)

These results were re-evaluated assuming no energy recovery and including a flare ($2,500 per CAFO; see Cost Report) instead of a generator. The results of this analysis are presented in Table 8-36. Costs include the compliance costs from Option 2 for land application, recordkeeping, reporting, and other costs incurred as a result of the 2003 rule. Cost offsets for energy recovery can be readily determined by comparing the costs presented in Tables 8-35 and 8-36.

Table 8-36. Digester Cost per Swine without Generator or Energy Recovery

Manure Type	Operation Type	Region	Total Cost ($ per head)	Annual Cost ($ per head)
Pit	GF	MA	31.28	1.71
Pit	GF	MW	38.64	1.50
Pit	FF	MA	33.38	1.36
Pit	FF	MW	39.13	1.21
Liquid	GF	MA	24.42	1.69
Liquid	GF	MW	35.34	1.50
Liquid	FF	MA	25.95	1.35
Liquid	FF	MW	34.42	1.21
Evaporative	GF	CE	24.53	1.19
Evaporative	FF	CE	25.69	0.90

The next step was to estimate the total cost under Option 6 for the new scenario (no energy recovery and a flare) by multiplying model farm costs by the number of farms. Table 8-37 shows a summary of the results and Appendix A has the detailed model farm results. These costs include consultation fees for dairies (as described in EPA Docket OW-2005-0037, DCN 1-01128).

Table 8-37. Summary of Results for the Modified Option 6 for Swine

Animal	Type Manure Type	Operation Type	Capital	Annual	Fixed	3-Year Recurring	5-Year Recurring
Chic	Liquid	LW	$13,973,304	$1,463,489	$138,625	$21,729	$90,529
Chic	Solid	BR	$84,021,646	$3,406,773	$1,864,429	$71,074	$958,713
Chic	Solid	LA	$32,320,857	$1,896,668	$324,297	$46,202	$219,660
Swine	Evapor	FF	$31,883,745	$1,801,689	$128,481	$8,947	$79,291
Swine	Evapor	GF	$31,241,133	$2,215,633	$131,848	$9,180	$81,339
Swine	Liquid	FF	$213,681,593	$14,002,802	$821,738	$72,010	$6,479,157
Swine	Liquid	GF	$159,459,230	$12,421,397	$605,426	$54,106	$5,023,542
Swine	Pit	FF	$206,321,208	$23,085,413	$829,828	$66,532	$552,418
Swine	Pit	GF	$270,568,974	$34,886,081	$1,091,786	$88,524	$724,830
Turk	Solid	SL	$30,569,896	$2,767,751	$783,724	$33,539	$556,494

Note: Values in the highlighted cells were forced to be the same as Option 2.

8.6.2.3 Lime Addition to Dairy Manure

Lime treatment increases both the pH and temperature of CAFO wastes, resulting in a decrease in pathogenic microorganism numbers, while converting a portion of the soluble phosphorous in the waste stream to an insoluble calcium phosphate. Section 8.6.2.3 provides a description of two model dairy CAFOs with different manure removal methods (flush and scrape). These two models have different volumes of wastes (manure, wash water, flush water, runoff, etc) that are used to size and cost a lime disinfection system. For each model farm, this section provides a description of the necessary lime treatment system equipment, and the costs for each of the major lime disinfection system components.

Model Dairy CAFO Description

EPA developed two model farms to represent Large dairy operations in the United States: a flush dairy and a scrape dairy. The Large dairy lime disinfection models are assumed to be in the Midwest, since this region receives an average amount of rainfall as compared to other regions of the United States. Using an area of the country with average rainfall allows for a moderately sized reaction tank because the tank is sized to allow for manure and runoff from rainfall. Also, the soils in the Midwest area have typical curve numbers. This means that the soils have an average runoff potential which also allows for a moderately sized reaction tank.

EPA's Large Dairy model farm has 1,430 milk cows assumed to be housed in three free-stall barns. The model dairies are assumed to have a hospital barn, a milking parlor, and an earthen dry lot for heifers and calves. For one model dairy, EPA assumed the free-stall barn alleys are flushed three times per day. For another model dairy, EPA assumed the free-stall barn and alleys are scraped three times per day. Sawdust is used for bedding in the barns. Feed is brought into the barns and spread along a center drive-through alley. For milking, the herd is moved from the barn or dry lot into a covered holding area where they are washed, then into the milking parlor, and back out into the barn or lot three times each day.

For the dairy with a flush system, EPA estimated wastewater is generated at a rate of 130 gallons per day per cow1. EPA assumed that all flush water from the free-stall barns, parlor, and staging areas is discharged to a liquid lime treatment system.

For the scrape system, only wash water from the parlor is discharged to the liquid lime treatment system. EPA estimated wastewater generation in the parlor to be 0.96 gallons per day per cow. Only 15 percent of the total daily manure generation from the scraped dairy enters the liquid lime system. The remainder of manure is collected and stockpiled during scraping. Stockpiled manure is treated through a pug-mill with solid lime.

EPA also assumed that runoff from the dry lots and free-stall barn areas for both the flush dairy and scrape dairy enter the liquid lime treatment system for disinfection. To estimate the amount of runoff that will be treated by the liquid lime treatment system at both the flush and scrape dairies, EPA used data contained in Table 4.7.3-2 of the CAFO Cost Report. Table 4.7.3-2 includes runoff amounts by model farm and by region. According to this table, the runoff volume from a Large Midwest dairy from a 25-year, 24-hour storm event is 111,004 ft3 (830,300 gallons). Therefore, the lime treatment systems must be sized to handle 830,300 gallons of runoff per day, plus manure, flush water (flush system), parlor water, and any wash waters.

Table 8-38 shows the number of head selected for each model dairy, estimated manure and nutrient generation, and the estimated amount of runoff that will be captured and treated by the lime disinfection system.

Table 8-38. Model Dairy Waste Generation and Precipitation Collection

Model Dairy CAFO Design	Flush System	Scrape System
Lactating dairy cows (a)	1,430	1,430
Heifers (a)	429	429
Calves (a)	429	429
Dairy cow manure generation (lbs/day as excreted)	161,200	161,200
Flush water and wash water volume (gal/day) (a)	186,400	1,373
Ammonia nitrogen generation (lbs/day) (b)	837	837
Phosphorous generation (lbs/day) (b)	130	130
Captured runoff volume (gal/day)	830,300	830,300

(a) Cost Report
(b) TDD

Lime Disinfection System Description

The lime disinfection systems requires a quick-lime (calcium oxide) storage and slaking system, a reaction tank to allow for contact between the lime and liquid CAFO waste, a pug mill for contact between scraped manure and lime (scrape dairy only) and a scrubber system to capture gaseous ammonia emissions from the liquid reaction tank. Figure 8-1 is a conceptual diagram showing the primary pieces of equipment included in the lime disinfection system for a flush dairy. Figure 8-2 is a conceptual diagram showing the primary pieces of equipment included in the lime disinfection system for a scrape dairy. For all the flush dairy waste, and the parlor waste from the scrape dairy, the conceptual design assumes that quick lime is diluted in water to approximately a 12 percent (w/w) slurry and metered into the dairy waste using a pH meter and controller to raise the pH to approximately 10. The dairy waste/lime mixture is agitated to promote mixing, and is held in the reaction tank for approximately 8 hours. For both the model farms (flush and scrape), EPA estimated the lime slurry addition to the liquid treatment tank to be 0.5 lbs per pound of manure solids (Eric Males, EPA Docket OW-2002-0025, DCN 40267). Dry lime addition to the pug mill is also based on 0.5 lbs per pound of manure solids. Table 8-39 shows the design parameters for the lime disinfection systems.

Table 8-39. Lime Disinfection System Design Parameters

Design Parameter	Flush System	Scrape System
Lime disinfection tank volume (ft^3)	92,100	61,900
Lime disinfection tank shape	Square	Square
Lime disinfection tank materials	In-ground, epoxy-coated, concrete, covered with vent to scrubber	In-ground, epoxy-coated, concrete, covered with vent to scrubber
Lime disinfection tank depth (ft)	14	14
Lime disinfection tank width and length (ft)	107	88
Pug mill size (tons/hour)	NA	80
Pug mill and manure pad size (sq feet)	NA	1,280
Lime requirements (lbs/day) Liquid system Pug mill scrape manure	 9,700 NA	 1,570 8,130
Tank head space blower size (cfm)	100	100
Manure pump/agitator size (HP)	50	50
Number of manure pump/agitator assemblies	12	8
Lime-manure pump out rate at max flow (gpm)	18,000	12,000

NA: Not applicable for flush dairy model farm

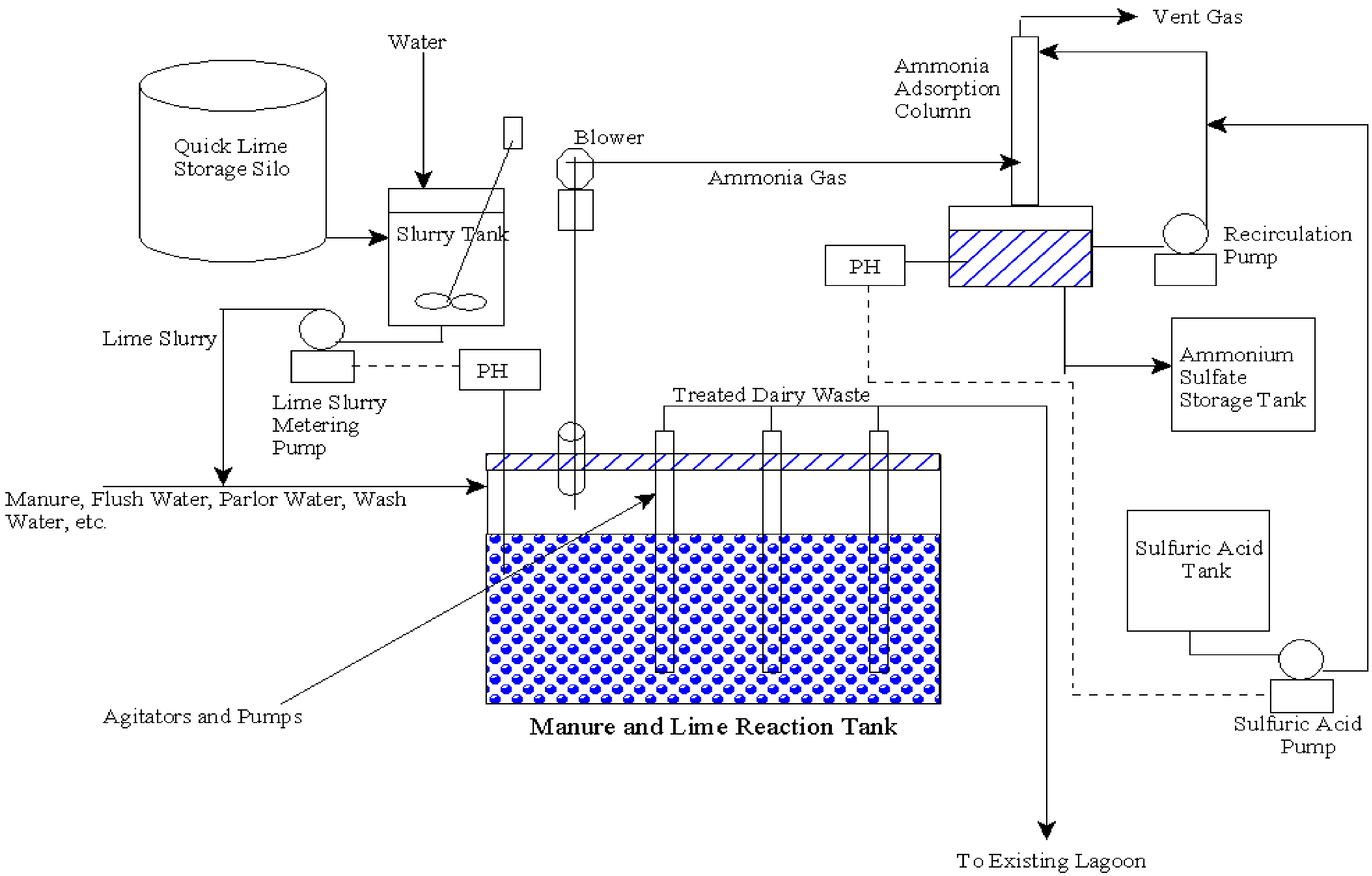

Figure 8-16. Diagram of a Flush Dairy Lime Disinfection System

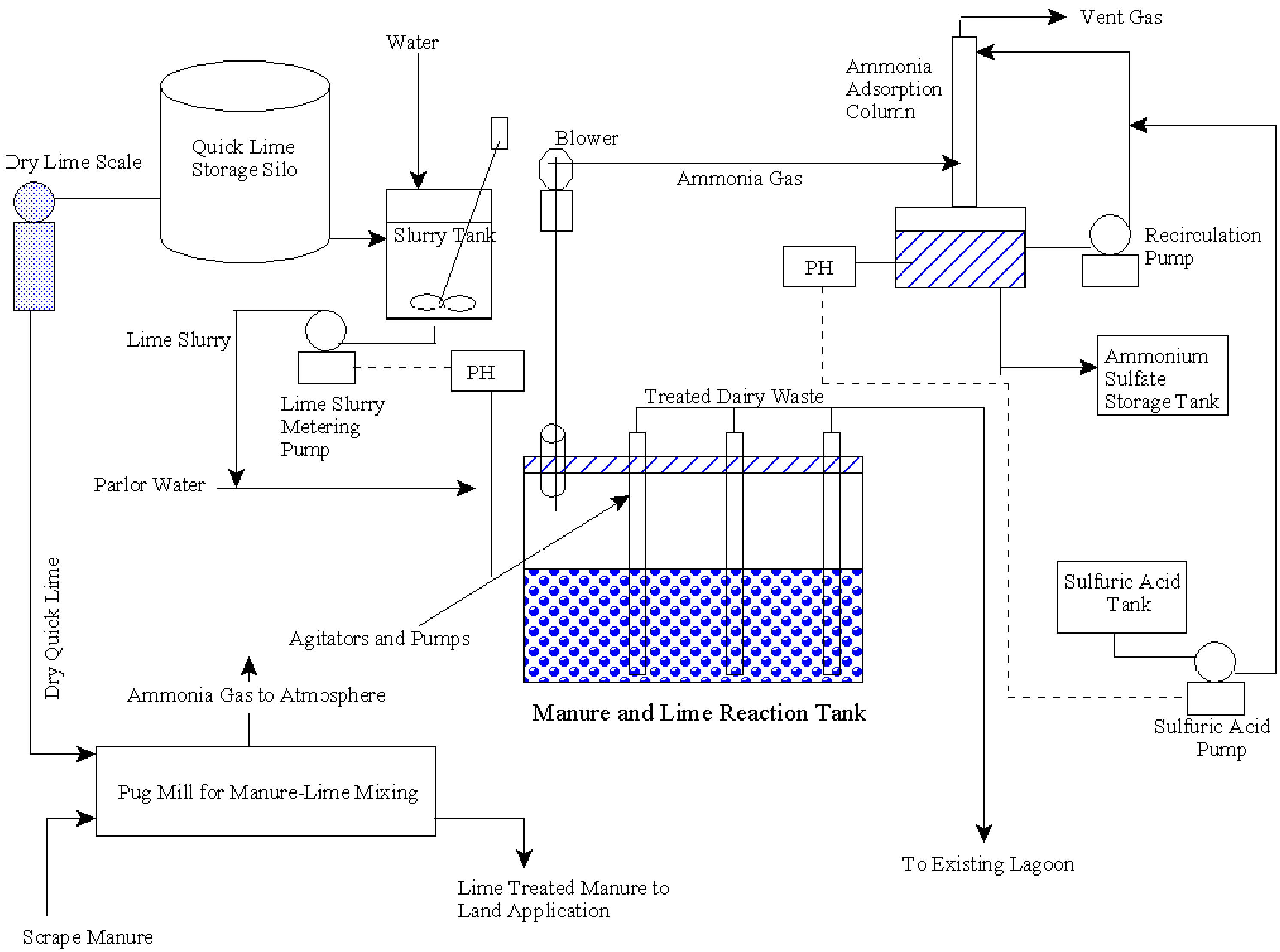

Figure 8-17. Diagram of a Scrape Dairy Lime Disinfection System

To size the liquid lime disinfection tanks, EPA assumed that two-thirds of the tank volume would be removed during each batch, leaving one-third of the tank contents (manure plus residual lime) to react with the incoming raw waste. EPA also sized the manure pump and agitator assemblies to transfer the contents of the lime disinfection tank to an existing on-site lagoon in 30 minutes. Vendor information on the pumping and agitation units is provided in the CAFO record (EPA Docket OW-2005-0037, DCN 1-01218). Addition of lime to the dairy waste will generate heat (up to 70°C) that will aid in the disinfection process. To maintain the temperature of the disinfection tank during winter months, EPA assumed the tank was in-ground. The size of the pug mill needed to mix lime and scraped manure is based on the amount of manure collected in the free-stall barn and yard areas. Vendor information on the pug mill is also included in the CAFO record (EPA Docket OW-2005-0037, DCN 1-01205).

