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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October 2008

ACKNOWLEDGMENTS AND DISCLAIMER

This report has been reviewed and approved for publication by the Engineering and Analysis Division, Office of Science and Technology. This report was prepared with the support of Eastern Research Group, Inc. and Tetra Tech, Inc., under the direction and review of the Office of Science and Technology. Neither the United States government nor any of its employees, contractors, subcontractors, or other employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use of, or the results of such use of, any information, apparatus, product, or process discussed in this report, or represents that its use by such a third party would not infringe on privately owned rights.

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Version Control

Version	EPA Publication Number	Publication Date	Description of Changes	Author's Initial
1	EPA-821-R-03-001	December 2002	Initial Release	PHS
2	EPA-821-R-06-007	June 2006	Updated Introduction and Table of Contents; new subsections to Chapters 2, 8, and 15; new Appendices	PHS
3	EPA-821-R-06-007	October 2008	Updated Introduction and Table of Contents; new subsections to Chapters 2, 8, and 15; new Appendices	PHS

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 REGULATIONS

The regulations described in this Addendum include revisions to the effluent limitations guidelines and standards (ELGs) promulgated for CAFOs on February 12, 2003 (68 FR 7176). Section 2.3.1 describes the revisions related to NSPS and Section 2.3.2 describes the revision related to BCT for the control of pathogens.

2.3 Summary of the Second Circuit Court of Appeals Decision Concerning Remanded Issues

The Second Circuit Court of Appeals (the Court) remanded certain elements of the 2003 CAFO rule related to new sources. Specifically, the court directed EPA to clarify the statutory and evidentiary 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 that allows 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 Clean Water Act (CWA)'s public participation requirements. (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 Court 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 Revised Regulation of NSPS

The CWA requires EPA to promulgate NSPS for new (as opposed to already existing) sources of pollution (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 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)).

In the initial rule, EPA proposed that NSPS for the production areas of swine, poultry, and veal CAFOs prohibit production area discharges. In the final rule, however, 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 rulemaking record for either of these decisions. This subsection summarizes EPA's changes to NSPS addressing the Court's determination.

2.3.1.1 100-Year Storm Containment Structure

EPA is deleting 40 CFR 412.46(a)(1), the provision allowing subpart D CAFOs to meet the no-discharge standard by using the 100-year, 24-hour rain event containment structure. As part of this approach, EPA is modifying Section 412.37(a)(2) by removing the 100-year, 24-hour rainfall specification but retaining the requirement that all open surface liquid impoundments have a depth marker to indicate the minimum capacity to contain the runoff and direct precipitation from a 25-year, 24-hour rainfall event. While revising the requirement, 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. The land application requirements will remain unchanged.

Additionally, EPA is presenting an alternative that authorizes the NPDES Program Director to establish no-discharge BMP effluent limitations based upon a site-specific evaluation for an individual CAFO. Compliance with such limitations provides an alternative for CAFOs to meet the zero-discharge requirement. Specifically, EPA authorizes permit writers, upon request by a CAFO, to establish best management, zero-discharge effluent limitations on a case-by-case basis when a facility demonstrates through a rigorous modeling analysis that it has designed an open containment system that will comply with the no-discharge requirements. If a facility complies with the specified site-specific design, construction, operation, and maintenance components of such a system demonstrated to meet the zero-discharge requirement, it is deemed to be in compliance with the no-discharge requirement even in the event of an unanticipated discharge.

EPA established precedence for such a provision during several case studies that utilize the USDA-NRCS's Animal Waste Management (AWM) and Soil Plant Air Water Hydrology (SPAW) tool. For this rulemaking, EPA gives the permit authority the discretion to authorize similar models and tools (71 FR 37,762).

2.3.1.2 Superior Alternative Performance Standards

EPA is deleting 40 CFR 412.46(d) and removing 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 withdrew this provision.

2.3.2 Revised Regulation of BCT for Pathogen Control

In response to the Court's ruling, 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. EPA evaluated these regulatory options despite the previous determinations of technical infeasibility, disproportionately high costs, and low affordability because these options may reduce pathogen concentrations more than the option selected for the final 2003 CAFO ELGs. EPA did not consider Options 1 and 4 because they do not reduce conventional pollutants further than the final selected Option 2. EPA also evaluated additional candidate technologies for pathogen reduction, see Chapter 8.6 for a discussion of the evaluated technologies.

EPA conducted a cost analysis for technology options based on the available candidate technologies. (See Chapter 15 for a description of the BCT analysis). EPA concluded that there are no available and economically achievable technologies that are cost reasonable that would result in greater removal of FC than the technologies on which EPA based the 2003 best practicable control technology currently available (BPT) and BCT ELGs.

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).

8.6 Treatment Technologies and Practices Evaluated for BCT for Pathogen Control

To identify technologies to be included in the BCT analysis for pathogen control, EPA reviewed data on different types of CAFO manure management systems. These systems employed treatment technologies, best management practices (BMPs) for pollution prevention, and management practices for the handling, storage, treatment, and land application of wastes. Sources of information included 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.

EPA re-evaluated technologies and information reviewed during the 2003 rulemaking as candidates for best practicable control technology currently available (BPT). EPA also assessed new technologies and information developed since the 2003 rulemaking, including technologies studied in the North Carolina State University (NCSU) Program for the Development of Environmentally Superior Technologies (ESTs). The technologies and technology combinations evaluated as BCT candidate technologies for FC removal include the following, or combinations of the following:

- Aerobic blanket system;
- Ambient temperature anaerobic digestion and greenhouse;
- Anaerobic Digestion;
- Belt system for manure removal;
- Biofiltration;
- Bion system;
- Centralized fluidized bed combustion;
- Centralized incineration of poultry waste;
- Centralized waste processing;
- Composting (Super Soils Systems solid waste treatment);
- Composting of poultry manure or litter;
- Constructed wetlands;
- Closed loop liquid treatment;
- Deep stacking of poultry litter;
- Disinfection – chlorination;
- Disinfection – ozonation and UV radiation;
- Fluidized bed incinerators;
- Freeze drying and freeze crystallization or snowmaking;
- Gasification;
- High solids anaerobic digestion (ORBIT);
- Increased standards or monitoring of lagoons and storage ponds in environmentally sensitive areas;
- Insect biomass conversion;

- Lime addition;
- Mesophilic anaerobic digestion, aeration, filtration, and disinfection;
- Mesophilic anaerobic digestion with solids separation;
- Nitrification, denitrification, and phosphorus precipitation (Super Soils Systems liquid waste treatment);
- Permeable cover system;
- Pyrolysis;
- Reciprocating aerobic/anaerobic biological processes;
- Sequencing batch reactor;
- Single-cell lagoon with biogas generation;
- Solids buildup in an uncovered lagoon;
- Solids separation;
- Thermo Master™ system;
- Thermophilic aerobic digestion;
- Timing restrictions on land application of animal waste; and
- Vermicomposting.

Section 8.6.1 provides descriptions of treatment technologies and best management practices (BMPs) which were previously considered in the 2003 rule and were identified by EPA as possible BCT candidate technologies for the reduction of fecal coliform (FC) and other pathogens.

Section 8.6.2 presents a summary of technologies that were not reviewed in the 2003 rule, including the NCSU ESTs. More information on these technologies can be found the in *Development of Environmentally Superior Technologies* Reports (EPA Docket OW-2005-0037, DCNs 1-01192, 1-01193, and 1-03015).

Section 8.6.3 presents the estimated engineering compliance costs associated with the BCT candidate technologies. More detailed information on the cost methodology used for options identified in the 2003 rule is contained in the Cost Report.

Section 8.6.4 presents an estimation of the pollutant load reductions associated with the implementation of certain options. 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; they also include, where actual discharge data were 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 are applied. More detailed information on the loading methodology used for options identified in the 2003 rule is contained in *Pollutant Loading Reductions for the Revised Effluent Limitations Guidelines for Concentrated Animal Feeding Operations* (2002).

8.6.1 Descriptions of Technologies Options Previously Considered as Possible Candidates for BPT

EPA evaluated potential BCT candidate technologies from technology options considered for BPT for the 2003 rule, and technologies reviewed but not considered as BPT options in the 2003 rule.

The option selected as BPT in the 2003 rule was Option 2, which required zero discharge from a facility designed, maintained, and operated to hold manure, litter, and other process wastewaters, including direct precipitation and runoff from a 25-year, 24-hour rainfall event. In addition, the maximum allowable nitrogen-based application rates must be determined based on the nitrogen requirement of the crop to be grown and realistic crop yields that reflect the yields obtained for the given (or similar) field in prior years; nitrogen-based agronomic application rates should be replaced by phosphorus-based agronomic application rates when dictated by site-specific conditions. Manure, litter, and other process wastewater applications must not exceed the nitrogen or phosphorus-based application rate. In addition, at least once every three years, representative soil samples should be collected and analyzed for phosphorus content from all fields where manure, litter, and other process wastewaters are applied.:

EPA selected the following options considered for BPT from the 2003 rule for evaluation in the BCT analysis because these options may potentially provide pathogen reduction beyond that of the BPT option:

- Option 3, which includes the Option 2 requirements plus increased standards or monitoring of lagoons and storage ponds in environmentally sensitive areas;

- Option 5A, which includes the Option 2 requirements, plus the implementation of a drier manure management system (i.e. composting);

- Option 6, which includes the Option 2 requirements, plus anaerobic digestion with energy recovery for Large dairy operations; and

- Option 7, which includes the Option 2 requirements, plus timing restrictions on land application of animal waste to frozen, snow-covered, or saturated ground.