Another important unit process associated with the lime disinfection system is the bulk quick-lime storage and slaking system. For the quick-lime storage silo sizing requirements, EPA assumed 7 days of bulk lime storage. EPA notes in remote locations or locations subject to extended periods of heavy snow, this storage period may be inadequate and the costs may therefore be understated. The liquid disinfection systems operate by metering dry quick-lime into a 2,000-gallon mixed slurry tank and diluting with water to generate a 12 percent (w/w) lime slurry that is then metered into the manure disinfection tank. The pug mill system used for scraped manure operates by metering (by weight) dry quick-lime from the storage silo to the pug mill for contact with manure. Table 8-40 shows the design parameters used to size and cost the lime storage and slaking system.

Table 8-40. Lime Storage and Slaking System Design Parameters

Design Parameter	Flush System	Scrape System
Dry Lime storage capacity (ft^3)	1,100	1,100
Lime storage capacity (days)	7	7
Lime slurry tank volume (gal)	2,000	500
Lime slurry concentration (%)	12	12
Lime slurry tank mixer size (HP)	1.3	0.5
Lime slurry metering pump size (HP)	0.5	0.5
Number of lime slurry metering pumps	3	2

The disinfection tank is covered to prevent the loss of gaseous ammonia due to the increase in pH when quick lime is added. Literature information indicates between 10 and 40 percent of the ammonia nitrogen in manure is converted to gaseous ammonia when lime is added during disinfection. For the model dairy CAFOs, EPA assumed 25 percent of the ammonia nitrogen in the raw dairy waste entering the liquid manure disinfection tank is converted to gaseous ammonia nitrogen and is transferred from the head-space above the disinfection tank to a wet scrubber using a 100 cfm blower. For the pug mill system used for scraped manure, gaseous ammonia emissions are uncontrolled.

The wet scrubber selected for the flush and scrape dairy conceptual design is a pre-fabricated system that allows for counter-current contact between the ammonia rich gas and a dilute sulfuric acid liquid stream. Information on the ammonia scrubber requirements were provided by the scrubber vendor, Advanced Air Technologies (EPA Docket OW-2005-0037, DCN 1-01219). The ammonia scrubber converts gaseous ammonia to a concentrated ammonium sulfate solution that can be used as on-site fertilizer. Table 8-41 shows the design parameters for the ammonia scrubber systems.

Table 8-41. Ammonia Scrubber System Design Parameters

Design Parameters	Flush System	Scrape System
Gas flow rate (cfm)	100	100
Scrubber column height (feet)	9.2	9.2
Scrubber column diameter (inches)	13.5	13.5
Scrubber water flow rate (gpm)	3	3
Daily ammonia nitrogen load to scrubber (lbs/day)	170	26
Sulfuric acid requirement (lbs/day)	600	80
Ammonium sulfate production (lbs/day)	800	100
Ammonium sulfate solution concentration (%)	43	43
Ammonium sulfate solution storage tank (gal)	500	100

In addition to the ammonia scrubber, a concentrated sulfuric acid (98 percent w/w) storage and delivery system is required. For the flush dairy, the sulfuric acid storage system includes a 2,500-gallon fiberglass tank with secondary containment, two corrosion resistant metering pumps, a pH meter/controller, and corrosion resistant piping to transfer the concentrated acid from the storage tank to the ammonia scrubbers liquid recycle system. For the scrape dairy, the sulfuric acid storage system requires only a 150-gallon acid storage tank and a 100-gallon ammonium sulfate solution storage tank due to smaller amount of manure and ammonia nitrogen entering the liquid system.

<u>Lime Treatment System Costs</u>

EPA estimated installed capital, operating and maintenance (O&M), and annualized costs (2001$) for the model flush and scrape dairy CAFOs described above. Installed capital costs were estimated by applying design factors for items such as plumbing and electrical to equipment purchased costs and published cost data for specific construction activities (EPA Docket OW-2005-0037, DCN 1-01206). O&M costs were estimated based on published chemical cost data and from electrical requirements for motors associated with pumps and mixers used in the disinfection system (EPA Docket OW-2005-0037, DCNs 1-01207, 1-01209, 1-01221, and 1-01016A1) Labor requirements (hours per year) for the system were based on engineering judgment.

The annualized cost (capital and O&M) for the flush dairy lime disinfection system is approximately $335,300 per year based on an 11-year depreciation schedule and a 7 percent interest rate (2001$). Annualized costs for the scrape dairy CAFO is approximately $343,000 per year (2001$). Detailed costs for both capital and O&M items are described below.

Capital Cost Estimate

Capital costs for the lime disinfection system at the model dairy CAFO are summarized in Table 8-42. EPA estimated the total installed capital cost for the flush dairy lime disinfection system to be approximately $1,046,000 (2001$). EPA estimated the total installed capital costs for the scrape dairy lime disinfection system to be approximately $925,000 (2001$). Costs do not include engineering or contingency since these costs are highly variable and site-specific.

Table 8-42. Estimated Capital Cost for Lime Disinfection of Dairy Waste

Equipment	Flush System Capital Cost (2001 $)	Scrape System Capital Cost (2001$)
Quick lime storage and delivery system	$129,000	$129,000
Corrosion resistant lime disinfection tank and associated pumps, mixers, and controllers.	$851,000	$604,000
Pug mill system for contact of scraped manure with quick lime	NA	$142,000
Ammonia scrubber/ammonium sulfate generation system.	$43,000	$38,000
Concentrated sulfuric acid delivery and containment system	$23,000	$12,000
Total capital cost:	**$1,046,000**	**$925,000**

Annual Operating and Maintenance Costs

Annual operating and maintenance (O&M) costs for the lime disinfection systems at the model dairy CAFOs are summarized in Table 8-43. EPA estimated the annual O&M costs for the flush dairy to be $227,200 (2001$) and have included a cost credit for the value of ammonium sulfate generated by the capture and scrubbing of ammonia from the lime disinfection system. Estimated annual O&M costs for the scrape dairy are estimated to be $252,300. Electrical costs for both systems have been adjusted to account for periods when no precipitation is being treated in the liquid lime treatment tank. Annual O&M costs for the scrape dairy are higher than the flush system due to the added labor needed to operate the pug mill system, and the lower amount of recoverable ammonium sulfate due to the loss of ammonia in the pug mill.

Table 8-43. Estimated Annual O&M Cost for Lime Disinfection of Dairy Waste

O&M Item	Flush System Annual O&M Cost (2001 $/yr)	Scrape Annual O&M Cost (2001 $)
Chemicals		
Lime	$192,000	$192,000
Sulfuric Acid	$8,300	$1,300
Ammonium Sulfate	($28,000)	($4,000)
Electrical	$38,000	$32,000
Labor	$16,900	$31,500
Total annual O&M:	**$227,200/yr**	**$252,300/yr**

Lime Treatment System Conclusions

The annual costs for the flush and scrape model dairy lime disinfection systems are approximately $335,300 per year and $343,000 per year, respectively. This cost estimate is based only on the equipment, electricity, chemical, and labor costs; this estimate does not include the cost of solids separation and is in addition to the costs associated with nutrient management planning, land application costs, and other best management practices.

To appropriately extrapolate the model lime disinfection system cost to the entire dairy industry, EPA would need to estimate the additional costs associated with solids separation and the costs that would be required for each model dairy to meet BPT. However, a rough estimate of the minimum dairy industry costs for lime disinfection can be calculated by multiplying the model system cost by the number of dairies in the Large category using either a flush or scrape system. Table 8-44 shows the estimated cost for the entire industry. The numbers of Large dairy farms by region were determined from the Cost Report. This calculation produces an estimate of $489,359,000. Even without taking into account the additional costs of solids separation and BPT requirements, the cost for lime disinfection is more expensive than any other regulatory option for dairy (other option costs are presented in Section 15.2.3).

Because of the extremely high costs associated with lime disinfection, EPA does not consider this technology to be a viable option. As stated in Section 8.6.2.3, costs do not include engineering and contingency, and lime storage costs may be understated for many locations. Less expensive technologies can potentially reduce FC by 99 percent. Therefore, even though this technology could remove an estimated 99 percent of FC, the high cost renders the FC pollution reductions irrelevant. Accordingly, FC loads for this technology option were not calculated.

Table 8-44. Estimated Industry Cost for Lime Disinfection

Region	Number of Large Dairies	Percent Flush	Percent Scrape	Flush Dairy Annualized Cost (2001$)	Scrape System Annualized Cost (2001$)
Central	401	75	25	$100,841,000	$34,386,000
Mid-Atlantic	104	50	50	$17,436,000	$17,836,000
Midwest	95	50	50	$15,927,000	$16,292,000
Pacific	759	75	25	$190,870,000	$65,084,000
South	91	75	25	$22,884,000	$7,803,000
Totals:	**1,450**			**$347,958,000**	**$141,401,000**

8.6.2.4 Composting of Poultry Manure or Litter

EPA investigated the technical applicability and costs for composting of poultry manure or litter. Section 8.6.2.4 describes the methodology and resources used to calculate costs for applying composting technology to poultry operations.

Figures 8-3 and 8-4 present the components of poultry composting systems for wet layers and other poultry operations. EPA used a step-wise process to calculate composting costs for the poultry industry.

1. Estimate poultry manure/litter composting costs using the Methodology for Estimating the Costs of Composting Swine and Poultry Manure (referred to as the Poultry Composting Report, EPA Docket OW-2002-0025, DCN 120039)

2. Add costs for storage ponds to collect runoff from the composting area at broiler, dry layer, and turkey operations. Add costs for solids separation technology at wet layer operations.

3. Apply the dollar per bird composting costs (including storage ponds and solids separation) from the Poultry Composting Report to the model farms developed for the CAFO rulemaking process.

4. Add irrigation costs to apply pond water to land application areas.

5. Sum CAFO model farm costs to calculate a total industry cost for a poultry composting option.

These steps and the resulting costs are explained in detail in the remainder of Section 8.6.2.4.

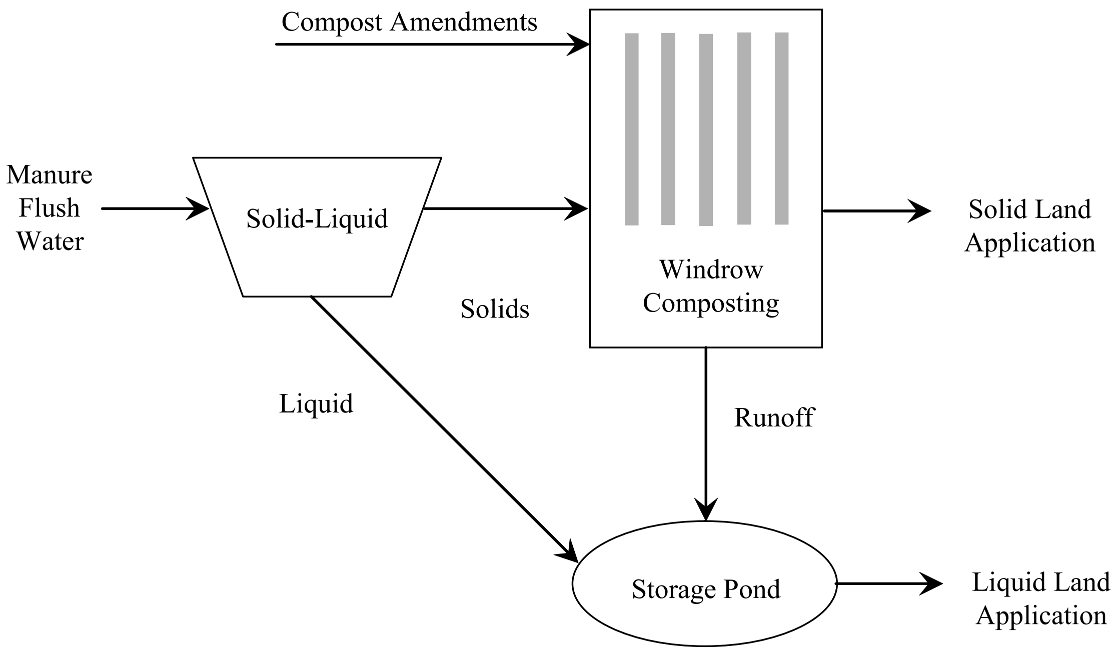

Figure 8-18. Poultry Composting System for Wet Layers

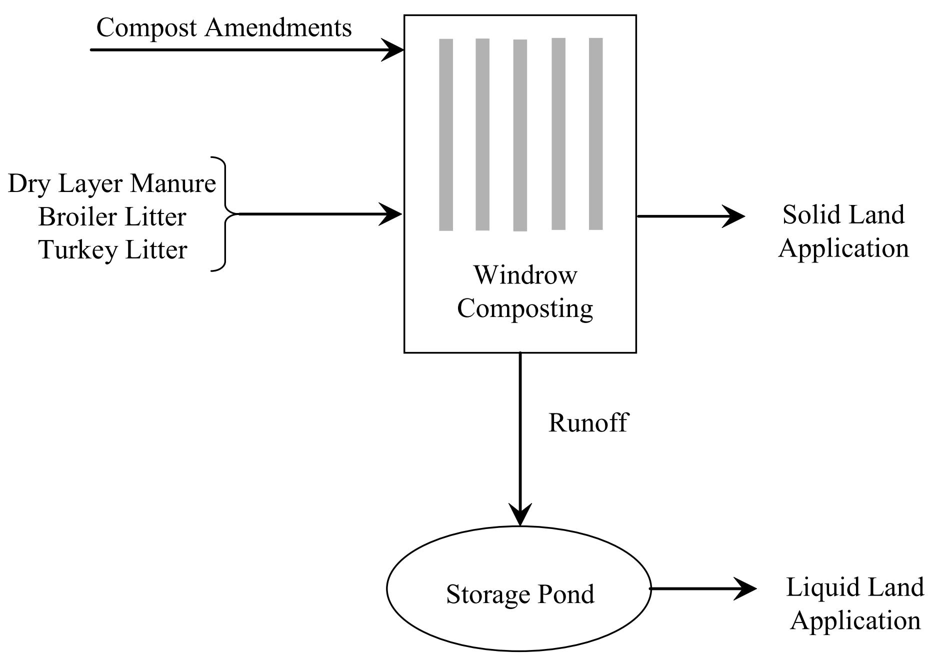

Figure 8-19. Poultry Composting System for Dry Layers, Broilers, and Turkeys

<u>Poultry Composting Report Model Farms and Composting Costs</u>

The Poultry Composting Report presents the model poultry farms and calculated costs for composting at each model farm. The report presents windrow composting costs in dollars

(1997$) per ton of manure/litter for model farms with wet and dry layers, broilers, and turkeys, using two different types of compost amendments. The characteristics of these model farms are specific to the Poultry Composting Report and are different from the model farm characteristics developed for the final CAFO rule and presented in the Cost Report. This change was necessary to more accurately reflect the costs of composting to various types of poultry facilities. (See the "Application of Table 8-47 Costs to Model Farms Developed for the CAFO Rule
" section below for a description of how these two sets of model farms are correlated.) The total cost for each model farm in the Poultry Composting Report includes the following components:

- Planning;
- Compost amendments (including water);
- Land rental for the composting area;
- Equipment for windrow turning (capital and operation & maintenance) and compost monitoring; and
- Labor for windrow turning and monitoring (temperature and moisture content).

Costs for solids separation of liquid waste, storage ponds to collect runoff from the composting areas, or irrigation from the storage ponds are not included in this step. Revenue from compost sales are presented in Section 8.6.2.4. Table 8-45 summarizes the model farm characteristics and final composting costs from the Poultry Composting Report.

Table 8-45. Model Farms and Costs Presented in the Poultry Composting Report

Sector	Region	Number of Birds	Annual Manure Production per Model Farm (tons)	Compost Amendments	Windrow Area (acres)	Total Annualized Cost (1997$/ton manure)
Layer: Wet	South	3,654	149	Wheat straw & Sawdust	0.0928	$36.51
Layer: Wet Sawdust	South	3,654	149	Sawdust	0.0715	$18.63
Layer: Dry	South	884,291	6,838	Wheat straw	24.0815	$229.79
Layer: Dry Sawdust	South	884,291	6,838	Sawdust	11.1950	$49.30
Broiler	Mid-Atlantic	36,796	587	Wheat straw	1.0045	$91.65
Broiler Sawdust	Mid-Atlantic	36,796	587	Sawdust	0.5306	$19.81
Turkey	Mid-West	158,365	9,691	Wheat straw	10.7043	$46.34
Turkey Sawdust	Mid-West	158,365	9,691	Sawdust	7.1424	$11.05

The total annualized costs in Table 8-45 provide the starting point for EPA's other cost calculations, which incorporate additional costs for runoff storage ponds, solid-liquid separation of manure, and irrigation into a $/bird poultry composting cost.