More detailed descriptions of these options are included in Table 1-1 and Chapter 10.

Anaerobic digestion (Option 6) was considered as a BPT option in the 2003 rulemaking; however, the focus of the technology was not to reduce pathogens. Anaerobic digestion for pathogen removal is not identical to the technology considered as Option 6 and therefore, has different costs and pollutant removals. EPA discusses anaerobic digestion for pathogen removal in Section 8.6.2.1. EPA presents calculated costs and loads for anaerobic digestion with a focus on pathogen reduction in Section 8.6.2.2.

In addition to the options considered for BPT in the 2003 rule, EPA also reevaluated certain technology options that were rejected as BPT candidate technologies. These technologies were reconsidered for the BCT analysis because they show potential in reducing pathogens. These technologies include:

- Centralized incineration of poultry waste;
- Composting of poultry manure or litter;
- Deep stacking of poultry litter;
- Disinfection – chlorination;
- Disinfection – ozonation and UV radiation;
- Fluidized bed incinerators;
- Freeze drying and freeze crystallization or snowmaking;
- Gasification;
- Lime addition;
- Pyrolysis;
- Sequencing batch reactor;
- Single-cell lagoon with biogas generation;
- Solids buildup in an uncovered lagoon;
- Thermo Master™ system;
- Thermophilic aerobic digestion; and
- Vermicomposting.

EPA reviewed currently available data for each of the technologies above. For a number of the technologies, EPA did not identify new data that supported that the technologies were more technically feasible or further demonstrated than they had been during the 2003 rule. These technologies include centralized incineration of poultry waste, deep stacking of poultry litter, fluidized bed incinerators, freeze drying and freeze crystallization or snowmaking, gasification, pyrolysis, sequencing batch reactors, single-cell lagoon with biogas generation, solids buildup in an uncovered lagoon, the Thermo Master™ system, thermophilic aerobic digestion, and vermicomposting. Information for these technologies remains unchanged and the descriptions provided in earlier sections of this TDD should be used as the reference for those technologies. EPA rejects these technologies for BCT for the same reasons the technologies were rejected for BPT.

EPA identified and evaluated additional information for composting of poultry manure or litter, disinfection with chlorination, disinfection with ozonation and UV radiation, and lime addition. These technologies are discussed in Sections 8.6.1.2 to 8.6.1.5.

8.6.1.1 Anaerobic Digestion for Pathogen Removal

Anaerobic digestion was included as an option for BPT in the 2003 rule (Option 6). This technology has been demonstrated at roughly 80 CAFOs in the United States, with an additional 80 sites, approximately, undergoing evaluation and design. As described in Section 8.2.3.1, 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. For mesophilic digestion to occur, a constant temperature of 90 to 105 degrees Fahrenheit must be maintained and the retention period reduces to 12 to 20 days. Thermophilic digestion takes place at temperatures of 135 to 155 degrees Fahrenheit with retention times of 6 to 12 days.

Heated digestion operations (mesophilic and thermophilic) provide more pathogen removal than lagoons operating at ambient temperatures (psychrophilic). In limited cases digesters have been shown to reduce FC by as much as 99 percent (particularly by thermophilic digestion). However, regrowth of 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.

A disadvantage to anaerobic digestion is that the technology does not reduce the total nutrients present 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. Another disadvantage of anaerobic digestion is that the digester does not eliminate the need for the CAFO to have liquid impoundments for process wastewater, treated wastewater, and stormwater runoff.

The primary reasons for anaerobic digestion are manure stabilization (including odor reduction) and energy production. The increased number of mesophilic (and in some cases thermophilic) anaerobic digester installations at CAFOs is due to the increased success rate of installed systems, an increasing number of engineering and equipment supply companies, and an increase in cost share and local market incentives. Since 2003, about $25 million in grants has offset costs at a select few farms in California, Pennsylvania, Wisconsin, and New York. Although most digester systems are farm owned and operated, an increasing number of projects include commingling of high-strength organic wastes from multiple facilities to increase biogas production. In 2006, the U.S. Department of Agriculture (USDA), EPA, and the Association of State Energy Research and Technology Transfer Institutions assisted in developing a standardized protocol to standardize the process used to evaluate the performance of anaerobic digestion systems used to produce and capture methane emissions from livestock manure. This protocol has been used to evaluate a number of digesters and other waste management processes.

EPA assumes that a mesophilic digester system will reduce FC of the stored manure by 99 percent (a 2 log-order reduction). The performance data suggests the lower temperature of psychrophilic digesters is insufficient to obtain similar levels of FC removal. EPA's anaerobic digester 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 use liquid storage structures. The resources needed for a mesophilic digester designed to target pathogen reduction are expected to be higher than those for a digester designed to stabilize manure and produce biogas. Additionally, CAFO operators are unlikely to have the experience and technical expertise for start-up, troubleshooting, and routine diagnostics to ensure that the digester is operating as intended. Therefore, EPA's costs also include annual technical consultation and services necessary to ensure effective digester system operation. The total incremental costs and pollutant reductions of this option are presented in Tables 15-8 and 15-12.

Based on the available information, EPA developed cost estimates for anaerobic digesters 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 methodologies for calculating the costs. The costs 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.

8.6.1.2 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 higher operating 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. Assuming adequate space is available, composting is a technically available technology for incremental pathogen removals at most poultry operations.

EPA estimated costs for windrow composting for poultry manure/litter. EPA conservatively estimates that composting reduces FC by 99 percent. Costs for poultry composting include:

- Planning;
- Compost amendments (including water);
- Land rental for the composting area;
- Equipment for windrow turning (capital and operation and maintenance, or O&M) 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 8.6.3.4 provides a detailed explanation of the windrow composting option and methodology used to calculate costs for applying composting technology to poultry operations.

8.6.1.3 Disinfection – Chlorination

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. Commonly used disinfection technologies in the United States include the addition of chemicals such as chlorine.

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 byproducts.

Chlorine, UV light and ozone are commonly used as disinfectants in water and wastewater treatment facilities. There has been little research on disinfection of animal wastes generated at CAFOs. Chemical addition is not currently practiced in the United States for treatment of animal wastes (Macauley). In order for chlorination to be optimally effective and to minimize the generation of chlorinated byproducts, 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. The unit operations and precautions of chlorine disinfection are similar to that of lime addition, including pH control, chemical storage, mixing tanks, and holding tanks. In addition, as described above, solids removal must occur prior to chlorine disinfection. The solids must be treated separately for disinfection. Therefore, even though the costs of lime treatment will understate the costs of chlorine disinfection, EPA has assumed the cost of chlorine disinfection are the same as the cost estimates for lime treatment. Accordingly, EPA rejected chlorine disinfection as undemonstrated at CAFOs, not technically available, and impractical due to undesirable disinfection byproducts, high O&M requirements, high operator skill, considerable worker safety concerns, and overall high costs.

8.6.1.4 Disinfection – Ozonation and UV Radiation

Ozone and UV radiation are highly effective disinfectants against a wide range of pathogenic organisms, including bacteria, protozoa, and viruses. Ozone and UV radiation use in U.S. wastewater treatment is limited due to high capital and operating costs and intensive energy requirements(Macauley). Ozonation and UV radiation, like chlorination, require 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 used in the United States to treat animal wastes. EPA has been unable to identify any full scale application of ozone at a CAFO. The processes are costly and require higher levels of maintenance and operator skill. Ozone disinfection efficiency depends on a pH of 6 to 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). The unit operations ozonation and UV disinfection are similar to that of lime addition, including solids control, chemical storage, mixing tanks, and holding tanks. In addition, as described above, solids removal must occur prior to disinfection. The solids must be treated separately for disinfection. Therefore, even though the costs of lime treatment will understate the costs of ozonation and UV disinfection, EPA has assumed the costs are the same as the cost estimates for lime treatment. Therefore, EPA rejected ozonation as impractical due to undesirable disinfection byproducts, high O&M requirements, high operator skill, considerable worker safety concerns, and overall high costs.

8.6.1.5 Lime Addition

Lime addition can be used to disinfect barns, 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 a pH of 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 necessitates outside heating of the material to be treated.

EPA developed a cost estimate for lime treatment of dairy manure, which is presented in Section 8.6.3.3. The cost estimate demonstrates that the capital costs for holding tanks, dosage tanks, mixing equipment, and neutralization tanks necessary for retrofitting this technology at CAFOs are prohibitively high for application at all CAFOs. 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. Also, the addition of lime to organic wastes has been shown to accelerate ammonia emissions.

8.6.2 Review of Technologies Not Identified in the 2003 Rule

EPA also considered technologies for BCT that had not previously been considered in the 2003 rule and which were suggested by commenters. The majority of these technologies are from NCSU’s EST development program. This program was created as a result of an agreement between the Attorney General of North Carolina and three swine production corporations: Smithfield Foods and its subsidiaries**,** Premium Standard Farms, and Frontline Farmers (DCN 1-02003A1). In this agreement, the parties agreed to identify, research, and implement ESTs to reduce pollution at swine farms in North Carolina. The Phase 1 assessment yielded 18 technology candidates, where the performance verification of these technologies was conducted only at swine farms. There is no evidence these technologies were evaluated for other types of CAFOS, and since many of the technologies were developed specifically for treating swine manure, the technical availability of these candidate technologies is limited or non-existent.

The program studied the following technologies and technology combinations:

- Aerobic blanket system;
- Ambient temperature anaerobic digestion and greenhouse;
- Belt system for manure removal;
- Biofiltration;
- Centralized fluidized bed combustion;
- Composting (Super Soils Systems);
- Constructed wetlands;
- Closed loop liquid treatment;
- Gasification;
- High solids anaerobic digestion (ORBIT);
- Insect biomass conversion;
- Mesophilic anaerobic digestion, aeration, filtration, and disinfection;
- Mesophilic anaerobic digestion with solids separation;
- Nitrification, denitrification, and phosphorus precipitation (Super Soils Systems);
- Permeable cover system;
- Reciprocating aerobic/anaerobic biological processes;
- Sequencing batch reactor; and
- Solids separation.

Multiple parameters were evaluated for each technology, including the reductions in pathogens. The parameters were studied in comparison to two surrogate farms with conventional (anaerobic lagoon) treatment and storage. Based on the results of this comparison, the technologies were classified as “superior,” “equivalent” or “inferior” to the conventional systems. For FC removal, a superior technology demonstrated greater reductions in FC than the conventional treatment and storage; an equivalent technology demonstrated FC removals similar to conventional treatment, and an inferior technology demonstrated less FC removal than conventional treatment.

Pathogen reduction data for all of the candidate ESTs are presented in *Development of Environmentally Superior Technologies: Phase 3 Report for Technology Determinations per Agreements Between the Attorney General of North Carolina and Smithfield Foods, Premium Standard Farms, and Frontline Farmers*, DCN 1-03015 (the Phase 3 Report). Descriptions of the technologies and technology combinations are presented in Sections 8.6.2.1 to 8.6.2.18, along with the results of the comparison of the FC removal to conventional treatment. The EST Phase 3 report concluded none of the candidate technologies were economically viable for existing swine facilities.

Two additional technologies identified by commenters, included:

- Bion system; and
- Centralized waste processing.

These technologies are discussed in Sections 8.6.2.19 and 8.6.2.20.

8.6.2.1 Aerobic blanket system

The aerobic blanket systems (ABS) studied in the NCSU EST Program was developed by ISSUES (Innovative Sustainable Systems Utilizing Economical Solutions). The ABS includes an anaerobic lagoon which is covered by a layer of aerated water which is sprayed over the top of the lagoon. The sprayed water is designed to reduce ammonia emissions and odor. Waste from the lagoon is sent to an aerated nitrification pond, a denitrification pond, then used as flush or irrigation water.

The NCSU study determined that this technology is equivalent to traditional lagoon treatment for the removal of FC. Since the technology does not result in incremental removals of fecal coliform, it is not a BCT candidate. In addition, this technology has only been demonstrated on the NCSU EST study site.

8.6.2.2 Ambient temperature anaerobic digestion and greenhouse

The ambient temperature anaerobic digestion and greenhouse system evaluated in the NCSU EST Program is located on Barham Farm. The system consists of an in-ground covered lagoon, a methane recovery and utilization system, a nitrification and denitrification system, and greenhouses. The captured methane is used to produce heat and electricity for on-farm use. The treated water is used to irrigate the greenhouse plants.

The NCSU study determined that this technology is superior to conventional treatment for the removal of FC. However, the technology is a systems approach that incorporates anaerobic digestion, a technology already rejected for other reasons.

8.6.2.3 Belt system for manure removal

The two belt systems for manure separation studied in the NCSU EST Program were evaluated in laboratories on the NCSU campus. Physical and mechanical separation or conveyance processes are not expected to reduce pathogen content in manure. This assumption is confirmed by the NCSU study, which determined that both of the belt separation technologies are inferior to conventional treatment for the removal of FC.

8.6.2.4 Biofiltration

Biofiltration uses microorganisms to capture and degrade pollutants. The NCSU biofilitration EST was provided by Ekokan, LLC and consists of solids/liquid separation and filtration of the liquid with upflow aerated biological filters. Treated water is stored in a storage basin and either recycled to the solid separation basin or used as flush waster for the barns.

The NCSU study determined that this technology is inferior to conventional treatment for the removal of FC.

8.6.2.5 Composting (Super Soils)

Composting is one part of the process developed by Super Soils Systems, USA which was evaluated by the NCSU EST Program. Solids are separated at the farm using a flocculating agent, and transported to a composting facility where they are mixed with other materials, including cotton gin waste. The resulting product is intended to be sold for profit.

The NCSU study determined that this portion of the Super Soils Systems technology is inferior to conventional treatment for the removal of FC. However, when the Super Solids composting technology includes 30 days of curing, the NCSU study determined it to be superior to conventional treatment for the removal of FC. NCSU determined the technology was not economically viable for swine facilities. EPA’s analysis concluded the costs were not economically achievable for Subpart D facilities, and not cost reasonable for Subpart C facilities.

8.6.2.6 Constructed wetlands

The constructed wetland (CW) system studied in the NCSU EST Program is located on the Brandon Howard farm. The CW system includes mechanical and gravity solid separation and constructed wetland cells. The separated liquid is treated in the CW and undergoes nitrification and denitrification; the treated liquid may be land applied or used as flush water. The separated solids may be land applied.

The NCSU study determined that this technology is superior to conventional treatment for the removal of FC. Due to the large land requirements of constructed wetland systems, the technology is not technically available for CAFOs with an insufficient land base. The costs may further be understated to the extent the CAFO must take cropland out of production in order to construct the wetland system. However, EPA does not have data to determine precisely how many CAFOs would not have sufficient land.

8.6.2.7 Centralized fluidized bed combustion

The NCSU EST evaluated for fluidized bed combustion was a pilot scale project evaluated at Energy Projects of Idaho (EPI) using separated manure solids from Biomass Energy Sustainable Technology (BEST) solid separation technologies (which were also evaluated by the NCSU EST Program, as discussed in Section 8.6.2.18). The swine manure solids were mixed with poultry litter and combusted, producing heat which could be used for drying the waste to be combusted or to produce process steam or electricity. The resulting ash may be used as a feed supplement.

The NCSU study did not evaluate this technology for FC removal. EPA believes the technology is highly likely to reduce FC, but believes the system is not technically available due to lack of availability of independent centralized treatment locations for all CAFOs nationwide. EPA also has concerns about the costs for all CAFOs to haul to a centralized center, and the increased NWQI resulting from truck emissions.

8.6.2.8 Closed loop liquid treatment

The NCSU EST Program evaluated a closed loop treatment system developed by Environmental Technologies, LLC. The system includes solids separation, with the solids being composted. The liquids are treated with a flocculating agent and sanitizer in a settling tank. Treated liquid is used as flush water in the barn or treated further for use as drinking water for the swine.

The NCSU study determined that the liquid portion of this technology is inferior to conventional treatment for the removal of FC. However, the composting portion of the project was determined to be superior to conventional treatment for FC removal. The technology has only been demonstrated on the site which was studied in the NCSU EST Program.

8.6.2.9 Gasification

The gasification system studied in the NCSU EST Program was evaluated in a pilot-scale analysis in the Grinnells Laboratory on the NCSU campus. The combination of the gasifier with belt manure separation comprises the RE-Cycle system. The pilot scale gasifier represents a centralized batch process facility used to treat manure solids which are collected from a belt separator. Solids with a moisture content greater than 50 percent are deposited into the gasifier and heated to temperatures in excess of 1,100 degrees Celsius.

The NCSU study determined that this technology is superior to conventional treatment for the removal of FC. However, this technology must be implemented in conjunction with a solids separation technology that results in solids concentrations of greater than 50 percent. In addition, a separate treatment technology would have to be employed to treat the liquid portion of the waste. Finally, this technology has been demonstrated only in a laboratory setting, and not on-farm.

8.6.2.10 High solids anaerobic digestion (ORBIT)

The ORBIT technology consists of a high solids anaerobic digester that receives separated solids as the influent to the digester. The biogas generated by the digester is used to produce electricity or heat. Treated waste is separated into liquid and solid portions. The liquid portion is used to make liquid fertilizer and the solid portion is processed in the Super Soils Systems composting facility to create a soil amendment.

The NCSU study determined that this technology is superior to conventional treatment for the removal of FC. However, the technology has only been demonstrated on the one site which was studied in the NCSU EST Program.

8.6.2.11 Insect biomass conversion

Insect biomass conversion is another technology identified as an EST by NCSU. This technology uses soldier fly larva to treat manure. Manure is the principal food of black soldier flies, and these flies contribute to natural recycling of nutrients in manure. Soldier fly larva convert residual manure proteins and other nutrients into their biomass. One significant advantage of using solder fly larvae to treat manure solids is that the larvae achieve a notable reduction of biomass, and convert the biomass to a state that can be reused elsewhere.