Runoff Storage Pond Costs

For dry layer, broiler, and turkey model farms, where poultry waste is handled as a dry substance, EPA added the cost of storage ponds to collect runoff from the composting area. The process described in Chapter 5.5 of the Cost Report was used to calculate the cost of storage ponds. The storage pond calculations from the Cost Report were originally developed for beef feedlot runoff, so EPA modified some elements to reflect poultry composting runoff as described below.

First, EPA determined the necessary pond volume using the following equation.

Pond Volume = Sludge Volume + Runoff (normal and peak) + Net Precipitation + Design Storm + Freeboard

Where:

- Sludge Volume: The sludge volume calculation uses an animal-specific sludge accumulation ratio to determine sludge volume. However, the Cost Report only presented this ratio for beef cattle. EPA consulted the USDA *Agricultural Waste Management Field Handbook* to identify sludge accumulation ratios for layers and broilers. Sludge accumulation ratios for layers and broilers are 0.0295 and 0.455 cubic feet per pound, respectively. The sludge accumulation ratio for turkeys was assumed to be the same as broilers, since both use a litter-based manure management system.

- Runoff: The amount of runoff entering the pond is determined from the net precipitation, composting area size, and number of days of storage. Runoff estimates reflect precipitation values for each region using the same climate data used for beef cattle model farms. Peak precipitation represents a 25-year 24-hour storm. The composting area size for each model farm is provided in the Poultry Composting Report, and Option 5A requires 180 days of storage capacity. The runoff contribution to the pond is reduced by the amount of water retained by the solids that settle out in the basin. For the purposes of estimating solids entering the runoff pond, EPA assumed that poultry compost runoff and settling in storage ponds would have similar characteristics to beef feedlot runoff and settling. Therefore, EPA used a value of 1.5 percent solids in runoff, while the solids entering the pond are 50 percent of the basin solids.

- Net Precipitation and Design Storm: The pond depth is increased to allow for direct net precipitation (average precipitation minus average evaporation) plus the design storm (24-hour, 25-year storm). Again, regional climate data corresponding to beef cattle model farms for the same location was used.

- Freeboard: A minimum of 1 foot of freeboard is added to the depth.

After determining an appropriate volume for the storage pond, EPA used equations from the Cost Report to calculate the best-fit dimensions for ponds at each model farm based on the required volume. Because the storage pond volumes for poultry operations are smaller than the beef feedlots described in Chapter 5.5 of the Cost Report, EPA used an initial pond depth of 9 feet (instead of 10 feet, recommended in the Cost Report), and a final pond depth of 10 feet when calculating pond dimensions. EPA also assumed that embankments surround the ponds would be the same size as berms that surround feedlots, 6 feet wide at the base and 3 feet tall.

Next, EPA calculated the pond surface area and excavation and embankment volumes. Using these data, along with equations and unit cost data from Table 5.5.3-1 in the Cost Report, EPA calculated capital and annual costs for constructing storage ponds.

$$\text{Capital Cost} = \text{Mobilization} + \text{Excavation} + \text{Compaction} + \text{Conveyance}$$

$$\text{Annual Cost} = 5\% \times \text{Capital Cost}$$

EPA annualized these costs, using the 11-year, 7 percent amortization rate from the Cost Report. EPA then calculated the $/ton manure cost by dividing the annualized cost by the annual tons of manure at each model farm (from Table 8-45). Table 8-46 presents these storage pond costs.

Table 8-46. Storage Pond Volume and Costs

Sector	Total Pond Volume (cu ft)	Capital Cost	Operation & Maintenance	Annualized Cost (1997$)	$/ton manure
Layer: Dry	1,962,953	$481,136	$23,675	$81,415	$11.91
Layer: Dry Sawdust	919,073	$229,879	$11,112	$38,718	$5.66
Broiler	91,554	$30,357	$1,136	$4,812	$8.20
Broiler Sawdust	49,726	$20,219	$629	$3,090	$5.26
Turkey	551,652	$141,375	$6,687	$23,678	$2.44
Turkey Sawdust	369,221	$97,400	$4,488	$16,205	$1.67

Solid-Liquid Separation Costs for Wet Layer Waste

Liquid manure from wet layer operations has a moisture content of 75 percent. In comparison, the respective moisture contents of dry layer manure, broiler litter, and turkey litter are 40 percent, 25 percent, and 35 percent (Poultry Composting Report, p. 6). Solid-liquid separation must be performed on wet layer waste before it can be composted.

EPA used the process described in Chapter 5.7 of the Cost Report to calculate the cost of installing and operating screen solid-liquid separation equipment at wet layer operations. The solids content of separated solids is assumed to be 23 percent and the separation efficiency is assumed to be 30 percent (based on Poultry Composting Report). Capital costs are determined by the following equation, and annual costs are estimated to be 2 percent of the capital costs.

$$\text{Separation Capital Cost} = (\text{Solids volume generated over 6 months} \times \text{safety factor} \times \text{Storage tank cost}) + \text{Separator device} + (\text{Pipe length} \times \text{Pipe cost}) + (\text{Installation labor} \times \text{Labor rate})$$

EPA calculated the solids volume generated over a 6-month period using the following equation.

$$\text{6-mo. Solids Volume} = \frac{(\text{Annual manure generation [gallons]} \times \text{\% Solids in manure} \times \text{\% Efficiency of separation})}{2}$$

EPA calculated capital and annual operation and maintenance (O&M) costs for wet layers, then annualized the costs. The resulting annualized cost for solid-liquid separation at wet layer model farms is $4,117 (regardless of compost amendment type). EPA calculated the $/ton manure cost by dividing the annualized cost by the annual tons of manure at each model farm (from Table 8-45). The solid-liquid separation cost is $27.58 per ton of manure.

Composting Costs Including Storage Ponds and Solids Separation

EPA added the $/ton manure storage pond or solids separation costs from Table 8-46 to the $/ton manure composting cost at model farms presented in Table 8-45. Costs were converted from 1997$ to 2001$ using *RS Means* Historical Cost Indices so they can be compared or added to other estimated industry costs. EPA calculated $/bird composting costs from the $/ton manure costs using data from Table 8-45 in the following equation.

$$\text{Annual Cost per Bird} = \text{Cost of Composting with Pond/Solid Sep.} \times \frac{\text{Annual Manure Production}}{\text{\# Birds}}$$

Based on the Poultry Composting Report, EPA assumed that both types of compost amendments (wheat stalks and sawdust) are equally available, and farmers would choose the least expensive amendment option. The least expensive compost amendment option for all poultry types is sawdust, so EPA selected the sawdust option to represent the layer, broiler, and turkey sector composting costs. Table 8-47 presents the $/ton manure and $/bird composting cost data.

Table 8-47. Poultry Composting Costs Including Storage Ponds and Solids Separation

Sector	Composting Cost from Table 8-45 ($/ton)	Annual Cost of Pond or Solids Sep. per Ton Manure ($/ton)	Total Cost of Composting with Pond or Solids Sep. (1997$/ton)	Total Cost of Composting with Pond or Solids Sep. (2001$/ton)	Total Cost of Composting with Pond or Solids Sep. (2001$/bird)
Layer: Wet Sawdust	$18.63	$27.58	$46.21	$49.89	$2.04
Layer: Dry Sawdust	$49.30	$5.66	$54.96	$59.35	$0.46
Broiler Sawdust	$19.81	$5.26	$25.07	$27.07	$0.43
Turkey Sawdust	$11.05	$1.67	$12.72	$13.74	$0.84

Application of Table 8-47 Costs to Model Farms Developed for the CAFO Rule

The poultry composting costs presented through Table 8-47 have been based on the model farms described in the Poultry Composting Report. The $/bird costs from these four model farms used in the Poultry Composting Report need to be correlated and applied to the ninety-nine “Large” poultry model farms that were the basis for the final CAFO rule.

EPA matched model farms from the Poultry Composting Report to the CAFO Cost Report model farms by animal type and operation. Then, EPA multiplied Table 8-47$/bird costs by the number of animals at “Large1” and “Large2” model farms to estimate a composting cost for each model farm. Table 8-48 presents these poultry composting costs for CAFO Cost Report model farms.

Irrigation Costs

Next, EPA calculated capital and annual costs for irrigation systems in all CAFO Cost Report model poultry farms. Irrigation costs were set to zero for wet layer operations where storage ponds and irrigation systems would already be in place. Irrigation costs for dry layers, broilers, and turkeys were calculated using the process described in Chapter 5.8 of the Cost Report. Although Chapter 5.8 describes beef and dairy irrigation costs, no changes were needed to translate the methodology to poultry costs. The only variable used to determine irrigation costs is the total number of irrigated acres.

Using the capital and annual cost equations from Table 5.8.3-1 in the Cost Report, costs for traveling gun irrigation were calculated for model farms with less than 30 acres of cropland and costs for center pivot irrigation were calculated for model farms with greater than 30 acres of cropland. EPA then annualized the irrigation costs and added the irrigation costs to other composting costs at model farms. Appendix B presents the irrigation costs for model farms.

Poultry Composting Industry Cost

EPA summed the model farm costs presented in Table 8-47 to obtain industry-level costs for composting. Table 8-48 presents these composting costs for the poultry industry.

Table 8-48. Poultry Industry Costs for Composting

Operation	# of Large Facilities	Total Cost of Composting (2001$)
Wet Layers	383	$114,220,000
Dry Layers	729	$137,260,000
Broilers	1,632	$166,540,0000
Turkeys	388	$48,610,000
ALL	**3,132**	**$466,600,000**

The costs in Table 8-48 represent only the composting portion (plus irrigation) for CAFO Regulatory Option 5A. To calculate the entire cost of Option 5A for the poultry industry, these additional costs must be added:

- Production area and land application best management practices;
- Mortality-handling requirements;
- Nutrient management planning and recordkeeping; and
- Transport of manure or litter to other farms.

EPA believes that the poultry industry cost for Option 5A could be estimated by adding the composting costs (from Table 8-48) to Option 2 costs ($41 million, from Table 15-8). However, there is some uncertainty in this estimation. Depending on what components the original Option 2 costs include, there may be double counting or omission of some costs.

Assuming that Option 5A costs can be calculated by adding composting costs and Option 2 costs and there are no cost offsets for compost sale revenue, the total industry cost will be $508 million.

Revenue and Cost Offsets from Compost Sales

A portion of the industry costs for composting could be offset by selling the finished compost product. The Poultry Composting Report estimates revenue from compost sales at each of the model farms. These costs are based on two assumptions: 1) 80 percent volume reduction of the manure and amendments composted, and 2) a compost sale price of $6 per cubic yard. EPA examined these assumptions and found that the compost volume reduction is reasonable, but $6/cubic yard seems to be a low price estimate for poultry compost in today's market. EPA researched current compost prices and determined that a more reasonable price estimate for poultry compost is $20/cubic yard. Table 8-49 presents the data sources that EPA consulted.

Table 8-49. Compost Prices and Data Sources

Compost Sale Price ($/cubic yard)	Type of Compost	Data Source
$30.00	Mix of layer manure and broiler litter	*Biocycle*, Aug. 2001
$30.00	Layer manure	*Biocycle*, Aug. 2001
$25.40	Buffalo chip	Cheyenne Composting Facility
$11.50	Manure	Whatcom County *Manure Compost Marketing Guide*
$10.00	General - bulk	*Biocycle*, Dec. 2004
$15.00	General - bulk	*Biocycle*, Oct. 2004
$6.00 - $15.00	Yard waste	North Carolina Department of Environment and Natural Resources

To estimate compost sale revenues for the poultry CAFO industry, EPA calculated a dollar per bird ($/bird) revenue for wet and dry layer, broiler, and turkey operations using data from the Poultry Composting Report and the price estimate of $20/cubic yard in the following equation:

$$\text{Dollar per Bird Revenue} = \frac{\text{Compost Sale Price per Cubic Yard} \times \text{Cubic Yards of Compost per Model Farm}}{\text{\# Bird per Model Farm}}$$

EPA applied this $/bird value to model farms used in the CAFO rule-making process. The CAFO model farm revenues were summed to determine industry revenue from compost sales. Assuming a price of $20 per cubic yard of compost, the industry revenue from compost sales will be $252,630,000. When this revenue is subtracted from the industry composting costs, the Option 5A cost is $255 million. The sales price of compost may decrease or increase depending on availability of bulking materials and market demand. For example, if all Large poultry CAFOs composted manure, in some areas an influx of compost may flood the market, driving the sales price down or even eliminating the positive dollar value.

Appendix B contains data tables presenting the costs per model farm for poultry composting.

8.6.3 Pollutant Load Calculations

EPA applied the estimated pollutant loads generated for the Options 2, 3 and 5 in 2003 rule to this BCT cost test. For Option 5a, 6 and 7 EPA updated the models' assumptions and recreated (or in some cases generated for the first time) the loads estimations (EPA Docket OW-2005-0037 DCN 1-02000). The updated assumptions for each of the modified options were:

- Option 5A for beef, dairy, and heifer operations has the same elements as Option 2, plus implementation of a drier manure management system (i.e., composting). To estimate the loads from Option 5a it was assumed that the bacteria levels were reduced by 99 percent prior to land application. In addition, the loads from the overflows were reduced by the efficiencies reported for solids separation in the TDD (BOD: 40%, TS: 57%, TN: 58%, TP: 50%, Bacteria: 57%). Sediment discharges from cropland were assumed to equal those previously estimated for Option 2.

- Option 6 has the same elements as Option 2 plus implementation of anaerobic digestion with energy recovery for the large swine and dairy operations only. (Note heifer operation would not have to install digesters, but they are presented under the general DAIRY category). To estimate the loads from Option 6 it was assumed that the bacteria levels were reduced by 99 percent prior to land application. In addition, the loads from the lagoon overflows were reduced by the efficiencies reported for anaerobic digesters in the TDD (BOD: 85%, TS: 30%, TN: 65%, TP: 85%, Bacteria: 99%). These reductions were applied to large swine and dairy operations only. As noted above there were no changes to the pollutants in the overflows from heifer operations.

- Option 7 has the same elements as Option 2, plus timing restrictions on land application of animal waste to frozen, snow-covered, or saturated ground. To estimate the loads from Option 7 it was assumed that model facilities that incurred costs for additional storage would also eliminate any lagoon overflows. Under Option 7, the costs model had costs for swine facilities in the MA and MW. It was assumed that beef and dairy facilities in the MA and MW would also conservatively eliminate all lagoon overflows under this option.

The models available for simulating pollutant reductions from land application practices (GLEAMS, EPIC, and BASINS) do not measure BOD, and EPA was not able to quantify BOD from land application in the 2003 final CAFO rule. BOD in runoff from land application areas contains BOD from manure and process wastewaters, but it also contains BOD from organic matter including background soil organic materials and crop residues. In contrast to crop residues, degradation of manure BOD is highly sensitive to moisture and aerobic conditions, and quickly forms inorganic materials and nutrients after land application, as evidenced by significant off-gassing (odor) as the manure decomposes immediately following land application (EPA Docket OW-2005-0037, DCN 1-01230). BOD deliveries to surface water are also highly variable, but current literature suggests the timing of land application in relation to future rainfall events is a key parameter.

Since the 2003 CAFO rule, models including WAM (Watershed Assessment Model) and WMM (Watershed Management Model) were developed that have some watershed level BOD modeling capability (for example, see "TMDLs for Nutrient, DO, and BOD for Delaney Creek," March 2005, EPA Docket OW-2005-0037, DCN 1-01222). The data required for the WMM model includes: area of all the land use categories and the area served by septic tanks; percent impervious area of each land category; event mean concentration of runoff (EMC) from land use for each pollutant type and land use category; percent EMC of each pollutant type that is in suspended form; and annual precipitation. The lack of data/literature to support estimation of national BOD loadings from land applied manure is a significant issue. EPA concludes the capability is still not available to more accurately model BOD runoff.

The 2003 CAFO rule prohibits dry weather discharges from land application areas, and EPA further believes the BPT land application requirements (including technical standards for timing, form, and rate of application, as well as the required vegetated buffer, setback, or equivalent practices) already minimize discharges of BOD from land application areas. For all of these reasons, EPA believes the reductions in BOD in runoff from land application areas, specifically the BOD attributable to manure and process wastewater, are minimal in comparison to production area discharges of BOD. Therefore EPA's load reductions for BOD include production area discharges (overflows and runoff from manure storage), but do not include land application.

Runoff of land applied manure was simulated using the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) models EPA developed for the 2003 CAFO rule (See III-19 of Loads Report). GLEAMS is a field-scale model that simulates hydrologic transport, erosion, biochemical processes such as chemical transformation and plant uptake, and nutrient losses in surface runoff, sediment, and groundwater leachate and is described in the Loads Report. The National Water Pollution Control Assessment Model (NWPCAM) is a national surface-water quality model designed to characterize water quality for the nation's network of rivers, streams, and lakes. In the 2003 final CAFO rule analysis, NWPCAM simulations predict that, on average nationwide, 75 percent of FC, 88 percent of BOD, and 79 percent of TSS that reach the edge-of-field will reach surface waters (all calculated at the RF3 level). EPA summed the reduced discharges of conventional pollutants from modeled overflows (See Loads Report for more information) with the land application edge-of-field load analyses (the GLEAMS simulations followed by attenuation in the NWPCAM model) to quantify reductions in conventional pollutant discharges from both the production area and the land application area.