The EST literature indicates that larvae modify the microbial population of manure, potentially reducing harmful bacteria (EPA Docket OW-2005-0037, DCN 1-01193). The primary value of solider fly larvae, however, is their high value as an insect feedstuff, the reduction of the manure mass, moisture content, and reduction of offensive odor. NCSU research data indicate that treatment of swine waste with soldier fly larvae actually increases pathogenic microorganisms in the finished project (EPA Docket OW-2005-0037, DCN 1-03015).

8.6.2.12 Mesophilic anaerobic digestion, aeration, filtration, and disinfection

The ISSUES RENEW (Recycling of Nutrient, Energy, and Waster) system includes an equalization tank, solid separation, a mesophilic digester, microturbine electric generator, aerobic digester, a storage basin, and treatment for water reuse. Wastewater from the swine barns flows into the equalization tanks, then into the digester. The biogas produced from the digester is sold to the local power grid. The water from the digester is aerated and either used as flush water in the barn or filtered and disinfected and used as drinking water for the swine.

The NCSU study determined that this technology is superior to conventional treatment for the removal of FC. However, the technology has only been demonstrated on the one site which was studied in the NCSU EST Program. Further, the technology is a systems approach that incorporates anaerobic digestion, a technology already rejected for other reasons.

8.6.2.13 Mesophilic anaerobic digestion with solids separation

The NCSU EST Program evaluated a technology comprised of an AgriJet flush waste removal system in combination with an AgriClean mesophilic anaerobic digester and solids separation. Waste from the barns is stored in equalization tanks, then processed through the mesophilic digester. The treated waste is stored in another equalization tank, then separated into solid and liquid portions. The solids are land applied and the liquid is used to flush the barns.

The NCSU study determined that this technology is inferior to conventional treatment for the removal of FC. In addition, the technology has only been demonstrated on the site which was studied in the NCSU EST Program.

8.6.2.14 Nitrification, denitrification, and phosphorus precipitation (Super Soils)

The Super Soils Systems treatment for liquid waste uses a three-step process: solid separation, nitrification/denitrification, and phosphorus removal. Wastes are separated into solid and liquid portions using a flocculating agent. The separated solids are transported offsite for composting (see Section 8.6.2.5). The liquid waste is alternated between an aerobic and anaerobic tank which allows for nitrification and denitrification. Next, the waste is transported to a settling tank where phosphorus is removed using chemical treatment. The treated liquid is used for flush water in the barns or as irrigation water.

The NCSU study determined that this technology is superior to conventional treatment for the removal of FC. However, the technology has only been demonstrated on the one site which was studied in the NCSU EST Program.

8.6.2.15 Permeable cover system

The permeable cover system (PCS) is another ISSUES technology which was studied in the NCSE EST Program. The PCS system consists of a lagoon with a floating woven polypropylene cover which was designed to act as a barrier, biofilter, and matrix for aerobic bacteria. Water from the lagoon flows to an aerated nitrification pond, a denitrification pond, and then is used as flush or irrigation water.

The NCSU study determined that this technology is superior to conventional treatment for the removal of FC. However, the technology has only been demonstrated on the one site which was studied in the NCSU EST Program.

8.6.2.16 Reciprocating aerobic/anaerobic biological processes

The reciprocating aerobic and anaerobic biological processes technology (ReCip) studied in the NCSU EST Program was provided by BioConcepts, Inc. The system consists of wetland cells or basins which contain alternating anaerobic and aerobic conditions, which are designed to remove nitrogen from the treated water. Water from the swine barn flows to a settling tank for solid separation, the liquid portion flows to the wetland cells. Treated liquid is used as flush water or is land applied.

The NCSU study determined that this technology is inferior to conventional treatment for the removal of FC. In addition, the technology has only been demonstrated on the one site which was studied in the NCSU EST Program.

8.6.2.17 Sequencing batch reactor

The NCSU EST Program sequencing batch reactor (SBR) technology is provided by Alternative Natural Technologies (ANT). Waste from the swine barns is collection in an equalization tank, and then pumped into the SBR. The SBR alternates between aerobic and anaerobic conditions to increase nitrogen removal. Water from the SBR is placed into a lagoon.

The NCSU study determined that the SBR by itself is equivalent to conventional treatment for the removal of FC. However, the FC removal provided by the SBR and lagoon is superior to conventional treatment.

8.6.2.18 Solids separation

The NCSU ESTs included a number of solid separation technologies, including a screw press (provided by FAN® Separator USA, Inc) with a tangential flow separator (TFS) and a Filtramat™ separator with a TFS. As stated earlier, physical and mechanical separation or conveyance processes are not expected to reduce pathogen content in manure. Therefore, EPA is not considering mechanical separation processes for BCT because mechanical separation processes do not reduce FC beyond conventional treatment This assumption was confirmed by the NCSU Report, which determined that both solids separation technologies were inferior to conventional treatment for the removal of FC.

8.6.2.19 Bion system

The Bion System consists of an enclosed manure treatment system for manure slurry treatment and biosolids recovery. EPA reviewed the available data from the vendor, and did not locate quantifiable pathogen reduction data for this technology. EPA notes that the manufacturer indicates this is an effective treatment for pathogens; however, there are no independent confirmations quantifying the pathogen reduction at this time.

8.6.2.20 Centralized Waste Processing

A centralized waste processing facility receives manure and process wastewater, mixes it with other sources, and then treats it. This is not a widely demonstrated technology, and there is an increase in emissions from the additional transportation required for manure and manure process wastewater.

8.6.3 Technology Cost Calculations

This section presents the cost calculations EPA developed for the BCT analysis. This section includes a description of the costs developed for the BPT options considered in the 2003 CAFO final rule, and costs for new technologies that EPA estimated for this BCT analysis, including costs for lime disinfection at Large dairy operations, anaerobic digestion for pathogen removal at Large swine and dairy operations (i.e., recalculated Option 6), and windrow composting at Large poultry operations (Option 5A for poultry). Also included is an estimate of the costs associated with the NCSU technologies.

8.6.3.1 Cost Calculations from the 2003 Final Rule

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. EPA used the following approach to estimate compliance costs for the CAFO 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 CAFO 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 considered in the 2003 rulemaking.

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, including stormwater 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	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Groundwater 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				✓						
Groundwater 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.

8.6.3.2 Anaerobic Digestion for Pathogen Removal

EPA estimated the costs for anaerobic digestion for pathogen removal at Large dairy and swine operations. This section describes the methodology and resources EPA used to calculate these costs.

8.6.3.2.1 Anaerobic Digestion for Pathogen Removal at Large Dairy Operations

EPA investigated the technical applicability, costs, and FC reductions associated with anaerobic digestion for pathogen removal at Large dairy operations. Some anaerobic digester systems can treat CAFO wastes at elevated temperatures, resulting in a decrease in pathogenic microorganism numbers, while converting the volatile solids into reusable energy. Section 8.6 describes 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, 1,500, and 2,500 dairy cows. Each farm is assumed to have both calves and heifers in addition to dairy cows. Based on data and assumptions previously presented in the Cost Report:

- The number of calves and heifers on site was each assumed to equal 30 percent of the dairy cows.
- The dairy cows spend 4 hours in the milking parlor and 20 hours in the free stall barn.
- The heifers and calves spend the entire time in a dry lot.

Cost Methodology

During the development of the CAFO 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 implementing 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, 1,500, and 2,500 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. O&M 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 at Large dairy operations with and without energy recovery under regulatory Option 6 with pathogen removal.

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 (http://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 (EPA Docket OW-2005-0037, DCN 1-01203). These costs are in 1997 dollars, and therefore present a conservative approach to testing affordability of this technology. 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 United States. 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; 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 8-29 lists 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 on 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 2 was specified. A flush frequency of 2.5 was established as representative of the industry (from the Cost Report) but FarmWare only recognizes whole numbers. 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 (U.S. Department of Energy, 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 (1997$)	Annual Energy Benefit (1997$)
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 (1997$)	Annual Energy Benefit (1997$)
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 O&M 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-2002-0025, 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 ongoing 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 O&M 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 USDA NASS to calculate weighted average farm sizes and counts (USDA NASS 2005). 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%
1,000–1,999	1,500	770	36%
2,000+	2,500	325	15%
	Total	**2,115**	**100%**

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

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

Farm Type	Capital (1997$)	Annual O&M with Energy Recovery (1997$)	Annual O&M without Energy Recovery (1997$)
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 1999). The cost annualization model thus incorporates a 10-year annualization period to compute annual costs.

Table 8-34. Total Annualized Model Farm Costs for Digestion at Dairies

Farm	Annualized Cost with Energy Recovery (1997$)	Annualized Cost without Energy Recovery (1997$)
Flush	$329,190	$405,363
Scrape	$56,945	$135,258

Industry Total Costs

To obtain industry costs for Option 6 with pathogen removal, the annualized anaerobic digestion costs were added to the model farm costs for Option 2. 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 $365 million with energy recovery and $476 million without energy recovery.

8.6.3.2.2 Anaerobic Digestion for Pathogen Removal at Large Swine Operations

EPA calculated the costs for an anaerobic digester option for swine operations. EPA estimated the costs with and without energy recovery (EPA Docket OW-2005-0037, DCN 1-02001).

EPA used FarmWare version 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:

- EPA used Sampson County, North Carolina, as the representative mid-Atlantic farm; Blue Earth, Minnesota, as the Midwest farm; and Beaver County, Utah, as the central United States farm.

- EPA assumed “flush everything” as the existing manure management system for liquid manure and evaporative ponds and “pull plug or cascade dam” for pit.

- Flush water is reduced to twice per day (33 percent reduction in flush water use to reduce overall system size and, therefore, reduce system cost).

- 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

- EPA used a model default of $.06 per kWh (1997$) (1999 U.S. average of 4.5 cents industrial use, 7.43 cents commercial, and 8.27 cents residential).

- Engineering costs of $25,000 (FarmWare model default, 1997$) were assumed for grow-finish facilities. Engineering costs for farrow-to-finish operations were increased to $40,000 (1997$) 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 $30,000 to $50,000 are incurred to construct an effluent holding structure, for an additional estimated $4,500 annual expense (1997$).

- “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) (1997$)	Annual Cost ($ per Head) (1997$)
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) (1997$)	Annual Cost ($ per Head) (1997$)
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 assessed to dairies ($60 hourly rate for 6 hours each month as described in DCN 1-01128).

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

Animal	Type Manure Type	Operation Type	Capital (1997$)	Annual (1997$)	Fixed (1997$)	3-Year Recurring (1997$)	5-Year Recurring (1997$)
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

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

8.6.3.3 Lime Addition

EPA estimated the costs for a Large dairy to add lime to treat manure for pathogens. This section describes the methodology and resources used to calculate costs for lime addition at Large dairy operations.

Lime treatment increases both the pH and the 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. This section describes two model dairy CAFOs with different manure removal methods (flush and scrape). These two model farms 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 that the free-stall barn alleys are flushed three times per day. For the other model dairy, EPA assumed that 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 animals are 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 that wastewater is generated at a rate of 130 gallons per day per cow. 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 the scrape dairy enters the liquid lime treatment system for disinfection. To estimate the amount of runoff that the system will treat 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 Midwestern dairy from a 25-year, 24-hour storm event is 111,004 cubic feet (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, the 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
Phosphorus 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 system 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 (by weight) 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 pounds per pound of manure solids (EPA Docket OW-2002-0025, DCN 40267). Dry lime addition to the pug mill is also based on 0.5 pounds per pound of manure solids. Table 8-39 shows the design parameters for 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 (ft^2)	NA	1,280
Lime requirements (lbs/day)		
Liquid system	9,700	1,570
Pug mill scrape manure	NA	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

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 (DCN 1-01218). Addition of lime to the dairy waste will generate heat (up to 70 degrees Celsius) 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 that, 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 (by weight) 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.