Tables 8-50, 8-51, and 8-52 summarize the pollutant loads data as they were calculated and used for the EPA CAFO rulemaking process and BCT cost test. Appendix C presents additional pollutant loads data.

Table 8-50. Sediment Load Reductions from Large CAFOs in Millions of Pounds per Year

Sector	Option 1	Option 2	Option 3	Option 5a	Option 5	Option 6	Option 7
Cattle	1200.8	1200.8	1200.8	1225.6	N/A	1200.8	1200.9
Dairy	99.3	99.4	99.4	106.6	N/A	108.2	106.7
Swine	0.0	112.8	112.8	N/A	113.4	113.3	113.4
Poultry	31.2	172.4	172.4	172.4	N/A	172.4	172.4
Poultry (wet)	0.0	8.5	8.5	N/A	98.0	8.5	8.5
Total	1331.4	1594.0	1594.0	1504.5	211.4	1603.3	1601.8

Table 8-51. FC Load Reductions from Large CAFOs in 10^{19} Colony Forming Units

Sector	Option 1	Option 2	Option 3	Option 5a	Option 5	Option 6	Option 7
Cattle	10.5	10.6	10.6	260.4	N/A	10.6	11.1
Dairy	1.0	1.0	1.0	31.4	N/A	34.3	23.9
Swine	0.4	0.4	0.4	N/A	137.8	137.4	136.5
Poultry	6.7	6.7	6.7	7.2	N/A	6.7	6.7
Poultry (wet)	0.0	0.0	0.0	N/A	56.5	0.0	0.0
Total	18.7	18.7	18.7	299.0	194.3	189.0	178.2

Table 8-52. BOD Load Reductions from Large CAFOs in Millions of Pounds per Year

Sector	Option 1	Option 2	Option 3	Option 5a	Option 5	Option 6	Option 7
Cattle	0.0	0.0	0.0	2.9	N/A	0.0	0.0
Dairy	0.0	0.0	0.0	1.2	N/A	2.2	1.8
Swine	0.0	0.0	0.0	N/A	7.4	6.3	7.2
Poultry	6.0	6.0	6.0	6.0	N/A	6.0	6.0
Poultry (wet)	0.0	0.0	0.0	N/A	13.3	0.0	0.0
Total	6.0	6.0	6.0	10.1	20.7	14.5	15.0

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Chapter 15

ADDITIONAL ANALYSES IN RESPONSE TO THE 2005 SECOND CIRCUIT COURT DECISION

Chapter 15 presents the additional analyses that EPA performed in response to the 2005 Second Circuit Court decision. EPA reexamined the New Source Performance Standards (NSPS) and developed an alternative BCT cost test for fecal coliform. EPA performed the conventional BCT cost test for BOD and TSS and the alternative fecal coliform cost test for candidate technologies.

15.1 New Source Performance Standards

Section 15.1 presents the information supporting the proposed regulations for NSPS, including the 100-year storm containment structure and superior alternative performance standards.

15.1.1 100-Year Storm Containment Structure

EPA proposed to remove the provision allowing CAFOs to meet the no discharge standard through the use of the 100-year, 24-hour rain event containment structure. Facilities with open manure storage structures may demonstrate the no discharge requirements using site-specific design, construction, operation, and maintenance components and the U.S. Department of Agriculture Natural Resources Conservation Service Animal Waste Management (AWM) model.

While one mechanism to prevent discharge from an open system is to provide ‘adequate’ storage of manure and wastewater during critical periods, EPA believes it is much more complex than that. In fact, the capacity for any specified storm event (such as a 100-year, 24-hour rainfall) is a small component in determining overall storage capacity. Adequate storage is based on a site-specific evaluation of the CAFO’s entire waste handling system. Factors such as rainy seasons and storage capacity for the winter are readily factored into the proper design and construction of any storage facility. Adequate storage has to be defined in terms of climate-specific variables that define the appropriate storage volume, but of equal importance are the nutrient management plan and other management decisions that dictate when and how the storage can be emptied. The link between adequate storage and land application practices is one of the most critical considerations in developing and implementing a site-specific nutrient management plan. For example, the amount of land available for application, the hydraulic limitations (ability of the land to handle additional water without the occurrence of runoff), geology, and soil properties of the available land base can play an important role. See Chapter 2 of EPA’s technical guidance for CAFOs “Managing Manure Nutrients at Concentrated Animal Feeding Operations” (EPA-821-B-04-00) for more information.

Given these concerns, EPA has developed a set of procedures with the expectation that a system designed in accordance with such procedures can be reasonably expected to meet the no discharge requirements. They are:

1. Gather information about the specific operation to be analyzed and the regulatory framework in which it operates.

2. Design the storage facility using design procedures in the NRCS "Agricultural Waste Management Field Handbook," NEH-651.

3. Evaluate the adequacy of the AWM designed storage facility using the Soil Plant Air Water (SPAW) Hydrology Tool.

This three-step procedure to design and then evaluate a manure storage facility can be applied to any given location (a manure treatment lagoon that has a storage component is essentially a manure storage facility for this discussion). The process in general was previously described in two papers delivered to the American Society of Agricultural Engineers, Moffitt et al, 2003 and Moffitt and B. Wilson, 2004 (EPA Docket OW-2005-0037, DCNs 1-01223 and 1-01224).

The first step in the process is to gather information about the specific operation to be analyzed and the regulatory framework in which it operates. The regulatory framework could include: state requirements for minimum storage periods for rainy seasons or winter or additional minimum capacity requirements for chronic rainfalls; technical standards that prohibit or otherwise limit land application to frozen, saturated, or snow-covered ground; standards that further limit land application where there is a high risk of nutrient transport; increased storage capacity with the intent to transfer the manure to another recipient at a later time; and any other special requirements that would impact the size of the storage facility. The operator's management options and needs are to be included in the design and evaluation, as discussed below. For example, frequent dewatering for continuous grasses is quite different from seasonal applications to a given crop rotation.

The second step is the design of the storage facility using design procedures in the NRCS "Agricultural Waste Management Field Handbook," NEH-651. This can be accomplished using Animal Waste Management (AWM) software, which is NRCS's manure storage/treatment planning/design software tool for animal feeding operations that can be used to estimate the production of manure, bedding, and process water and to determine the size of storage/treatment facilities. The Common Computing Environment (CCE) version of AWM 2.10 is currently available on the web, and planned software updates in the near future are not expected to change the general form of the tool. Site-specific input to AWM includes climate data for 30 years consisting of historical average monthly precipitation obtained from local weather stations, and evaporation values obtained from the National Oceanic and Atmospheric Administration (NOAA). Additional inputs include animal numbers and typical animal sizes/weights, added water and bedding (if any), and the size and condition of outside areas exposed to rainfall and contributing runoff to the storage facility. AWM allows the user to specify a storage period (months), and the software will design for the series of months with the most rainfall. The program will not design a system in excess of 12 months, as such designs are not recommended. As an alternative, the user can designate months when the storage pond can be emptied, and AWM sizes the pond based on the months with the most precipitation between pumping events. The output of this step is the design of a waste storage facility. AWM provides a series of reports describing the storage facility and providing a listing of the related specifications including the dimensions of the storage facility, daily manure and wastewater additions, the size and characteristics of the fields, and other management assumptions such as storage period.

The third step is an evaluation of the adequacy of the AWM designed storage facility using the Soil Plant Air Water (SPAW) Hydrology Tool. The current version of SPAW is 6.1. SPAW is a field-level tool that uses a modified Soil Conservation Service Curve Number Method to develop water budgets for agricultural fields. Water budget processes are evaluated by making daily adjustments to crop canopy cover and antecedent soil moisture. Field water budgets can be used for evaluating runoff and infiltration from precipitation events. SPAW also provides an integrated pond module to develop pond water budgets that is ideal for evaluation purposes. Input to SPAW includes daily precipitation, temperature, and evaporation data; storage facility dimensions and manure related quantities extracted from AWM; and the strategies for managing the storage facility. For each user-specified soil profile and crop rotation, SPAW simulates possible runoff from fields as well as the irrigation water needs of fields receiving the storage effluent. Hydrologic groups are used to rate soils for potential to release excess water down grade.

EPA notes that where AWM software is used for design and SPAW is used for evaluation, additional software for nutrient management planning may be appropriately linked and the NMP data can then be imported. For example, see p. 6-12 of *Managing Manure Nutrients at Concentrated Animal Feeding Operations* (EPA-821-B-04-009) for a discussion of "Manure Management Planner" or "MMP," a comprehensive Windows-based planning tool for manure management.

SPAW is then run with the site-specific historic rainfall records to see if the open containment system (referred to as a pond in SPAW) and associated management and land application are adequate to eliminate any discharge. EPA believes that a historical look at 100 years is an adequate timeframe to support a finding of no discharge. However, EPA is aware that 100 years of continuous rainfall data may not be available for many CAFOs. The SPAW model can be run using actual rainfall data where available, and then simulated with a confidence interval analysis over a period of 100 years. The SPAW model shows not only that the storage facility does not discharge, but also that there is no runoff of wastewater from fields during land application activities, a necessary step in meeting the hydraulic limitations of the land application area. In practice, if the SPAW evaluation indicated any level of discharge or any spillway flow, the pond design volume could be increased in size in AWM, the new dimensions converted to SPAW input, and the simulation done again. This iterative procedure could continue until the pond simulation predicts no discharge. If the facility shows no discharge over the 100-year simulation, then the requirement of no discharge has been achieved.

EPA has developed several case studies using this approach. Case studies of swine facilities using this approach are presented in Table 15-1. More detailed information on the inputs to SPAW as well as the SPAW outputs may be found in a separate memo to the record (EPA Docket OW-2005-0037, DCNs 1-01225 and 1-01226).

Table 15-1. Case Studies Using AWM and SPAW to Demonstrate No Discharge

Location	Number of Head	Storage Period (months)	Modeled Dewatering Frequency	Do the manure levels reach the maximum operating level?	Any predicted overflows??
North Carolina	5000	6 months	Pumpout every 6 months	Yes	No
Iowa	5000	6 months	Pumpout every 6 months	Yes	No
Georgia	2454	6 months	Continuous irrigation	No	No
			Pumpout every 6 months	Yes	No
Nebraska	1600	5 months	Pumpout 3 times per year	No	No
South Carolina	3520	5 months	Spring followed by seasonal irrigation	No	No

If the AWM design does not provide the result of no predicted overflows, the CAFO could evaluate different designs and management options (such as different storage periods and dewatering schedules consistent with the CAFO's NMP) that do not result in any predicted discharges, or the CAFO could conclude an open system is not appropriate for the particular site being evaluated.

The demonstration requires certain information regarding design, operation, and maintenance of the system that would be included in the CAFO's NMP under 40 CFR 122.42(e)(1). This information includes the key user-defined inputs and model system parameters. The site-specific design, construction, operation, and maintenance measures would then become enforceable requirements in the CAFO's permit. As long as the CAFO complies with these requirements, the CAFO would presumptively meet no discharge even if it actually did discharge during extreme weather conditions. As with the "Voluntary alternative performance standards" provision for existing sources, the burden is on the CAFO to demonstrate any open system they employ meets the new source standard. EPA believes that this would provide a clear and enforceable element for the CAFO as well as provide assurance to the public that the proposed system would comply with the no discharge requirements.

15.2 Best Conventional Pollutant Control Technology

Section 15.2 presents a summary of the proposed BCT methodology, including the incorporation of FC removals into the two-part cost-reasonableness test, and presents the results of the BCT cost test.

In considering whether to propose revised BCT limits for the Subpart C and D subcategories, EPA considered whether technologies are available that achieve greater removals of conventional pollutants than the current BPT effluent limitations guidelines. See Chapter 8 for a description of these technologies. EPA also considered whether those technologies are cost-reasonable according to the BCT cost test, which compares the incremental removals and costs associated with BCT limitations to a baseline associated with BPT. The candidate BCT technologies do not pass the BCT cost test. Therefore, EPA is not proposing more stringent BCT limitations for Subparts C and D of this industry category.

15.2.1 Background of BCT Cost Test

The CWA Amendments that created BCT also specify that the cost associated with BCT effluent limitations be "reasonable" with respect to the effluent reductions. Accordingly, the "BCT Methodology" was developed to answer the question of whether it is "cost-reasonable" for industry to control conventional pollutants at a level more stringent than already required by BPT effluent limitations. The BCT methodology was originally published on August 29, 1979 along with the promulgation of BCT ELGs for 41 subcategories of the secondary industries (44 FR 50732). The crux of the methodology was a comparison of the costs of removing conventional pollutants for an average-sized publicly owned treatment works (POTW). The Fourth Circuit Court remanded the regulation, and directed EPA to develop an industry cost test in addition to the POTW test. EPA proposed a revised BCT methodology in 1982 (47 FR 49176) that addressed the industry cost test. EPA proposed to base the POTW benchmark on model plant costs in a 1984 notice (49 FR 37046).

The final BCT methodology was published on July 9, 1986 (51 FR 24974), maintaining the basic approach of the 1982 proposed BCT methodology and adopting the use of the new model POTW data. These guidelines state that the BCT cost analysis "...answers the question of whether it is 'cost reasonable' for industry to control conventional pollutants at a level more stringent than BPT effluent limitations already require." Conventional pollutants are five-day biological oxygen demand (BOD), total suspended solids (TSS), oil and grease, FC, and pH.

The 1986 BCT methodology analysis incorporates two cost tests to establish cost reasonableness: the POTW Test and the Industry Cost Test. Each of these tests are compared with established benchmarks. The POTW benchmark used in the 1986 FRN is $0.25 per pound (in 1976 dollars) for industries where cost per pound is based on long-term performance data. This benchmark was developed using only BOD and TSS pollutant removals. (See 51 FR 24974 for more information on these two cost tests and benchmarks.)

The 1986 FRN notes that FC is not included in the POTW Test calculations because control of that pollutant is not measurable as "pounds removed" (FC is typically measured in colony forming units (CFUs)[1], but offers no alternative means for addressing FC in BCT cost analyses. As such, the established cost test benchmarks do not incorporate FC removals. However, the 1986 FRN also notes that in the case where there is a lack of comparable industry data, a strict comparison to the benchmark may undermine Congress' intent on cost reasonableness. Therefore, EPA can develop appropriate industry-specific procedures to evaluate cost reasonableness. (51 FR 24976) For CAFOs, EPA developed procedures for evaluating cost reasonableness of BCT controls for FC.

[1]A colony forming unit is actually a single bacterium. The "CFU" term is derived from the test method where sample water is applied to a controlled medium (such as a Petri dish) and individual bacteria cells multiply until they form colonies, which can be easily recognized and counted.

15.2.1.1 BCT Cost Test Calculation Steps

Establishing BCT effluent limitations for an industrial category or subcategory begins by identifying technology options that provide additional conventional pollutant control beyond that provided by application of BPT effluent limitations. EPA evaluates the candidate technologies by applying the two-part BCT cost test.

The first part of the BCT cost test is the POTW test. To "pass" the POTW test, the cost per pound of conventional pollutant discharges removed in upgrading from BPT to the candidate BCT must be less than the cost per pound of conventional pollutant removed in upgrading POTWs from secondary treatment to advanced secondary treatment.

The second part of the test that the "candidate" BCT technology must pass is the industry cost test. In this test the ratio of incremental costs to upgrade from BPT to BCT over the incremental costs to upgrade from no treatment to BPT is compared to the ratio of incremental costs for a POTW to upgrade from secondary treatment to advanced treatment over the incremental costs for a POTW to upgrade from no treatment to secondary treatment.

Historically, EPA has evaluated the cost-reasonableness of each technology option on a subcategory basis. However, the candidate technologies being evaluated for BCT vary in costs and feasibility among species within a subcategory of CAFOs. The candidate technologies are also not likely to be applicable across an entire subcategory of CAFOs. For this reason, the historical approach will provide results that are less meaningful for the CAFO rule. Therefore EPA has evaluated each candidate technology based on a species-specific basis (the animal species for which the technology is believed to be feasible) rather than based on the subcategory as a whole. This approach eliminates the need to consider subcategories as a factor in the overall BCT methodology as applied to the CAFO industry.

EPA reviewed the POTW cost estimate methodology in the 1986 FRN. Five model POTWs were established to represent five different flow ranges of POTWs, as shown in Table 15-2. Costs were developed by multiple engineering firms for each of the model POTWs. The costs represent the construction and operation costs of a secondary POTW, and the total annual cost to upgrade to advanced secondary treatment (i.e., polymer addition). The costs include chlorination (see 51 FR 24982, 2nd column, last paragraph).

Table 15-2. Model POTWs and Representative Flow Ranges from the 1986 FRN

Model POTW	Representative Flow Range
0.052 MGD	0 - 0.105 MGD
0.38 MGD	0.106 - 1.05 MGD
3.3 MGD	1.06 - 10.5 MGD
25 MGD	10.0 - 50.2 MGD
140 MGD	>50.2 MGD

The average model POTW costs were extrapolated to represent the entire industry by multiplying the average model POTW cost by a weighting factor. The weighting factors represent the flow ranges of the model POTW, and were determined by dividing the amount of POTW industry flow in each flow range by the national POTW industry total flow.