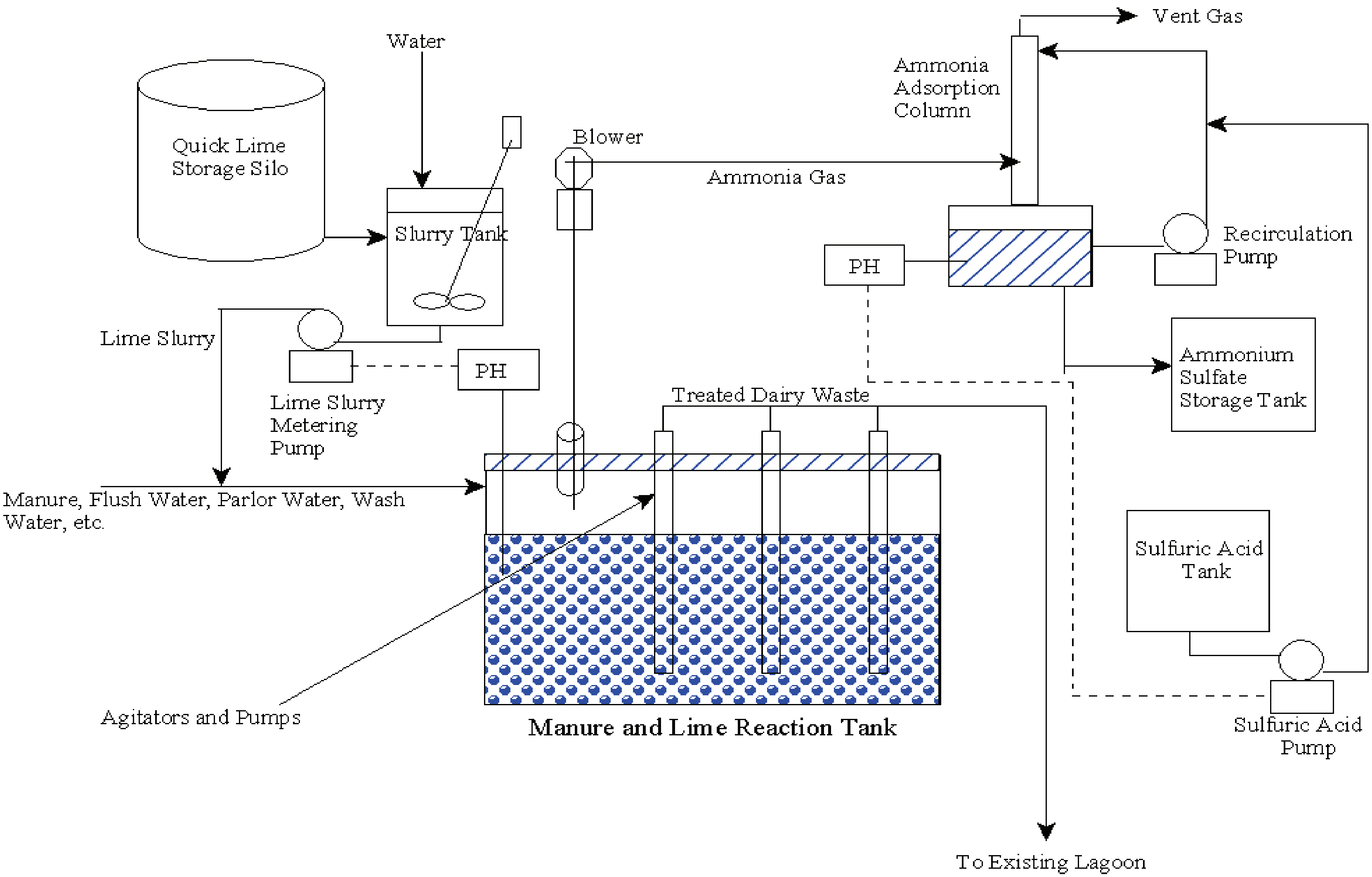

Figure 8-16. Diagram of a Flush Dairy Lime Disinfection System

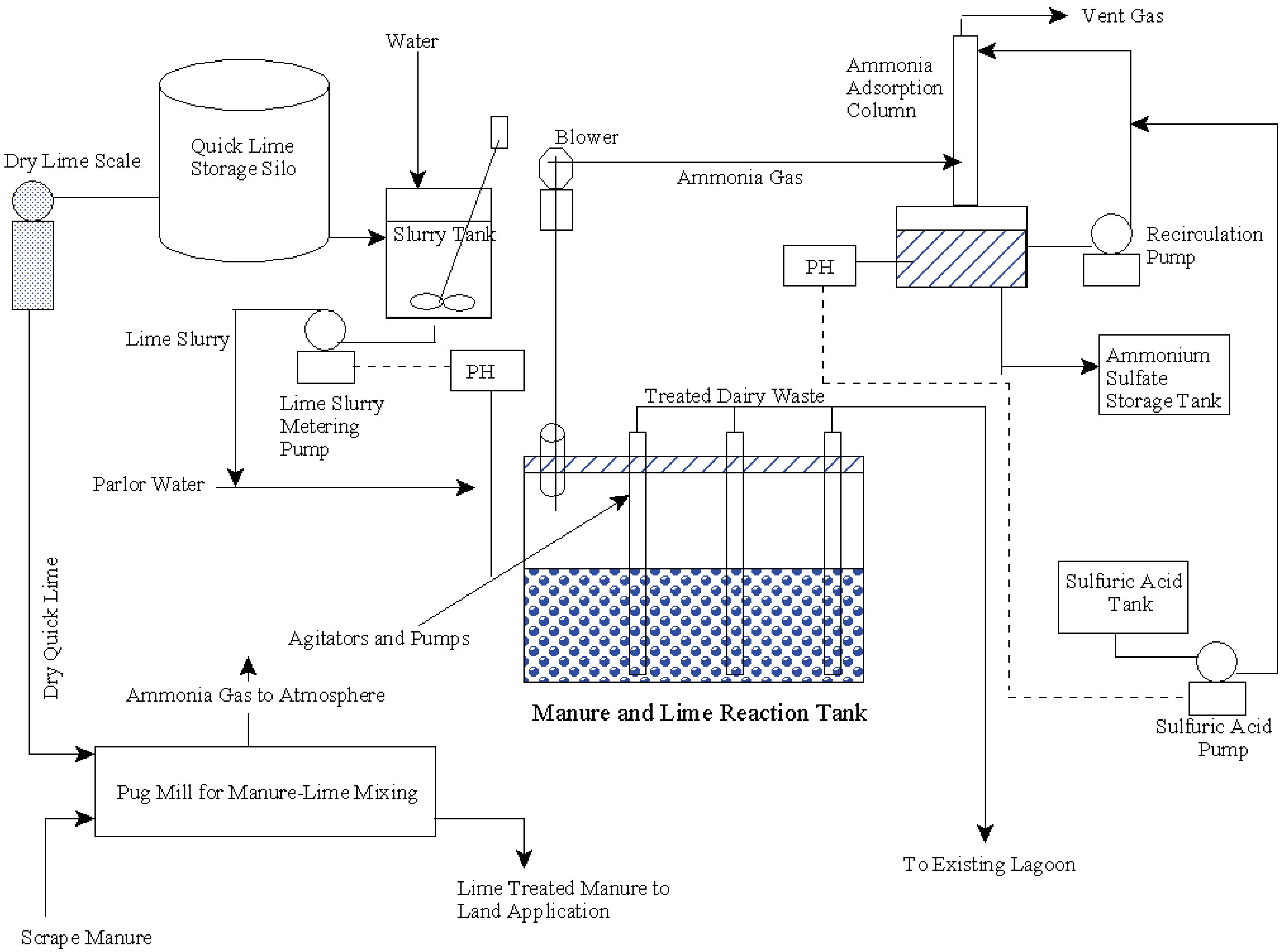

Figure 8-17. Diagram of a Scrape Dairy Lime Disinfection System

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 that 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 that 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 (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 (ft)	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 by weight) 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.

Lime Treatment System Costs

EPA estimated installed capital, 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 to equipment purchased costs for items such as plumbing and electrical 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 $335,300 per year based on an 11-year depreciation schedule and a 7 percent interest rate (2001$). The annualized cost 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

Table 8-42 summarizes capital costs for the lime disinfection system at the model dairy CAFO. 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 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 for 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 estimated cost is based only on the equipment, electricity, chemical, and labor costs; it 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 BMPs described in Option 2.

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 made 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 higher than for 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**

8.6.3.4 Composting of Poultry Manure or Litter

EPA investigated the technical applicability and costs for composting of poultry manure or litter for pathogen removal. This section describes the methodology and resources used to calculate costs for composting technology at 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. Figures 8-18 and 8-19 are conceptual diagrams of composting systems for wet layers and other poultry CAFOs.

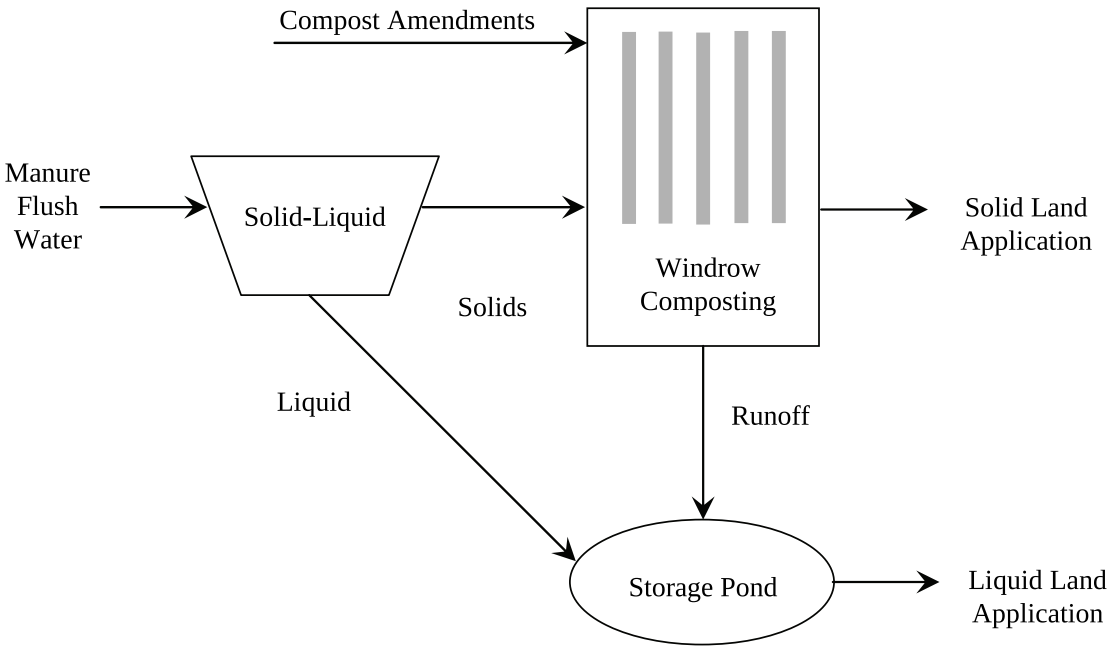

Figure 8-18. Poultry Composting System for Wet Layers

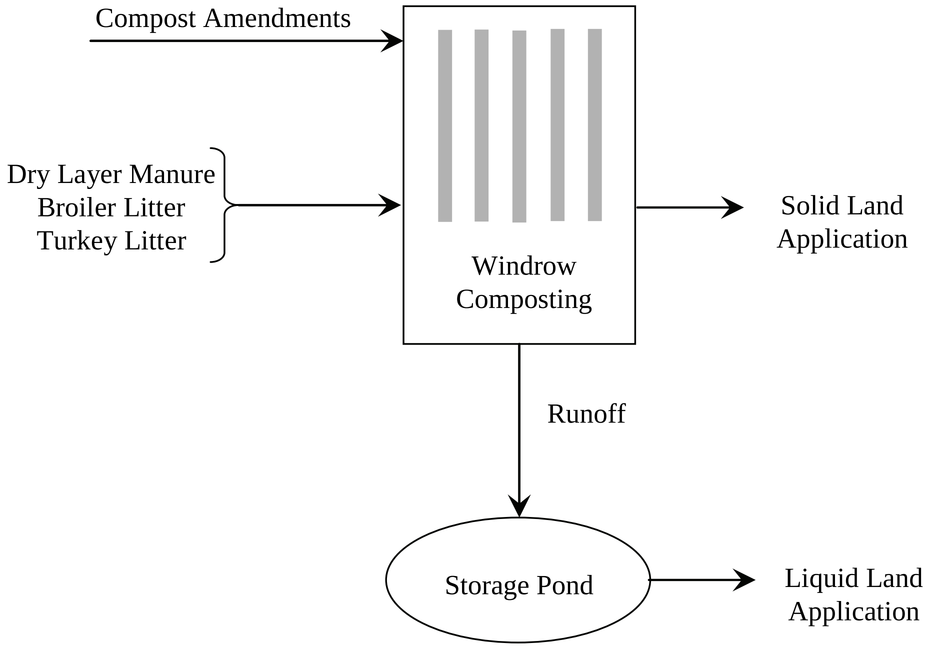

Figure 8-19. Poultry Composting System for Dry Layers, Broilers, and Turkeys

Poultry Composting Report Model Farms and Composting Costs

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 O&M) 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 model farm costs presented in the Poultry Composting Report. Revenue from compost sales is 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 and 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	Midwest	158,365	9,691	Wheat straw	10.7043	$46.34
Turkey sawdust	Midwest	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—0.0295 and 0.455 cubic feet per pound, respectively (DCN 55158). The sludge accumulation ratio for turkeys was assumed to be the same as for 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 were 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 for 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 surrounding 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.

Capital Cost = Mobilization + Excavation + Compaction + Conveyance

Annual Cost = 5% × 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 and 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.

Separation Capital Cost = (Solids Volume Generated over 6 Months × Safety Factor × Storage Tank Cost) + Separator Device + (Pipe Length × Pipe Cost) + (Installation Labor × 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 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 RSMeans Historical Cost Indices so they could be compared or added to other estimated industry costs. EPA calculated $/bird composting costs from the $/ton manure costs, using data shown in 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 99 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's $/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 more 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	$166,540,000
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 costs must be added:

- Production area and land application BMPs;
- 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) an 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 estimate 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*, August 2001 (DCN 1-01012)
$30.00	Layer manure	*Biocycle*, August 2001 (DCN 1-01012)
$25.40	Buffalo chip	Cheyenne Composting Facility (DCN 1-01009)
$11.50	Manure	Whatcom County *Manure Compost Marketing Guide* (DCN 1-01011)
$10.00	General—bulk	*Biocycle*, December 2004 (DCN 1-10101)
$15.00	General—bulk	*Biocycle*, October 2004 (DCN 1-01008)
$6.00–$15.00	Yard waste	North Carolina Department of Environment and Natural Resources (DCN 1-01013)

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 specified in the 2003 CAFO Cost Report. 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 to meet BCT requirements, in some areas an influx or excess of compost may flood the market, driving the sales price down or eliminating the positive dollar value.

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

8.6.3.5 Estimated Technology Costs for NCSU ESTs

EPA evaluated annualized technology cost data provided by the NCSU EST Program, which were presented for a 4,320-head finishing farm using a pit recharge system for manure and nitrogen-based land application to forages (EPA Docket OW-2005-0037, DCN 1-03015). The annualized costs were presented on a dollar per 1,000 pounds steady state live weight basis. EPA extrapolated the NCSU cost data to represent all farms that are considered CAFO and other animal species.

To estimate the technology costs for all swine CAFOs, EPA used data from the 2003 CAFOs rule to determine the number of swine farms that are considered CAFOs (all swine operations in the Large size category) (68 FR 7243). EPA then used farm size and animal inventory data from USDA National Agricultural Statistics Service (NASS) to determine the number of animals present on the swine CAFOs (USDA NASS 2008). EPA estimated the average weight of a U.S. pig using swine population and animal weight data from EPA's Greenhouse Gas Inventory for Manure Management (EPA 2008). The average weight was multiplied by the total number of swine present on CAFOs to determine the total weight of swine present on CAFOs. EPA then applied the NCSU dollars per 1,000 pounds animal weight to the total weight of swine present on CAFOs to develop an estimate of the total cost for swine CAFOs.

To extrapolate the NCSU swine costs to represent dairy, beef, and poultry operations, using manure production rates as the metric by which to relate to different animal types. EPA obtained manure production rate data (pounds of manure produced per 1,000 pounds of animal weight) from USDA's Natural Resource Conservation Service (NRCS) (USDA NRCS 1992). Animal groups with higher manure production rates than swine were assumed to have higher costs per 1,000 pounds animal weight in the same proportion that the manure production rate was greater. EPA is aware that factors other than the amount of manure produced would affect the actual costs to implement these technologies. In addition, EPA is aware that not all technologies would be applicable for all manure types. However, simplifying assumptions were made to estimate industry-level costs for all animal types.

EPA used the estimated technology cost per 1,000 pounds animal weight for dairy, beef, and poultry to develop an estimate of the total cost for dairy, beef, and poultry CAFOs. These costs were estimated in the same manner as described for swine above.

The NSCU technology costs and the extrapolated costs for swine, dairy, beef, and poultry CAFOS are presented in Table 15.3.

Table 8-50. Estimated Technology Costs for CAFOs, Extrapolated from NCSU EST Program Annualized Costs

Technology		NCSU Annualized Cost[1] ($/1,000 lbs. SSLW swine/year)	Estimated Total Cost for CAFOs (Millions of Dollars)			
			SWINE	DAIRY	BEEF	POULTRY
On-Farm Complete Systems	Mesophilic Anaerobic Digester and Solids Separation (AgriClean)	Insufficient data	NA	NA	NA	NA
	Sequencing Batch Reactor System (ANT)	$221.43	$349	$1,567	$2,212	$289
	Ambient Temperature Anaerobic Digester and Greenhouse (Barham Farm)	$89.17	$140	$631	$891	$117
	Belt System for Manure Removal (Grinnells)	$89.39	$141	$633	$893	$117
	Solids Separation – Site 1 (BEST: FAN + TFS)	$114.56	$180	$811	$1,144	$150
	Solids Separation – Site 2 (BEST: Filtramat + TFS)	$146.50	$231	$1,037	$1,464	$191
	Constructed Wetlands	$168.05	$265	$1,190	$1,679	$220
	Biofiltration (EKOKAN)	$342.26	$539	$2,423	$3,419	$447
	Closed Loop Liquid Treatment (Environmental Technologies, Sustainable NC-Frontline Farmers)	$136.70	$215	$968	$1,366	$179
	Aerobic Blanket System (ISSUES ABS)	$95.02	$150	$673	$949	$124
	Permeable Cover System (ISSUES PCS)	$114.52	$180	$811	$1,144	$150
	Mesophilic Anaerobic Digester, Aeration, Filtering, and Disinfection (ISSUES RENEW)	$125.93	$198	$891	$1,258	$165
	Reciprocating aerobic/ anaerobic biological processes (Re-cip)	$143.21	$225	$1,014	$1,431	$187
	Solids Separation, Nitrification/ Denitrification/ Phosphorus Precipitation (Super Soils)	$399.71	$629	$2,830	$3,993	$522
Separated Solids Treatment Systems (Add-On Technologies)[2] (assumes 0.43 dry tons of solids collected / 1,000 lbs. SSLW / year)	Centralized fluidized bed combustion facility (BEST Idaho)	$255.68	$403	$1,810	$2,554	$334
	Gasifier (RE-Cycle)	$76.33	$120	$540	$763	$100
	High Solids Anaerobic Digester (ORBIT)	$373.22	$588	$2,642	$3,728	$488
	Insect Biomass from Solids (black soldier fly)	Insufficient data	NA	NA	NA	NA
	Composting Facility (Super Soils)	$83.27	$131	$589	$832	$109

SSLW= steady state live weight

[1] Annualized Costs as shown in the table are from the NCSU EST Phase 3 Report, and are calculated for a 4,320-head finishing farm using a pit recharge systems of manure and nitrogen based land application to forages

[2] The annualized incremental costs for the solids treatment technologies include the avoided cost of on-farm land application of solids. Therefore, ($ / 1,000 lbs. SSLW / yr.) = ($ / dry ton technology cost - $ / dry ton avoided land application cost) * (dry tons of solids / 1,000 lbs. SSLW / yr.). Because the avoided land application costs are accounted for, the incremental annualized costs for the solids treatment systems can be added directly to the incremental annualized costs for complete on-farm systems (which include the cost of land applying solids).

8.6.4 Pollutant Load Calculations

EPA applied the estimated pollutant loads generated for 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 as follows:

- 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 percent, TS: 57 percent, TN: 58 percent, TP: 50 percent, bacteria: 57 percent). 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 that 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 percent, TS: 30 percent, TN: 65 percent, TP: 85 percent, bacteria: 99 percent). 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, EPA 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; Knisel et al., 1993, Sharpley and Williams, 1990, U.S. EPA, 2001) 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 that the timing of land application in relation to future rainfall events is a key parameter.

After 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, DCN 1-01222). The data required for the WMM model includes the 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 that 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 that 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 the 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 8-51. 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 8-52. 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 8-53. 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

8.6.5 References

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Chapter 15

ADDITIONAL ANALYSES IN RESPONSE TO THE 2005 SECOND CIRCUIT COURT DECISION

In response to the 2005 Second Circuit Court decision regarding the 2003 promulgated rule, EPA reexamined the New Source Performance Standards (NSPS) and evaluated technologies for BCT for fecal coliform (FC). These analyses and the resulting proposed revisions to the rule are discussed in this chapter.

15.1 New Source Performance Standards

EPA removed the provisions that authorized two alternatives for compliance with the NSPS requirement for no discharge of manure, litter, or process wastewater into waters of the U.S. from the production area. A new provision would allow a CAFO using an open surface manure storage structure to request the NPDES permitting authority to establish site-specific effluent limitations for its NPDES permit that incorporate the NSPS no discharge requirement. Facilities with open manure storage structures may demonstrate the no-discharge requirements using site-specific design, construction, operation, and maintenance components and an appropriate computer model such as the Animal Waste Management (AWM) model from the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS).

A CAFO may prevent discharge from an open storage system by providing adequate storage of manure and wastewater during critical periods. Adequate storage is based on a site-specific evaluation of the CAFO's entire waste-handling system. Conditions such as seasonal precipitation and winter storage capacity must be factored into the proper design and construction of any storage facility. In addition, removing manure and wastewater from the storage system for land application is an important component in ensuring adequate storage. The land application rate is determined from a site-specific nutrient management plan (NMP). 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. Factors such as the amount of land available for manure and wastewater application, site topography, and soil characteristics (e.g., soil type, moisture content) can play an important role in developing the site-specific nutrient management plan. See Chapter 2 of EPA's technical guidance titled *Managing Manure Nutrients at Concentrated Animal Feeding Operations* (EPA-821-B-04-009) for more information on storage requirements and development of nutrient management plans.

To assist CAFOs with the design and permitting of a manure and wastewater storage facility to meet the no-discharge requirements, the following three-step procedure may be used. A CAFO may apply this three-step procedure to design and evaluate a manure storage facility for any given location:

1. The NPDES Program Director gathers information about the specific operation to be analyzed and the regulatory framework in which it operates.

2. The CAFO owner/operator designs the storage facility using design procedures such as in the NRCS *Agricultural Waste Management Field Handbook*, NEH-651.

3. The NPDES Program Director evaluates the adequacy of the AWM-designed storage facility using the Soil Plant Air Water (SPAW) Hydrology Tool or equivalent.

This general process was described in two papers delivered to the American Society of Agricultural Engineers: Moffitt et al., 2003, and Moffitt and Wilson, 2004 (EPA Docket OW-2005-0037, DCNs 1-01223 and 1-01224). The following section describes each of these steps in more detail.

Step 1: The NPDES Program Director gathers information on the regulatory framework for the particular CAFO under review. 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 will be included in the design and evaluation, as discussed below. For example, frequent dewatering to irrigate perennial grasses is quite different from seasonal irrigation for a given crop rotation.

Step 2: Using the information collected in Step 1, the CAFO owner/operator then *designs* the storage facility using design procedures in the NRCS *Agricultural Waste Management Field Handbook*, NEH-651. The CAFO can use the AWM software available from NRCS to estimate manure production, bedding use, and process wastewater generation needed 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 the AWM software includes average monthly precipitation data for the past 30 years, location-specific evaporation rates obtained from the National Oceanic and Atmospheric Administration (NOAA), animal numbers and typical animal sizes/weights, added water and bedding (if any), and the size and condition of outside areas that contribute runoff to the storage facility. The AWM software 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 storage system in excess of 12 months. As an alternative, the user can designate months when the storage pond can be emptied, and the AWM software will size the storage facility based on the months with the most precipitation between pumping events. The output of this step is the design of a waste storage facility. The AWM software provides a series of reports describing the storage facility, including dimensions, daily manure and wastewater additions, the size and characteristics of the fields, and other management assumptions such as storage period.