Historically, the two conventional pollutants used in calculating the POTW pollutant removal are BOD and TSS. In the first part of the BCT cost test, the POTW upgrade cost, or POTW benchmark, is compared to the upgrade cost to industry. The POTW benchmark from the 1986 FRN was $0.25 (1976$) per pound BOD and TSS removed. EPA used cost index data from RS Means Historical Cost Indices to update this POTW benchmark to 2001$ according to the following equation:

$$\frac{\text{Index for 2001}}{\text{Index for 1976}} \times \text{Cost in 1976\$} = \text{Cost in 2001\$}$$

$$\frac{121.8}{46.9} \times \$0.25 = \$0.65$$

EPA then calculated incremental costs per pound of BOD and TSS removed ($/lb) for each candidate technology. The upgrade cost to industry must be less than the POTW benchmark of $0.65 per pound (in 2001 dollars). If any candidate technology option passes the first part of the BCT cost test, the technology is further evaluated in the second part of the test.

To pass the second part of the BCT cost test, the industry cost test, EPA computes a ratio of two incremental costs. The first incremental cost is the cost per pound removed by the candidate technology relative to BPT. The second incremental cost is the cost per pound removed by BPT relative to no treatment (i.e., raw wasteload). As in the POTW test, the ratio of the first cost divided by the second cost is compared to an industry cost benchmark. The industry cost benchmark is the ratio of two incremental costs: the cost per pound to upgrade a POTW from secondary treatment to advanced secondary treatment is divided by the cost per pound to initially achieve secondary treatment. If the industry ratio is lower than the benchmark, then the candidate technology passes the cost test. The industry cost benchmark is 1.29 (i.e., the cost increase must be less than 29 percent) (see 51 FR 24974; also see the pulp and paper final rule Technical Development Document, EPA-821-R-97-011).

15.2.1.2 Data Sources Used in the BCT Cost Test Calculations

EPA evaluated numerous sources of data on CAFO manure management systems, including treatment technologies and best management practices (BMPs) for pollution prevention, as well as for the handling, storage, treatment, and land application of wastes. These data sources include available technical literature, over 11,000 comments submitted by industry and other public commenters, and insights gained from conducting over 116 site visits to CAFOs.

For this BCT cost test analysis, EPA calculated POTW costs and FC reductions to represent current POTW performance. EPA also calculated or revisited costs and FC reductions for lime treatment of dairy manure, anaerobic digestion of swine and dairy manure for pathogen reduction, and composting of poultry manure/litter. A variety of data sources were used in these analyses, including EPA data from the 2004 Clean Watersheds Needs Survey and Permit Compliance System database, items from the CAFO rule docket (OW-2002-0025), and new sources relating to technology costs and performance in the CAFO industry. Chapter 5 discusses how EPA calculated costs and loads for the technology options evaluated in the BCT cost test. Section 15.3 presents the references used for the BCT cost test.

EPA estimated costs, baseline conventional pollutant loads, and conventional pollutant reductions based on the *Cost Methodology for the Final Revision to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations*, December 2002 (i.e., "Cost Report"), and *Pollutant Loading Reductions for the Effluent Limitations Guidelines for Concentrated Animal Feeding Operations*, December 2002 (i.e., "Loads Report"). In general, EPA assumed an upper bound of 99 percent FC reductions are achieved by each production area technology considered. The literature suggests such high removals are not likely to be achieved. However, EPA notes if no technology passes the cost test at the upper bound 99 percent FC removals, then any technology of similar cost will also not pass the cost test. Chapter 5 presents a description of each technology option's costs and pollutant loads.

15.2.2 Development of BCT Cost Test for FC

Although FC is not typically evaluated in the BCT cost test, EPA's BCT methodology specifically contemplated that in certain instances, EPA would need to develop appropriate procedures to evaluate cost-reasonableness on an industry-specific basis. (51 FR 24976) Moreover, CWA Section 304(b)(4)(B) authorizes EPA to consider other appropriate factors in establishing BCT. Therefore, Section 15.2.2 presents an alternative approach to conducting the cost-reasonableness test that directly accounts for pathogens by specifically looking at FC, the only conventional pollutant that is a possible pathogen. The approach is identical to the two-part cost-reasonableness test described in Section 15.2.1.1, except pounds of BOD and TSS are replaced by colony forming units (CFU) of FC. EPA's methodology to perform the BCT cost test for FC employed the following steps.

1. Calculate a POTW cost test benchmark for FC reduction ($/trillion CFU of FC removed).

2. Calculate an industry cost test benchmark, which is the ratio of the POTW secondary to advanced incremental cost/unit of FC removed to the POTW raw to secondary cost/trillion CFU of FC removed.

3. Obtain industry costs from regulatory options explored in the original rulemaking and calculate industry costs for newly explored technologies ($/trillion CFU of FC removed).

4. Perform the first part of the BCT cost test (the POTW test) by comparing the industry option cost to the POTW benchmark cost.

5. Perform the second part of the BCT cost test (the industry cost test) by comparing the POTW cost ratio to the candidate technology industry cost ratio.

The remainder of this section describes the development of the POTW and industry benchmarks for FC removal. Section 15.2.3 presents the results of the BCT cost tests.

15.2.2.1 Calculation of POTW Benchmark for FC

EPA developed a new benchmark to use for the POTW test, which estimates the cost to reduce FC bacteria at a POTW. Because the 1986 FRN costs include biological treatment and disinfection, EPA assumed that no additional treatment would be needed to remove FC, and the costs from the 1986 FRN could be used as the starting point for the analysis. EPA updated the 1986 FRN annual costs for each model POTW from 1976$ to 2001$, using the RS Means Historical Cost Indices. (See Tables 15-3 and 15-4.)

EPA then calculated annual influent and effluent FC loads. EPA estimated the FC concentration in untreated wastewater using accepted engineering design manuals, (EPA Docket OW-2005-0037, DCNs 1-01001, 1-01002 and 1-01220). Domestic wastewater typically contains FC concentrations between 1 and 10 million CFU/100mL. EPA compared this range of FC concentrations with other data sources and considers this to be a good estimate.[2] EPA used the mid-point of this range (5,000,000 CFU/ 100 mL) as the influent FC concentration for all model POTWs (secondary and advanced secondary). EPA considered using measured POTW data from EPA's Permit Compliance System (PCS) data, but there were insufficient data reported in PCS for influent[3] FC concentrations at POTWs.

Secondary treatment does not require FC reductions. Therefore, EPA estimated the final effluent FC concentration from POTWs with secondary treatment to be 200 CFU/100mL, which is the standard water quality criterion for FC according to EPA's Ambient Water Quality Criteria for Bacteria. EPA multiplied the effluent and influent FC concentrations by the annual flow at each model POTW to calculate influent and effluent FC loads. EPA estimated FC removals by subtracting effluent loads from influent loads for each model POTW. The removal cost was calculated by dividing the annual cost of operation by the trillions of CFUs removed. Table 15-3 shows EPA's estimated costs of secondary treatment and FC removal at each model POTW.

EPA estimated costs and loads at POTWs with advanced secondary treatment using the same process as secondary treatment at POTWs, with the exception of the effluent FC concentration. For advanced secondary POTWs, EPA used Permit Compliance System (PCS) data to determine the effluent FC concentrations that POTWs are actually achieving. Based on the median point of all POTWs that report to PCS, EPA used an effluent FC concentration of 21 CFU/100 mL for advanced secondary POTWs. Table 15-4 shows EPA's estimated costs of advanced secondary treatment and FC removal at each model POTW.

EPA determined the incremental cost per trillion CFU removed between secondary and advanced secondary treatment for each model POTW, and applied a flow weighting factor to determine an incremental cost per trillion CFU removed for the entire POTW industry. EPA created updated weighting factors, following the same methodology as the 1986 FRN and using the flow data from the 2004 Clean Watersheds Needs Survey (CWNS). EPA divided the total flow in each POTW size category by the sum of all POTW flows. Table 15-5 presents the data used to calculate the flow weighting factors.

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[2]Other FC data sources include EPA's *Meat & Poultry Processing Final Rule, Onsite Wastewater Treatment Systems Manual,* and *Small and Decentralized Wastewater Management Systems* (Crites & Tchobanoglous).
[3]Both influent and effluent data are needed to calculate FC reductions.

EPA multiplied the incremental costs for each model POTW by the flow weighting factor and summed the results to get a flow weighted cost. The resulting incremental cost is the POTW benchmark value for FC. The benchmark was determined to be $0.33 per trillion CFU removed (in 2001$). Table 15-6 presents these incremental costs used to calculate the POTW benchmark.

Table 15-3. Cost of Secondary Treatment

BCT POTW Flow Ranges and Model POTW Flows (MGD) (a)	**Annual Cost of Model POTW Operation (1976$)** (b)	**Annual Cost of Model POTW Operation (2001$)**	**Influent FC Load (trillion CFU/year)** (c)	**Effluent FC Load (trillion CFU/year)** (d)	**FC Removal (trillion CFU/year)**	**Removal Cost ($/trillion CFU)**
0 - 0.105 (Model=0.052)	$40,000	$103,881	3.5923E+15	1.4369E+11	3.5922E+15	$28.92
0.106 - 1.05 (Model=0.38)	$156,000	$405,134	2.6252E+16	1.0501E+12	2.6251E+16	$15.43
1.06 - 10.5 (Model=3.3)	$1,351,000	$3,508,567	2.2798E+17	9.1190E+12	2.2797E+17	$15.39
10.6 - 50.2 (Model=25)	$5,456,000	$14,169,313	1.7271E+18	6.9084E+13	1.7270E+18	$8.20
> 50.2 (Model=140)	$20,151,000	$52,332,448	9.6717E+18	3.8687E+14	9.6713E+18	$5.41

(a) 51 FR 24974 Table 2, page 24983.
(b) 51 FR 24974 Table 4, page 24983.
(c) Based on influent FC concentration of 5,000,000 CFU/100mL.
(c) Based on effluent FC concentration of 200 CFU/100mL.

Table 15-4. Cost of Advanced Secondary Treatment

BCT POTW Flow Ranges and Model POTW Flows (MGD)	**Annual Cost of Model POTW Operation (1976$)**	**Annual Cost of Model POTW Operation (2001$)**	**Influent FC Load (trillion CFU/year)** (c)	**Effluent FC Load (trillion CFU/year)** (d)	**FC Removal (trillion CFU/year)**	**Removal Cost ($/trillion CFU)**
0 - 0.105 (Model=0.052)	$40,000	$103,881	3.5923E+15	1.5088E+10	3.5923E+15	$28.92
0.106 - 1.05 (Model=0.38)	$156,000	$405,134	2.6252E+16	1.1026E+11	2.6252E+16	$15.43
1.06 - 10.5 (Model=3.3)	$1,398,000	$3,630,627	2.2798E+17	9.5750E+11	2.2797E+17	$15.93
10.6 - 50.2 (Model=25)	$5,696,000	$14,792,567	1.7271E+18	7.2538E+12	1.7271E+18	$8.57
> 50.2 (Model=140)	$20,034,000	$54,625,612	9.6717E+18	4.0621E+13	9.6717E+18	$5.65

(a) 51 FR 24974 Table 2, page 24983.
(b) 51 FR 24974 Table 4, page 24983.
(c) Based on influent FC concentration of 5,000,000 CFU/100mL.
(c) Based on effluent FC concentration of 21 CFU/100mL.

Table 15-5. Weighting Factors

Size of Model POTW (MGD)	Representative Flow Range (MGD)	Total Flow for All POTWs (MGD) (a)	Weighting Factor
0.052	0 - 0.105	303	0.0091
0.38	0.106 - 1.05	2395	0.0720
3.3	1.06 - 10.5	8983	0.2701
25	10.6 - 50.2	8644	0.2599
140	> 50.2	12939	0.3890
ALL	ALL	33264	1

(a) The total flow for all POTWs column reflects CWNS data.

Table 15-6. POTW Benchmark for FC

Size of POTW (MGD)	Weighting Factor	Annual Incremental Cost per Trillion CFUs Removed from Secondary Treatment to Advanced Secondary Treatment
0.052	0.0091	$0.00
0.38	0.0720	$0.00
3.3	0.2701	$0.53
25	0.2599	$0.36
140	0.3890	$0.24
Flow-weighted Incremental Cost ($/trillion CFU):		**$0.33**

15.2.2.2 Calculation of Industry Benchmark for FC

The second test that the candidate BCT technology must pass to be considered cost-reasonable is the industry cost test. As described previously, to pass the industry cost test, EPA computes a ratio of two incremental costs. In the alternative cost test, the FC reductions are used in lieu of pounds TSS and BOD. The first incremental cost is therefore the cost per CFU removed by the candidate technology relative to BPT. The second incremental cost is the cost per CFU removed by BPT relative to no treatment (i.e., raw wasteload). The industry cost benchmark is the ratio of two incremental costs: the cost per CFU to upgrade a POTW from secondary treatment to advanced secondary treatment (the POTW benchmark) is divided by the cost per CFU to initially achieve secondary treatment. If the industry ratio is lower than the benchmark, then the candidate technology passes the cost test.

The cost per CFU to initially achieve secondary treatment is presented for each model POTW in Table 15-4. Table 15-7 presents the flow-weighted cost of secondary treatment for the entire POTW industry.

Table 15-7. Flow–weighted Cost of Secondary Treatment

Size of POTW (MGD)	Upgrade Cost from Raw Waste to Secondary ($/trillion CFU)	Upgrade Cost from Secondary to Advanced (Incremental $/trillion CFU)	Cost Ratio	Weighting Factor	Weighted Ratio
0 - 0.105	$28.92	$0.00	0.0000	0.0090	0.00
0.106 - 1.05	$15.43	$0.00	0.0000	0.0712	0.00
1.06 - 10.5	$15.39	$0.53	0.0348	0.2677	0.01
10.6 - 50.2	$8.20	$0.36	0.0440	0.2619	0.01
> 50.2	$5.41	$0.24	0.0438	0.3901	0.02
				Flow-weighted Industry Cost Benchmark:	**0.04**

The cost ratio is calculated for each POTW size using the following equation:

$$\frac{\text{Cost per trillion CFU to upgrade to secondary treatment to advanced secondary treatment}}{\text{Cost per trillion CFU to initially achieve secondary treatment}}$$

The cost ratio for each POTW size is multiplied by a flow weighting factor and the weighted ratios are summed to determine the flow-weighted industry cost benchmark. For this BCT cost test, the industry cost benchmark is 0.04.

15.2.3 Results of BCT Cost Test

EPA identified several technology options that potentially provide additional control of some conventional pollutants beyond that provided by BPT. (See Chapter 5 for more details.) From these technology options, EPA identified five options that are technologically feasible at CAFOs:

- Groundwater controls (Option 3);
- No discharge (Option 5);
- Composting (Option 5A);
- Anaerobic digestion (Option 6); and
- Land application timing restrictions (Option 7).

In the BCT cost test, EPA evaluates various candidate technologies to assess whether they are "practical" (technologically feasible for all facilities in a subcategory) and would achieve greater reductions of FC than the technologies selected as the basis for BPT in the 2003 rule. EPA finds that none of these candidate technologies would pass both parts of the BCT cost test.

This section provides the results of EPA's BCT cost-reasonableness test for these options. EPA evaluated cost reasonableness for both BOD and TSS removals (the traditional cost reasonableness test, see Section 15.2.3.1), as well as FC removals (alternative cost reasonableness test, see Section 15.2.3.2).

15.2.3.1 BCT Cost Test for BOD and TSS Removals

In the traditional BCT cost test evaluation of BOD and TSS, EPA calculated incremental industry costs for all candidate BCT technologies compared to the BCT option. Table 15-8 provides a summary of the costs and BOD and TSS reductions of the 2003 CAFO rule BPT. Pollutant removals were determined using the 2003 final CAFO rule methodology, as described in Section 8.6.3. Table 15-9 provides incremental costs and incremental pollutant removals of candidate technologies in relation to BPT. Incremental costs are the costs of the technology option minus the BPT costs from Table 15-8. Incremental load reductions are the pounds removed by the technology option minus the BPT load reductions from Table 15-8. Total incremental reductions include the summation of BOD and TSS removals. EPA has evaluated the candidate technologies on a species-specific basis rather than on a subcategory wide basis.

Table 15-8. 2003 CAFO Rule BPT Costs and BOD & TSS Removals

Sector	Annualized costs ($2001, millions, pre-tax)	BOD removed (million pounds)	TSS removed (million pounds sediment)	Total pounds removed (million pounds)
Beef	86	0	1201	1201
Dairy	128	0	99	99
Swine	25	0	113	113
Poultry	41	6	181	187

Table 15-9. Incremental Costs and BOD & TSS Removals of Candidate Technologies

Candidate Technology	Animal Sector	Annualized Costs of Candidate Technology Option ($2001, millions, pre-tax)	Incremental Costs ($2001, millions, pre-tax)	Incremental BOD Removed (million pounds)	Incremental TSS Removed (million pounds sediment)	Total Incremental Reductions (million pounds)
Ground water Controls [a]	Beef	231	145	NC (a)	NC	NC
	Dairy	316	188	NC	NC	NC
	Swine	61	36	NC	NC	NC
No Discharge	Swine	133	108	7	0	7
Composting	Beef	1,367	1281	3	25	28
	Dairy	277	149	1	7	8
	Poultry	508	467	0	ND (b)	ND
Anaerobic Digestion	Dairy	505	377	2	9	11
	Swine	79	54	6	0.5	7
Land Application Timing Restrictions	Beef	112	26	0.01	0.06	0.08
	Dairy	318	190	2	7	9
	Swine	37	12	7	1	8

(a) NC Values were not calculated because no additional pollutant removal was expected for these options.
(b) ND - Values were non-zero, but too small to report in the indicated units

The POTW upgrade cost is referred to as the POTW benchmark; its derivation is described in the 1986 final BCT methodology notice (51 FR 24974). The upgrade cost to industry must be less than the POTW benchmark of $0.25 per pound (in 1976 dollars) or $0.65 per pound (in 2001 dollars). Table 15-10 provides the cost per pound of conventional pollutants (BOD and TSS) removed by the candidate technology and the results of the first part of the BCT cost test.

Table 15-10. BOD & TSS Cost Test Part One - POTW Test Results

Candidate Technology	Animal Sector	Incremental cost per pound removed by technology ($/lb)	POTW Test Result
Ground water controls	Beef	NC (a)	Fail
	Dairy	NC	Fail
	Swine	NC	Fail
No discharge	Swine	13.55	Fail
Composting	Beef	46.39	Fail
	Dairy	17.84	Fail
	Poultry	NC	Fail
Anaerobic Digestion	Dairy	34.15	Fail
	Swine	7.89	Fail
Land Application Timing Restrictions	Beef	366.65	Fail
	Dairy	20.90	Fail
	Swine	1.55	Fail

(a) NC Values were not calculated because no additional BOD or TSS removal was expected for these options.

In all cases, the POTW benchmark is lower than the cost per pound of conventional pollutants removed by the candidate technology. Since the candidate technologies all fail the POTW cost test, the candidate technologies are not cost-reasonable. EPA notes even though a candidate technology may be affordable for a subcategory, the candidate technologies must be cost-reasonable to be further considered as a basis for BCT.

EPA believes that since all candidate technologies fail the POTW test for each species evaluated, any technology option developed for subcategories C or D utilizing a combination of these candidate technologies also fails the POTW test. For example, for subcategory C CAFOs (beef and dairy facilities), no technology option passes the cost test for either beef or dairy operations, therefore no combination of technology options can be constructed for subcategory C (beef and dairy facilities) that will pass the cost test.

EPA is applying the results presented here for dairy, swine, and poultry operations to veal calf facilities because they are typically total confinement operations with similar waste management systems. Similarly, the results for beef cattle operations may be applied to heifer operations which use waste management technologies identical to those used by beef feedlots. EPA notes veal calf and heifer operations reflect approximately 2 percent of all Large CAFOs.

The second test that the candidate BCT technology must pass to be considered cost-reasonable is the industry cost test. (See Section 15.2.1.1.) The industry cost benchmark is 1.29 (i.e., the cost increase must be less than 29 percent) (see 51 FR 24974; also see the pulp and paper final rule Technical Development Document, EPA-821-R-97-011). Table 15-11 shows the ratio of the incremental costs for the candidate technology options and the results of the second part of the BCT cost test.

Table 15-11. BOD & TSS Cost Test Part Two – Industry Cost Test Results

Candidate Technology	Animal Sector	Candidate Technology Cost Ratio	Industry Cost Benchmark	Industry Cost Test Result
Ground water controls	Beef	NC (a)	1.29	Fail
	Dairy	NC	1.29	Fail
	Swine	NC	1.29	Fail
No discharge	Swine	61.15	1.29	Fail
Composting	Beef	647.70	1.29	Fail
	Dairy	13.86	1.29	Fail
	Poultry	NC	1.29	Fail
Anaerobic digestion	Dairy	26.52	1.29	Fail
	Swine	35.63	1.29	Fail
Land Application Timing Restrictions	Beef	5,119.52	1.29	Fail
	Dairy	16.23	1.29	Fail
	Swine	6.99	1.29	Fail

(a) NC—Values were not calculated because no additional pollutant removal was expected for these options.

In all cases, the industry cost ratio is higher than the industry cost benchmark. Even if a candidate technology was to pass the POTW cost test, none of the candidate technologies pass the industry cost test. EPA believes that since all candidate technologies fail the industry cost test for each species evaluated, any technology option developed for subcategories C or D utilizing a combination of these candidate technologies also fails the industry cost test.

15.2.3.2 BCT Cost Test for FC Removals

In the alternative BCT cost test for FC, EPA calculated incremental industry costs for all candidate BCT technologies compared to the BCT option. Table 15-12 presents the costs and FC removals of the 2003 CAFO rule (BPT). Table 15-13 provides incremental costs and incremental FC removals of candidate technologies in relation to BPT. FC removals were determined using the 2003 final CAFO rule methodology. In this alternative analysis, EPA has again evaluated the candidate technologies on a species-specific basis rather than on a subcategory basis.

Table 15-12. 2003 CAFO Rule BPT Costs and FC Removals

Sector	Annualized costs ($2001, millions, pre-tax)	FC Removed (million CFU)
Beef	86	10.56×10^{13}
Dairy	128	0.97×10^{13}
Swine	25	0.42×10^{13}
Poultry (wet and dry)	41	6.74×10^{13}

Table 15-13. Incremental Costs and FC Removals of Candidate Technologies

Candidate Technology	Animal Sector	Incremental Annualized Cost ($2001, millions, pre-tax)	Incremental FC Removed (million CFU)
Ground water controls [a]	Beef	145	NC (a)
	Dairy	188	NC
	Swine	36	NC
No discharge	Swine	108	$137.4\text{x } 10^{13}$
Composting	Beef	1281	$249.9 \text{ x } 10^{13}$
	Dairy	149	$30.4 \text{ x } 10^{13}$
	Poultry	467	$0.460 \text{ x } 10^{13}$
Anaerobic digestion	Dairy	377	$33.3\text{x } 10^{13}$
	Swine	54	$170.3\text{x } 10^{13}$
Land Application Timing Restrictions	Beef	26	$0.557 \text{ x } 10^{13}$
	Dairy	190	$22.9 \text{ x } 10^{13}$
	Swine	12	$136.1 \text{ x } 10^{13}$

(a) NC Values were not calculated because no additional pollutant removal was expected for these options.

EPA developed a new benchmark to use for this alternative POTW test, which reflects the cost to reduce FC at a POTW. The resulting incremental cost per trillion CFU removed was $0.33 ($2001). Table 15-14 shows the POTW test result using the alternative POTW benchmark for conducting part one of the cost-reasonableness test.

Table 15-14. Alternative Cost Test Part One - POTW Test Results

Candidate Technology	Animal Sector	Cost per trillion CFU removed by technology	POTW Test Result
Ground water controls	Beef	NC	Fail
	Dairy	NC	Fail
	Swine	NC	Fail
No discharge	Swine	1.46	Fail
Composting	Beef	0.51	Fail
	Dairy	0.49	Fail
	Poultry	101.44	Fail
Anaerobic digestion	Dairy	1.64	Fail
	Swine	0.04	Pass
Land Application Timing Restrictions	Beef	4.58	Fail
	Dairy	0.83	Fail
	Swine	0.01	Pass

In some cases, the alternate POTW benchmark is lower than the cost per pound of conventional pollutants removed by the candidate technology. In these cases, EPA believes the candidate technologies fail the alternate POTW test. The remaining candidate technologies pass the POTW test and move on to the second cost test.

The second test that the candidate BCT technology must pass to be considered cost-reasonable is the industry cost test. As described previously, to pass the industry cost test, EPA computes a ratio of two incremental costs. In the alternative cost test, the FC reductions are used in lieu of pounds TSS and BOD. The first incremental cost is therefore the cost per CFU removed by the candidate technology relative to BPT. The second incremental cost is the cost per CFU removed by BPT relative to no treatment (i.e., raw wasteload). The industry cost benchmark is the ratio of two incremental costs: the cost per CFU to upgrade a POTW from secondary treatment to advanced secondary treatment is divided by the cost per CFU to initially achieve secondary treatment. If the industry ratio is lower than the benchmark, then the candidate technology passes the cost test. The industry cost benchmark is 0.04. Table 15-15 shows the ratio of the incremental costs for the candidate technology options and the results of the second part of the BCT cost test.

Table 15-15. Alternative Cost Test Part Two – Industry Cost Test Results

Candidate Technology	Animal Sector	Candidate Technology Cost Ratio	Industry Cost Benchmark	Industry Cost Test Result
Anaerobic digestion	Swine	6.63	0.04	Fail
Land Application Timing Restrictions	Swine	1.48	0.04	Fail

All candidate technologies passing the POTW test fail the industry cost test. In all cases, the industry cost ratio is several orders of magnitude higher than the industry cost benchmark. As discussed in 4.1.2, EPA assumed 99 percent FC reductions were achieved by any candidate production area technology. Lower FC reductions result in higher industry cost ratios, and would result in failing the industry cost test by an even higher margin. Since all candidate technologies fail the cost-reasonableness test for each species evaluated, any technology option developed for subcategories C or D utilizing a combination of these candidate technologies also fails the cost test.

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Appendix A

MODEL FARM RESULTS FOR MODIFIED OPTION 6 FOR SWINE

Table A-1. Model Farm Results for Modified Option 6 for Swine

Option	Animal	Farm Type	Manure Type	Size Class	Region	Category	Performance Needs	Number of Facilities	Capital Costs	Fixed Costs	Annual O&M Costs	3-Year Recurring O&M Costs	5-Year Recurring O&M Costs
6	Swine	Evapor	FF	Large2	CE	1	H	3.1	$526,268	$8,783	$34,795	$387	$5,807
6	Swine	Evapor	FF	Large1	CE	1	H	4.3	$295,703	$7,408	$33,227	$218	$3,280
6	Swine	Pit	FF	Large2	MA	1	H	1.8	$461,407	$8,052	$28,345	$422	$6,324
6	Swine	Pit	FF	Large1	MA	1	H	2.5	$229,107	$5,647	$22,647	$216	$3,247
6	Swine	Liquid	FF	Large2	MA	1	H	5.6	$1,126,858	$21,636	$87,671	$1,084	$16,260
6	Swine	Liquid	FF	Large1	MA	1	H	7.8	$567,108	$16,002	$70,459	$570	$8,514
6	Swine	Pit	FF	Large2	MW	1	H	25.0	$5,594,708	$84,367	$306,328	$4,026	$60,367
6	Swine	Pit	FF	Large1	MW	1	H	34.8	$3,549,031	$73,412	$295,955	$2,674	$40,004
6	Swine	Liquid	FF	Large2	MW	1	H	19.3	$3,826,609	$61,008	$236,469	$2,835	$42,480
6	Swine	Liquid	FF	Large1	MW	1	H	26.9	$2,443,068	$54,324	$228,926	$1,909	$28,500
6	Swine	Evapor	GF	Large2	CE	1	H	3.2	$519,232	$9,066	$41,939	$399	$5,994
6	Swine	Evapor	GF	Large1	CE	1	H	4.4	$289,629	$7,580	$37,247	$223	$3,356
6	Swine	Pit	GF	Large2	MA	1	H	2.8	$673,250	$12,525	$51,346	$657	$9,837
6	Swine	Pit	GF	Large1	MA	1	H	3.9	$335,727	$8,810	$38,864	$336	$5,066
6	Swine	Liquid	GF	Large2	MA	1	H	4.7	$890,941	$18,159	$85,634	$910	$13,647
6	Swine	Liquid	GF	Large1	MA	1	H	6.6	$452,934	$13,540	$65,540	$482	$7,204
6	Swine	Pit	GF	Large2	MW	1	H	32.1	$7,094,895	$108,328	$446,151	$5,169	$77,512
6	Swine	Pit	GF	Large1	MW	1	H	44.7	$4,503,298	$94,297	$413,121	$3,435	$51,385
6	Swine	Liquid	GF	Large2	MW	1	H	13.3	$2,706,030	$42,042	$184,784	$1,954	$29,274
6	Swine	Liquid	GF	Large1	MW	1	H	18.5	$1,723,222	$37,361	$171,049	$1,313	$19,601
6	Swine	Evapor	FF	Large2	CE	2	H	7.0	$1,909,420	$26,010	$103,521	$1,287	$19,290
6	Swine	Evapor	FF	Large1	CE	2	H	9.7	$907,645	$18,239	$83,258	$593	$8,927

Table A-1 (Continued)

Option	Animal	Farm Type	Manure Type	Size Class	Region	Category	Performance Needs	Number of Facilities	Capital Costs	Fixed Costs	Annual O&M Costs	3-Year Recurring O&M Costs	5-Year Recurring O&M Costs
6	Swine	Pit	FF	Large2	MA	2	H	10.3	$4,485,065	$31,167	$981,905	$1,419	$21,279
6	Swine	Pit	FF	Large1	MA	2	H	14.3	$2,108,966	$23,601	$507,374	$652	$9,873
6	Swine	Liquid	FF	Large2	MA	2	H	32.7	$11,633,933	$98,949	$755,468	$4,505	$512,987
6	Swine	Liquid	FF	Large1	MA	2	H	45.6	$5,611,505	$75,260	$519,632	$2,079	$238,963
6	Swine	Pit	FF	Large2	MW	2	H	24.9	$9,717,679	$118,333	$696,738	$6,290	$94,429
6	Swine	Pit	FF	Large1	MW	2	H	34.7	$4,220,445	$75,164	$422,261	$2,788	$41,852
6	Swine	Liquid	FF	Large2	MW	2	H	19.2	$6,857,692	$91,245	$338,035	$4,850	$200,800
6	Swine	Liquid	FF	Large1	MW	2	H	26.8	$3,042,013	$58,052	$247,064	$2,154	$86,600
6	Swine	Evapor	GF	Large2	CE	2	H	7.2	$1,876,410	$26,753	$128,433	$1,324	$19,841
6	Swine	Evapor	GF	Large1	CE	2	H	10.0	$895,090	$18,803	$96,020	$612	$9,203
6	Swine	Pit	GF	Large2	MA	2	H	16.5	$6,737,094	$49,928	$1,669,864	$2,273	$34,088
6	Swine	Pit	GF	Large1	MA	2	H	23.0	$3,183,561	$37,960	$861,178	$1,048	$15,880
6	Swine	Liquid	GF	Large2	MA	2	H	27.5	$9,236,237	$83,214	$755,753	$3,788	$431,411
6	Swine	Liquid	GF	Large1	MA	2	H	38.4	$4,470,018	$63,376	$493,757	$1,750	$201,232
6	Swine	Pit	GF	Large2	MW	2	H	32.0	$12,333,453	$152,075	$1,028,622	$8,083	$121,355
6	Swine	Pit	GF	Large1	MW	2	H	44.6	$5,358,333	$96,609	$600,046	$3,584	$53,793
6	Swine	Liquid	GF	Large2	MW	2	H	13.2	$4,834,862	$62,731	$270,402	$3,334	$138,050
6	Swine	Liquid	GF	Large1	MW	2	H	18.5	$2,151,490	$40,073	$186,860	$1,487	$59,780
6	Swine	Evapor	FF	Large2	CE	3	H	4.0	$3,648,880	$-	$147,196	$-	$-
6	Swine	Evapor	FF	Large1	CE	3	H	5.5	$733,749	$-	$54,751	$-	$-
6	Swine	Pit	FF	Large2	MA	3	H	3.0	$1,517,530	$-	$368,816	$-	$-
6	Swine	Pit	FF	Large1	MA	3	H	4.2	$637,081	$-	$169,077	$-	$-
6	Swine	Liquid	FF	Large2	MA	3	H	9.6	$3,797,478	$-	$245,813	$-	$165,231

Table A-1 (Continued)

Option	Animal	Farm Type	Manure Type	Size Class	Region	Category	Performance Needs	Number of Facilities	Capital Costs	Fixed Costs	Annual O&M Costs	3-Year Recurring O&M Costs	5-Year Recurring O&M Costs
6	Swine	Liquid	FF	Large1	MA	3	H	13.3	$1,589,050	$-	$152,108	$-	$67,798
6	Swine	Pit	FF	Large2	MW	3	H	20.9	$13,908,052	$-	$1,383,458	$-	$-
6	Swine	Pit	FF	Large1	MW	3	H	29.1	$5,251,387	$-	$632,748	$-	$-
6	Swine	Liquid	FF	Large2	MW	3	H	16.1	$9,456,666	$-	$414,027	$-	$308,753
6	Swine	Liquid	FF	Large1	MW	3	H	22.5	$3,600,023	$-	$245,328	$-	$115,655
6	Swine	Evapor	GF	Large2	CE	3	H	4.1	$3,571,413	$-	$193,171	$-	$-
6	Swine	Evapor	GF	Large1	CE	3	H	5.7	$726,881	$-	$65,154	$-	$-
6	Swine	Pit	GF	Large2	MA	3	H	4.8	$2,276,425	$-	$614,825	$-	$-
6	Swine	Pit	GF	Large1	MA	3	H	6.7	$953,577	$-	$279,943	$-	$-
6	Swine	Liquid	GF	Large2	MA	3	H	8.1	$3,016,338	$-	$248,696	$-	$139,414
6	Swine	Liquid	GF	Large1	MA	3	H	11.2	$1,261,200	$-	$145,010	$-	$57,093
6	Swine	Pit	GF	Large2	MW	3	H	26.8	$17,611,766	$-	$1,906,487	$-	$-
6	Swine	Pit	GF	Large1	MW	3	H	37.4	$6,665,873	$-	$862,845	$-	$-
6	Swine	Liquid	GF	Large2	MW	3	H	11.1	$6,692,901	$-	$340,171	$-	$212,867
6	Swine	Liquid	GF	Large1	MW	3	H	15.5	$2,544,888	$-	$189,514	$-	$79,673
6	Swine	Evapor	FF	Large2	CE	1	L	3.1	$520,421	$-	$33,505	$310	$-
6	Swine	Evapor	FF	Large1	CE	1	L	4.3	$289,699	$-	$31,564	$174	$-
6	Swine	Pit	FF	Large2	MA	1	L	1.8	$460,262	$-	$27,588	$337	$-
6	Swine	Pit	FF	Large1	MA	1	L	2.5	$227,683	$-	$21,697	$173	$-
6	Swine	Liquid	FF	Large2	MA	1	L	5.6	$1,116,502	$-	$85,244	$867	$-
6	Swine	Liquid	FF	Large1	MA	1	L	7.8	$556,683	$-	$67,410	$451	$-
6	Swine	Pit	FF	Large2	MW	1	L	25.0	$5,579,646	$-	$296,319	$3,222	$-
6	Swine	Pit	FF	Large1	MW	1	L	34.8	$3,529,388	$-	$282,856	$2,142	$-

Table A-1 (Continued)

Option	Animal	Farm Type	Manure Type	Size Class	Region	Category	Performance Needs	Number of Facilities	Capital Costs	Fixed Costs	Annual O&M Costs	3-Year Recurring O&M Costs	5-Year Recurring O&M Costs
6	Swine	Liquid	FF	Large2	MW	1	L	19.3	$3,794,309	$-	$228,412	$2,271	$-
6	Swine	Liquid	FF	Large1	MW	1	L	26.9	$2,407,573	$-	$218,429	$1,529	$-
6	Swine	Evapor	GF	Large2	CE	1	L	3.2	$513,196	$-	$40,607	$320	$-
6	Swine	Evapor	GF	Large1	CE	1	L	4.4	$283,485	$-	$35,545	$178	$-
6	Swine	Pit	GF	Large2	MA	1	L	2.8	$671,469	$-	$50,168	$524	$-
6	Swine	Pit	GF	Large1	MA	1	L	3.9	$333,506	$-	$37,382	$271	$-
6	Swine	Liquid	GF	Large2	MA	1	L	4.7	$882,249	$-	$83,597	$728	$-
6	Swine	Liquid	GF	Large1	MA	1	L	6.6	$444,113	$-	$62,960	$381	$-
6	Swine	Pit	GF	Large2	MW	1	L	32.1	$7,075,555	$-	$433,298	$4,137	$-
6	Swine	Pit	GF	Large1	MW	1	L	44.7	$4,478,068	$-	$396,296	$2,751	$-
6	Swine	Liquid	GF	Large2	MW	1	L	13.3	$2,683,772	$-	$179,232	$1,565	$-
6	Swine	Liquid	GF	Large1	MW	1	L	18.5	$1,698,811	$-	$163,830	$1,052	$-
6	Swine	Evapor	FF	Large2	CE	2	L	7.0	$1,893,694	$-	$100,448	$1,029	$-
6	Swine	Evapor	FF	Large1	CE	2	L	9.7	$892,754	$-	$79,457	$474	$-
6	Swine	Pit	FF	Large2	MA	2	L	10.3	$4,478,968	$-	$972,421	$1,134	$-
6	Swine	Pit	FF	Large1	MA	2	L	14.3	$2,101,096	$-	$499,589	$523	$-
6	Swine	Liquid	FF	Large2	MA	2	L	32.7	$11,649,550	$-	$743,285	$3,601	$441,167
6	Swine	Liquid	FF	Large1	MA	2	L	45.6	$5,615,828	$-	$503,445	$1,669	$205,503
6	Swine	Pit	FF	Large2	MW	2	L	24.9	$9,701,644	$-	$686,129	$5,043	$-
6	Swine	Pit	FF	Large1	MW	2	L	34.7	$4,200,794	$-	$409,158	$2,217	$-
6	Swine	Liquid	FF	Large2	MW	2	L	19.2	$6,863,569	$-	$330,227	$3,889	$127,987
6	Swine	Liquid	FF	Large1	MW	2	L	26.8	$3,040,848	$-	$237,223	$1,712	$54,255
6	Swine	Evapor	GF	Large2	CE	2	L	7.2	$1,860,236	$-	$125,273	$1,058	$-

Table A-1 (Continued)

Option	Animal	Farm Type	Manure Type	Size Class	Region	Category	Performance Needs	Number of Facilities	Capital Costs	Fixed Costs	Annual O&M Costs	3-Year Recurring O&M Costs	5-Year Recurring O&M Costs
6	Swine	Evapor	GF	Large1	CE	2	L	10.0	$879,738	$-	$92,101	$489	$-
6	Swine	Pit	GF	Large2	MA	2	L	16.5	$6,727,328	$-	$1,654,672	$1,817	$-
6	Swine	Pit	GF	Large1	MA	2	L	23.0	$3,170,904	$-	$848,658	$842	$-
6	Swine	Liquid	GF	Large2	MA	2	L	27.5	$9,249,370	$-	$745,507	$3,029	$371,012
6	Swine	Liquid	GF	Large1	MA	2	L	38.4	$4,473,658	$-	$480,126	$1,405	$173,055
6	Swine	Pit	GF	Large2	MW	2	L	32.0	$12,312,846	$-	$1,015,012	$6,482	$-
6	Swine	Pit	GF	Large1	MW	2	L	44.6	$5,333,075	$-	$583,204	$2,849	$-
6	Swine	Liquid	GF	Large2	MW	2	L	13.2	$4,838,903	$-	$265,034	$2,674	$87,991
6	Swine	Liquid	GF	Large1	MW	2	L	18.5	$2,150,686	$-	$180,067	$1,182	$37,452
6	Swine	Evapor	FF	Large2	CE	3	L	4.0	$3,636,998	$-	$145,548	$-	$-
6	Swine	Evapor	FF	Large1	CE	3	L	5.5	$727,199	$-	$52,678	$-	$-
6	Swine	Pit	FF	Large2	MA	3	L	3.0	$1,517,440	$-	$367,754	$-	$-
6	Swine	Pit	FF	Large1	MA	3	L	4.2	$636,955	$-	$167,590	$-	$-
6	Swine	Liquid	FF	Large2	MA	3	L	9.6	$3,780,947	$-	$242,098	$-	$165,231
6	Swine	Liquid	FF	Large1	MA	3	L	13.3	$1,575,723	$-	$147,147	$-	$67,798
6	Swine	Pit	FF	Large2	MW	3	L	20.9	$13,907,425	$-	$1,376,059	$-	$-
6	Swine	Pit	FF	Large1	MW	3	L	29.1	$5,250,514	$-	$622,446	$-	$-
6	Swine	Liquid	FF	Large2	MW	3	L	16.1	$9,427,416	$-	$407,757	$-	$308,753
6	Swine	Liquid	FF	Large1	MW	3	L	22.5	$3,577,320	$-	$236,935	$-	$115,655
6	Swine	Evapor	GF	Large2	CE	3	L	4.1	$3,559,234	$-	$191,482	$-	$-
6	Swine	Evapor	GF	Large1	CE	3	L	5.7	$720,093	$-	$63,005	$-	$-
6	Swine	Pit	GF	Large2	MA	3	L	4.8	$2,276,281	$-	$613,126	$-	$-
6	Swine	Pit	GF	Large1	MA	3	L	6.7	$953,376	$-	$277,571	$-	$-

Table A-1 (Continued)

Option	Animal	Farm Type	Manure Type	Size Class	Region	Category	Performance Needs	Number of Facilities	Capital Costs	Fixed Costs	Annual O&M Costs	3-Year Recurring O&M Costs	5-Year Recurring O&M Costs
6	Swine	Liquid	GF	Large2	MA	3	L	8.1	$3,002,390	$-	$245,561	$-	$139,414
6	Swine	Liquid	GF	Large1	MA	3	L	11.2	$1,249,977	$-	$140,833	$-	$57,093
6	Swine	Pit	GF	Large2	MW	3	L	26.8	$17,610,962	$-	$1,897,000	$-	$-
6	Swine	Pit	GF	Large1	MW	3	L	37.4	$6,664,751	$-	$849,605	$-	$-
6	Swine	Liquid	GF	Large2	MW	3	L	11.1	$6,672,735	$-	$335,849	$-	$212,867
6	Swine	Liquid	GF	Large1	MW	3	L	15.5	$2,529,248	$-	$183,732	$-	$79,673
6	Swine	Evapor	FF	Large2	CE	1	M	6.2	$1,045,073	$9,874	$68,591	$695	$6,528
6	Swine	Evapor	FF	Large1	CE	1	M	8.6	$583,303	$8,326	$65,278	$394	$3,688
6	Swine	Pit	FF	Large2	MA	1	M	3.5	$895,070	$1,754	$54,490	$738	$1,376
6	Swine	Pit	FF	Large1	MA	1	M	4.9	$446,421	$1,238	$43,712	$382	$714
6	Swine	Liquid	FF	Large2	MA	1	M	11.2	$2,240,265	$4,851	$173,330	$1,955	$3,641
6	Swine	Liquid	FF	Large1	MA	1	M	15.6	$1,119,911	$3,579	$138,717	$1,022	$1,910
6	Swine	Pit	FF	Large2	MW	1	M	50.0	$11,160,942	$94,844	$604,737	$7,258	$67,844
6	Swine	Pit	FF	Large1	MW	1	M	69.6	$7,061,074	$82,539	$582,556	$4,795	$44,955
6	Swine	Liquid	FF	Large2	MW	1	M	38.6	$7,610,651	$68,585	$466,574	$5,103	$47,741
6	Swine	Liquid	FF	Large1	MW	1	M	53.8	$4,837,258	$61,078	$450,254	$3,422	$32,026
6	Swine	Evapor	GF	Large2	CE	1	M	6.3	$1,014,654	$10,033	$81,551	$707	$6,633
6	Swine	Evapor	GF	Large1	CE	1	M	8.9	$577,453	$8,616	$74,124	$408	$3,816
6	Swine	Pit	GF	Large2	MA	1	M	5.7	$1,367,107	$2,857	$103,508	$1,202	$2,241
6	Swine	Pit	GF	Large1	MA	1	M	7.9	$675,824	$1,996	$77,634	$616	$1,150
6	Swine	Liquid	GF	Large2	MA	1	M	9.4	$1,770,593	$4,071	$169,579	$1,641	$3,056
6	Swine	Liquid	GF	Large1	MA	1	M	13.1	$886,993	$3,005	$128,238	$858	$1,604
6	Swine	Pit	GF	Large2	MW	1	M	64.1	$14,131,183	$121,590	$880,759	$9,304	$86,976

Table A-1 (Continued)

Option	Animal	Farm Type	Manure Type	Size Class	Region	Category	Performance Needs	Number of Facilities	Capital Costs	Fixed Costs	Annual O&M Costs	3-Year Recurring O&M Costs	5-Year Recurring O&M Costs
6	Swine	Pit	GF	Large1	MW	1	M	89.4	$8,959,085	$106,020	$814,228	$6,160	$57,744
6	Swine	Liquid	GF	Large2	MW	1	M	26.6	$5,382,726	$47,263	$365,182	$3,517	$32,899
6	Swine	Liquid	GF	Large1	MW	1	M	37.1	$3,422,054	$42,119	$337,784	$2,360	$22,085
6	Swine	Evapor	FF	Large2	CE	2	M	14.0	$3,799,281	$29,234	$204,514	$2,312	$21,683
6	Swine	Evapor	FF	Large1	CE	2	M	19.5	$1,804,878	$20,608	$164,635	$1,073	$10,090
6	Swine	Pit	FF	Large2	MA	2	M	20.5	$8,915,128	$6,941	$1,940,363	$2,537	$4,748
6	Swine	Pit	FF	Large1	MA	2	M	28.6	$4,203,137	$5,278	$1,006,100	$1,190	$2,217
6	Swine	Liquid	FF	Large2	MA	2	M	65.4	$23,188,517	$22,143	$1,500,172	$8,095	$897,480
6	Swine	Liquid	FF	Large1	MA	2	M	91.2	$11,139,166	$16,829	$1,027,015	$3,793	$418,076
6	Swine	Pit	FF	Large2	MW	2	M	49.8	$19,404,930	$133,005	$1,384,309	$11,313	$106,124
6	Swine	Pit	FF	Large1	MW	2	M	69.4	$8,403,879	$84,485	$835,110	$5,040	$47,064
6	Swine	Liquid	FF	Large2	MW	2	M	38.5	$13,705,324	$102,825	$670,334	$8,746	$338,685
6	Swine	Liquid	FF	Large1	MW	2	M	53.7	$6,048,228	$65,372	$487,391	$3,900	$145,128
6	Swine	Evapor	GF	Large2	CE	2	M	14.3	$3,706,782	$29,861	$252,501	$2,361	$22,148
6	Swine	Evapor	GF	Large1	CE	2	M	20.0	$1,769,902	$21,136	$189,229	$1,101	$10,349
6	Swine	Pit	GF	Large2	MA	2	M	33.0	$13,455,745	$11,173	$3,317,330	$4,085	$7,642
6	Swine	Pit	GF	Large1	MA	2	M	46.0	$6,343,325	$8,488	$1,708,447	$1,913	$3,566
6	Swine	Liquid	GF	Large2	MA	2	M	55.0	$18,405,743	$18,622	$1,502,453	$6,808	$754,762
6	Swine	Liquid	GF	Large1	MA	2	M	76.7	$8,857,881	$14,153	$975,926	$3,190	$351,605
6	Swine	Pit	GF	Large2	MW	2	M	63.9	$24,589,323	$170,663	$2,042,317	$14,517	$136,171
6	Swine	Pit	GF	Large1	MW	2	M	89.1	$10,657,133	$108,467	$1,186,663	$6,470	$60,423
6	Swine	Liquid	GF	Large2	MW	2	M	26.5	$9,674,844	$70,776	$537,692	$6,020	$233,121
6	Swine	Liquid	GF	Large1	MW	2	M	36.9	$4,258,952	$44,921	$367,447	$2,680	$99,725

Table A-1 (Continued)

Option	Animal	Farm Type	Manure Type	Size Class	Region	Category	Performance Needs	Number of Facilities	Capital Costs	Fixed Costs	Annual O&M Costs	3-Year Recurring O&M Costs	5-Year Recurring O&M Costs
6	Swine	Evapor	FF	Large2	CE	3	M	7.9	$7,194,696	$-	$289,599	$-	$-
6	Swine	Evapor	FF	Large1	CE	3	M	11.1	$1,474,080	$-	$109,122	$-	$-
6	Swine	Pit	FF	Large2	MA	3	M	6.0	$3,034,892	$-	$736,960	$-	$-
6	Swine	Pit	FF	Large1	MA	3	M	8.4	$1,273,927	$-	$337,213	$-	$-
6	Swine	Liquid	FF	Large2	MA	3	M	19.1	$7,538,686	$-	$486,621	$-	$328,742
6	Swine	Liquid	FF	Large1	MA	3	M	26.7	$3,176,297	$-	$302,128	$-	$136,106
6	Swine	Pit	FF	Large2	MW	3	M	41.7	$27,748,391	$-	$2,755,626	$-	$-
6	Swine	Pit	FF	Large1	MW	3	M	58.2	$10,501,144	$-	$1,258,977	$-	$-
6	Swine	Liquid	FF	Large2	MW	3	M	32.3	$18,942,283	$-	$826,445	$-	$619,424
6	Swine	Liquid	FF	Large1	MW	3	M	45.0	$7,176,735	$-	$485,210	$-	$231,309
6	Swine	Evapor	GF	Large2	CE	3	M	8.1	$7,043,577	$-	$380,488	$-	$-
6	Swine	Evapor	GF	Large1	CE	3	M	11.3	$1,434,129	$-	$127,764	$-	$-
6	Swine	Pit	GF	Large2	MA	3	M	9.7	$4,600,005	$-	$1,241,372	$-	$-
6	Swine	Pit	GF	Large1	MA	3	M	13.5	$1,921,008	$-	$562,552	$-	$-
6	Swine	Liquid	GF	Large2	MA	3	M	16.1	$5,981,350	$-	$492,260	$-	$277,107
6	Swine	Liquid	GF	Large1	MA	3	M	22.5	$2,522,073	$-	$288,593	$-	$114,696
6	Swine	Pit	GF	Large2	MW	3	M	53.6	$35,222,032	$-	$3,806,971	$-	$-
6	Swine	Pit	GF	Large1	MW	3	M	74.7	$13,311,831	$-	$1,715,016	$-	$-
6	Swine	Liquid	GF	Large2	MW	3	M	22.2	$13,365,329	$-	$677,470	$-	$425,734
6	Swine	Liquid	GF	Large1	MW	3	M	31.0	$5,073,717	$-	$375,277	$-	$159,346

Appendix B

CAFO POULTRY MODEL FARM COMPOSTING COST

Table B-1. CAFO Poultry Model Farm Composting Costs

Operation	Region	Size ID	Category	Perfor-mance Needs	# Facilities	Number of Birds	Cropland (acres)	Model Farm Composting Cost (a)	Model Farm Irrigation Cost	Model Farm Total (b)	Total (c)
Broiler	Mid-Atlantic	Large1	1	H	4	125,000	493	$53,988	$25,806	$79,794	$287,372
Broiler	Mid-Atlantic	Large1	1	L	4	125,000	493	$53,988	$25,806	$79,794	$287,372
Broiler	Mid-Atlantic	Large1	1	M	7	125,000	493	$53,988	$25,806	$79,794	$574,744
Broiler	Mid-Atlantic	Large1	2	H	54	132,969	173	$57,430	$15,324	$72,753	$3,910,622
Broiler	Mid-Atlantic	Large1	2	L	54	132,969	173	$57,430	$15,324	$72,753	$3,910,622
Broiler	Mid-Atlantic	Large1	2	M	108	132,969	173	$57,430	$15,324	$72,753	$7,821,245
Broiler	Mid-Atlantic	Large1	3	H	27	150,049	0	$64,807	$6,803	$71,610	$1,911,765
Broiler	Mid-Atlantic	Large1	3	L	27	150,049	0	$64,807	$6,803	$71,610	$1,911,765
Broiler	Mid-Atlantic	Large1	3	M	53	150,049	0	$64,807	$6,803	$71,610	$3,823,530
Broiler	Mid-Atlantic	Large2	1	H	2	263,625	1,007	$113,861	$48,034	$161,894	$337,198
Broiler	Mid-Atlantic	Large2	1	L	2	263,625	1,007	$113,861	$48,034	$161,894	$337,198
Broiler	Mid-Atlantic	Large2	1	M	4	263,625	1,007	$113,861	$48,034	$161,894	$674,395
Broiler	Mid-Atlantic	Large2	2	H	31	327,459	297	$141,431	$19,377	$160,808	$4,998,971
Broiler	Mid-Atlantic	Large2	2	L	31	327,459	297	$141,431	$19,377	$160,808	$4,998,971
Broiler	Mid-Atlantic	Large2	2	M	62	327,459	297	$141,431	$19,377	$160,808	$9,997,942
Broiler	Mid-Atlantic	Large2	3	H	15	383,846	0	$165,784	$6,803	$172,588	$2,664,714
Broiler	Mid-Atlantic	Large2	3	L	15	383,846	0	$165,784	$6,803	$172,588	$2,664,714
Broiler	Mid-Atlantic	Large2	3	M	31	383,846	0	$165,784	$6,803	$172,588	$5,329,428
Broiler	South	Large1	1	H	3	125,000	853	$53,988	$40,387	$94,375	$261,168
Broiler	South	Large1	1	L	3	125,000	853	$53,988	$40,387	$94,375	$261,168
Broiler	South	Large1	1	M	6	125,000	853	$53,988	$40,387	$94,375	$522,337
Broiler	South	Large1	2	H	126	134,989	129	$58,302	$13,674	$71,976	$9,066,428
Broiler	South	Large1	2	L	126	134,989	129	$58,302	$13,674	$71,976	$9,066,428
Broiler	South	Large1	2	M	252	134,989	129	$58,302	$13,674	$71,976	$18,132,857

Table B-1 (Continued)

Operation	Region	Size ID	Category	Perfor-mance Needs	# Facilities	Number of Birds	Cropland (acres)	Model Farm Composting Cost (a)	Model Farm Irrigation Cost	Model Farm Total (b)	Total (c)
Broiler	South	Large1	3	H	46	132,017	0	$57,019	$6,803	$63,822	$2,917,831
Broiler	South	Large1	3	L	46	132,017	0	$57,019	$6,803	$63,822	$2,917,831
Broiler	South	Large1	3	M	91	132,017	0	$57,019	$6,803	$63,822	$5,835,661
Broiler	South	Large2	1	H	2	242,608	1,591	$104,783	$85,305	$190,088	$304,227
Broiler	South	Large2	1	L	2	242,608	1,591	$104,783	$85,305	$190,088	$304,227
Broiler	South	Large2	1	M	3	242,608	1,591	$104,783	$85,305	$190,088	$608,453
Broiler	South	Large2	2	H	73	313,353	213	$135,338	$16,686	$152,024	$11,074,940
Broiler	South	Large2	2	L	73	313,353	213	$135,338	$16,686	$152,024	$11,074,940
Broiler	South	Large2	2	M	146	313,353	213	$135,338	$16,686	$152,024	$22,149,881
Broiler	South	Large2	3	H	26	325,838	0	$140,731	$6,803	$147,534	$3,900,881
Broiler	South	Large2	3	L	26	325,838	0	$140,731	$6,803	$147,534	$3,900,881
Broiler	South	Large2	3	M	53	325,838	0	$140,731	$6,803	$147,534	$7,801,762
Layer: Dry	Mid-West	Large1	1	H	8	291,153	2,100	$133,616	$128,773	$262,389	$1,974,419
Layer: Dry	Mid-West	Large1	1	L	8	291,153	2,100	$133,616	$128,773	$262,389	$1,974,419
Layer: Dry	Mid-West	Large1	1	M	15	291,153	2,100	$133,616	$128,773	$262,389	$3,948,838
Layer: Dry	Mid-West	Large1	2	H	46	291,153	62	$133,616	$10,308	$143,923	$6,574,745
Layer: Dry	Mid-West	Large1	2	L	46	291,153	62	$133,616	$10,308	$143,923	$6,574,745
Layer: Dry	Mid-West	Large1	2	M	91	291,153	62	$133,616	$10,308	$143,923	$13,149,489
Layer: Dry	Mid-West	Large1	3	H	49	291,153	0	$133,616	$6,803	$140,419	$6,811,429
Layer: Dry	Mid-West	Large1	3	L	49	291,153	0	$133,616	$6,803	$140,419	$6,811,429
Layer: Dry	Mid-West	Large1	3	M	97	291,153	0	$133,616	$6,803	$140,419	$13,622,858
Layer: Dry	Mid-West	Large2	1	H	1	856,368	6,177	$393,003	$860,156	$1,253,159	$1,438,648
Layer: Dry	Mid-West	Large2	1	L	1	856,368	6,177	$393,003	$860,156	$1,253,159	$1,438,648
Layer: Dry	Mid-West	Large2	1	M	2	856,368	6,177	$393,003	$860,156	$1,253,159	$2,877,295
Layer: Dry	Mid-West	Large2	2	H	7	856,368	80	$393,003	$11,404	$404,407	$2,818,517

Table B-1 (Continued)

Operation	Region	Size ID	Category	Perfor-mance Needs	# Facilities	Number of Birds	Cropland (acres)	Model Farm Composting Cost (a)	Model Farm Irrigation Cost	Model Farm Total (b)	Total (c)
Layer: Dry	Mid-West	Large2	2	L	7	856,368	80	$393,003	$11,404	$404,407	$2,818,517
Layer: Dry	Mid-West	Large2	2	M	14	856,368	80	$393,003	$11,404	$404,407	$5,637,033
Layer: Dry	Mid-West	Large2	3	H	7	856,368	0	$393,003	$6,803	$399,807	$2,958,806
Layer: Dry	Mid-West	Large2	3	L	7	856,368	0	$393,003	$6,803	$399,807	$2,958,806
Layer: Dry	Mid-West	Large2	3	M	15	856,368	0	$393,003	$6,803	$399,807	$5,917,611
Layer: Dry	South	Large1	1	H	3	291,153	2,424	$133,616	$162,021	$295,636	$984,377
Layer: Dry	South	Large1	1	L	3	291,153	2,424	$133,616	$162,021	$295,636	$984,377
Layer: Dry	South	Large1	1	M	7	291,153	2,424	$133,616	$162,021	$295,636	$1,968,755
Layer: Dry	South	Large1	2	H	27	291,153	62	$133,616	$10,308	$143,923	$3,951,927
Layer: Dry	South	Large1	2	L	27	291,153	62	$133,616	$10,308	$143,923	$3,951,927
Layer: Dry	South	Large1	2	M	55	291,153	62	$133,616	$10,308	$143,923	$7,903,854
Layer: Dry	South	Large1	3	H	28	291,153	0	$133,616	$6,803	$140,419	$3,941,432
Layer: Dry	South	Large1	3	L	28	291,153	0	$133,616	$6,803	$140,419	$3,941,432
Layer: Dry	South	Large1	3	M	56	291,153	0	$133,616	$6,803	$140,419	$7,882,864
Layer: Dry	South	Large2	1	H	0	856,368	7,131	$393,003	$1,130,489	$1,523,493	$529,569
Layer: Dry	South	Large2	1	L	0	856,368	7,131	$393,003	$1,130,489	$1,523,493	$529,569
Layer: Dry	South	Large2	1	M	1	856,368	7,131	$393,003	$1,130,489	$1,523,493	$1,059,137
Layer: Dry	South	Large2	2	H	3	856,368	80	$393,003	$11,404	$404,407	$1,159,242
Layer: Dry	South	Large2	2	L	3	856,368	80	$393,003	$11,404	$404,407	$1,159,242
Layer: Dry	South	Large2	2	M	6	856,368	80	$393,003	$11,404	$404,407	$2,318,483
Layer: Dry	South	Large2	3	H	3	856,368	0	$393,003	$6,803	$399,807	$1,171,536
Layer: Dry	South	Large2	3	L	3	856,368	0	$393,003	$6,803	$399,807	$1,171,536
Layer: Dry	South	Large2	3	M	6	856,368	0	$393,003	$6,803	$399,807	$2,343,072
Layer: Wet	South	Large1	1	H	7	146,426	980	$298,477	$0	$298,477	$2,112,481
Layer: Wet	South	Large1	1	L	7	146,426	980	$298,477	$0	$298,477	$2,112,481

Table B-1 (Continued)

Operation	Region	Size ID	Category	Perfor-mance Needs	# Facilities	Number of Birds	Cropland (acres)	Model Farm Composting Cost (a)	Model Farm Irrigation Cost	Model Farm Total (b)	Total (c)
Layer: Wet	South	Large1	1	M	14	146,426	980	$298,477	$0	$298,477	$4,224,962
Layer: Wet	South	Large1	2	H	43	146,426	260	$298,477	$0	$298,477	$12,824,682
Layer: Wet	South	Large1	2	L	43	146,426	260	$298,477	$0	$298,477	$12,824,682
Layer: Wet	South	Large1	2	M	86	146,426	260	$298,477	$0	$298,477	$25,649,364
Layer: Wet	South	Large1	3	H	46	146,426	0	$298,477	$0	$298,477	$13,617,926
Layer: Wet	South	Large1	3	L	46	146,426	0	$298,477	$0	$298,477	$13,617,926
Layer: Wet	South	Large1	3	M	91	146,426	0	$298,477	$0	$298,477	$27,235,853
Turkey	Mid-Atlantic	Large1	1	H	1	127,396	1,233	$107,095	$60,852	$167,946	$204,585
Turkey	Mid-Atlantic	Large1	1	L	1	127,396	1,233	$107,095	$60,852	$167,946	$204,585
Turkey	Mid-Atlantic	Large1	1	M	2	127,396	1,233	$107,095	$60,852	$167,946	$409,170
Turkey	Mid-Atlantic	Large1	2	H	24	127,396	437	$107,095	$23,895	$130,990	$3,114,291
Turkey	Mid-Atlantic	Large1	2	L	24	127,396	437	$107,095	$23,895	$130,990	$3,114,291
Turkey	Mid-Atlantic	Large1	2	M	48	127,396	437	$107,095	$23,895	$130,990	$6,228,582
Turkey	Mid-Atlantic	Large1	3	H	16	127,396	0	$107,095	$6,803	$113,898	$1,794,127
Turkey	Mid-Atlantic	Large1	3	L	16	127,396	0	$107,095	$6,803	$113,898	$1,794,127
Turkey	Mid-Atlantic	Large1	3	M	32	127,396	0	$107,095	$6,803	$113,898	$3,588,254
Turkey	Mid-West	Large1	1	H	2	127,396	1,023	$107,095	$48,864	$155,959	$262,298
Turkey	Mid-West	Large1	1	L	2	127,396	1,023	$107,095	$48,864	$155,959	$262,298
Turkey	Mid-West	Large1	1	M	3	127,396	1,023	$107,095	$48,864	$155,959	$524,596
Turkey	Mid-West	Large1	2	H	33	127,396	437	$107,095	$23,895	$130,990	$4,299,731
Turkey	Mid-West	Large1	2	L	33	127,396	437	$107,095	$23,895	$130,990	$4,299,731
Turkey	Mid-West	Large1	2	M	66	127,396	437	$107,095	$23,895	$130,990	$8,599,461
Turkey	Mid-West	Large1	3	H	22	127,396	0	$107,095	$6,803	$113,898	$2,477,053
Turkey	Mid-West	Large1	3	L	22	127,396	0	$107,095	$6,803	$113,898	$2,477,053
Turkey	Mid-West	Large1	3	M	43	127,396	0	$107,095	$6,803	$113,898	$4,954,105

Appendix C

ADDITIONAL POLLUTANT LOADS DATA

Table C-1. BOD Loads from Large CAFOs (in millions of pounds per year)

Sector	Baseline	Option 1	Option 2	Option 3	Option 5a	Option 5	Option 6	Option 7
Cattle	7	7	7	7	4	N/A	7	7
Dairy	3	3	3	3	2	N/A	1	1
Swine	7	7	7	7	N/A	0	1	0
Poultry	6	0	0	0	0	N/A	0	0
Poultry (wet)	13	13	13	13	N/A	0	13	13
Total	37	31	31	31	6	0	22	22

Table C-2. Sediment Loads from Large CAFOs (in millions of pounds per year)

Sector	Baseline	Option 1	Option 2	Option 3	Option 5a	Option 5	Option 6	Option 7
Cattle	11339	10138	10138	10138	10113	N/A	10138	10138
Dairy	1856	1757	1757	1757	1749	N/A	1748	1749
Swine	2937	2937	2824	2824	N/A	2823	2824	2823
Poultry	10996	10965	10824	10824	10824	N/A	10824	10824
Poultry (wet)	885	885	877	877	N/A	787	877	877
Total	28013	26682	26419	26419	22686	3611	26410	26411

Table C-3. FC Loads from Large CAFOs in 10^{19} Colony Forming Units

Sector	Baseline	Option 1	Option 2	Option 3	Option 5a	Option 5	Option 6	Option 7
Cattle	422	412	411	411	162	N/A	411	411
Dairy	54	53	53	53	22	N/A	19	30
Swine	139	138	138	138	N/A	1	1	2
Poultry	7	0	0	0	0	N/A	0	0
Poultry (wet)	57	56	56	56	N/A	0	56	56
Total	678	659	659	659	184	1	489	500

Table C-4. Incremental Pollutant Reductions

OPTION 3	BOD	TSS	FC
Cattle	0.0	0.0	0.0
Dairy	0.0	0.0	0.0
Swine	0.0	0.0	0.0
Poultry	0.0	0.0	0.0
Poultry (wet)	0.0	0.0	0.0
Poultry total	0.0	0.0	0.0
OPTION 5a	**BOD**	**TSS**	**FC**
Cattle	2.9	24.7	249.9
Dairy	1.2	7.2	30.4
Swine	N/A	N/A	N/A
Poultry	0.0	0.0	0.5
Poultry (wet)	N/A	N/A	N/A
OPTION 5	**BOD**	**TSS**	**FC**
Cattle	N/A	N/A	N/A
Dairy	N/A	N/A	N/A
Swine	7.4	0.6	137.4
Poultry	N/A	N/A	N/A
Poultry (wet)	13.3	89.6	56.4
OPTION 6	**BOD**	**TSS**	**FC**
Dairy	2.2	8.8	33.3
Swine	6.3	0.5	137.0
OPTION 7	**BOD**	**TSS**	**FC**
Cattle	0.0	0.1	0.6
Dairy	1.8	7.3	22.9
Swine	7.2	0.5	136.1
Poultry	0.0	0.0	0.0
Poultry (wet)	0.0	0.0	0.0