Step 3: The NPDES Program Director evaluates the adequacy of the storage facility designed in Steps 1 and 2. This evaluation may be conducted using the 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 to evaluate 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.

AWM software is used for design and SPAW is used for evaluation; additional software can be linked to analyze nutrient management planning topics. 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 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 can illustrate whether or not a storage facility discharges, and also whether or not there is wastewater runoff 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 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, including case studies of swine facilities, 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 memorandum to the final CAFO rulemaking record (EPA Docket OW-2005-0037, DCNs 1-01225 and 1-01226).

Table 15-1. Swine 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	5,000	6 months	Pumpout every 6 months	Yes	No
Iowa	5,000	6 months	Pumpout every 6 months	Yes	No
Georgia	2,454	6 months	Continuous irrigation	No	No
			Pumpout every 6 months	Yes	No
Nebraska	1,600	5 months	Pumpout 3 times per year	No	No
South Carolina	3,520	5 months	Pumpout in the spring followed by seasonal irrigation	No	No

If the AWM design provides the results of predicted overflows, the CAFO could evaluate different designs and management options (such as different storage periods and dewatering schedules consistent with the CAFO's nutrient management plan) that do not result in any predicted overflow, or the CAFO could conclude that an open system is not appropriate for the particular site being evaluated.

This approach requires that the key user-defined inputs and model system parameters (i.e., site-specific design, construction, operation, and maintenance measures of the system) be included in the CAFO's NMP under 40 CFR 122.42(e)(1). These site-specific measures would then become enforceable requirements in the CAFO's permit. As long as the CAFO complies with these requirements, it 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 that any open system used meets the new source standard of no discharge. EPA believes that this approach will provide a clear and enforceable element for the CAFO, as well as assuring the public that the proposed system will comply with the no-discharge requirements.

The CAFO is not limited to using AWM and SPAW to inform their waste management decisions. The director may choose to use any tool that can adequately predict overflows and overland flows. In selecting a modeling tool, the director should consider what data the CAFO has available, what data the CAFO must collect, and the complexity of the model.

Two simple models that might be considered are the Universal Soil Loss Equation (USLE) and the Generalized Watershed Load Function (GWLF) models. More complex models include Agricultural Non-Point Source (AGNPS) and Hydrological Simulation Program—Fortran (HSPF), in addition to SWAT.

> **USLE:** Predicts the long-term average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, crop system, and management practices. USLE only predicts the amount of soil loss that results from sheet or rill erosion on a single

slope; it does not account for additional soil losses from gully, wind, or tillage erosion. Any estimated amount of erosion indicates that a runoff event (discharge) has occurred.

GWLF: Evaluates the effect of land use practices on downstream loads of sediment and nutrients (N, P) from mixed land use watersheds. This model is typically used to evaluate long-term loadings.

AGNPS: Predicts soil erosion and nutrient transport/loadings from agricultural watersheds for real or hypothetical storms. Erosion modeling is built upon the USLE applied on a storm basis; thus, it uses the erodibility index (EI) for single storm events. Its hydrology is based on the Soil Conservation Service Curve Number technique. AGNPS uses another ARS-developed model, named CREAMS, to predict nutrient/pesticide and soil particle size generation and interaction.

HSPF: Simulates, for extended periods of time, the hydrologic processes and associated water quality on pervious and impervious land surfaces and in streams and well-mixed impoundments.

The information, design, and evaluation process required of all CAFOs wishing to avail themselves of this alternative is intended to allow CAFOs the flexibility to demonstrate compliance with the no discharge requirements for any type of open storage facility. As a practical consideration, EPA expects that most CAFOs selecting this compliance alternative will submit designs for open manure storage structures accompanied by a narrow range of acceptable operation and management practices. However, for a given type of storage facility design (for example, an integrator with several company owned CAFOs each designed and constructed in an essentially identical manner within the same county), EPA believes it is possible to conduct a series of assessments that together fully encompass the range of operational and management measures that would be used across multiple CAFOs with the specified storage facility design. In this case, SPAW could be run to validate a wide range of NMP and storage pond management scenarios (to continue the above example, the CAFOs all have the same sets of crops, soil types, land application equipment, etc.). This alternative does not change the requirement for CAFOs to develop a site-specific NMP. These final amendments authorize the permitting authority to determine that any CAFO using the specified facility type and submitting a NMP that falls within the pre-approved range of operational and management practices would not need to conduct an individualized assessment step (i.e., the validation using SPAW).

The availability and use of such a geographical and categorical approach will require that the permit writer determine that a number of conditions are met. First, the assessment must fully account for all pertinent factors relevant to determination of the potential for discharge from an open storage system. The assessment must also include all parameters necessary to properly mirror the range of soil, plant, climatic, and hydrological conditions within the geographical area for which the assessment is intended to be representative. Second, the permittee must establish that the parameters reflected in the general assessment used to establish no discharge are, in fact, representative of those parameters for each CAFO. Finally, the assessment must reflect the operational and management practices to be employed by each CAFO at each individual site. As with the individual assessment, each CAFO must have a site-specific NMP that includes the operational and management measures utilized in the geographical assessment.

15.2 Best Conventional Pollutant Control Technology

After assessing various conventional pollutant removal technologies, EPA determined that there are no available and economically achievable technologies that are cost reasonable and would result in greater removal of FC than the technologies on which EPA based the 2003 best practicable control technology currently available (BPT) and BCT effluent limitations guidelines (ELG).

This subsection summarizes the BCT analysis, including the history of the BCT cost test, the calculations that have been used previously to evaluate BOD_5 and TSS removals, EPA's assessment to evaluate FC removals, and the proposed modified BCT cost test for FC (presented for reference only).

15.2.1 History of BCT Cost Test

The CWA requires point sources to achieve effluent pollutant levels established by EPA that are attainable through progressively more stringent pollutant control technology. The CWA calls for technology-based control in two stages:

1. The first stage, as originally enacted in 1972, requires existing point sources to comply in with EPA-established limitations that are achievable by application of the "best practicable control technology presently available" or "BPT." These limitations control conventional, toxic, and nonconventional pollutants. EPA has typically based BPT limitations on the average pollutant removal performance of the best facilities examined by EPA.

2. In 1972, the second stage required existing point sources to comply with EPA-established limitations that are achievable by the application of "best available technology economically achievable," or "BAT." These limitations also controlled conventional, toxic and non-conventional pollutants.

The 1977 amendments to the CWA replaced BAT for conventional pollutants with limitations that represent "best conventional pollutant control technology" or "BCT." Section 304(a)(4) designates the following as conventional pollutants: BOD5, TSS, FC, pH, and any additional pollutants defined by the Administrator as conventional. The Administrator designated oil and grease as an additional conventional pollutant, on July 30, 1979 (44 FR 44,501).

The CWA amendments that created BCT also specify that the cost associated with BCT effluent limitations must be "reasonable" with respect to the effluent reductions. Accordingly, EPA developed the "BCT Methodology" to answer the question of whether it is "cost-reasonable" for industry to control conventional pollutants BOD5 (or oil and grease in the case of certain metals industries) and TSS at a level more stringent than already required by BPT effluent limitations guidelines. The BCT Methodology was originally published on August 29, 1979, along with the promulgation of BCT effluent limitations guidelines for 41 industry subcategories (44 FR

50732). The methodology compares the costs of removing the conventional pollutants BOD5 (or oil and grease) and TSS for a candidate BCT technology within a particular industry segment, to the costs of removal for an average-sized publicly owned treatment works (POTW).

A number of industries and industry associations challenged the methodology, and, in 1981, the U.S. Court of Appeals for the Fourth Circuit remanded it to the Agency, directing EPA to include an assessment of the cost-effectiveness of industry conventional pollutant removal in addition to the POTW test in its evaluation of cost reasonableness. EPA proposed a revised BCT Methodology in 1982 (47 FR 49176) that addressed the industry cost effectiveness test (the Industry Cost Test, or “second” test), again limiting it the conventional pollutants BOD5 and TSS. EPA proposed to base the POTW Benchmark on model facility costs in a 1984 notice (49 FR 37046).

The final BCT Methodology was published on July 9, 1986 (51 FR 24974). This methodology maintained the basic approach of the 1982 proposed BCT Methodology and adopted 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 BOD_5, 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. If any candidate technologies are feasible and pass both the POTW and the industry cost test, then the most stringent technology option among them becomes the basis for setting BCT effluent limitations. Alternatively, if no candidate technology more stringent than BPT passes the cost test, then BCT effluent limitations are set equal to BPT effluent limitations (51 FR 24,976).

Each of these tests is compared with established benchmarks. The POTW Benchmark used in the 1986 Federal Register Notice (FRN) is $0.25 per pound of BOD_5 and TSS removed (in 1976 dollars) for industries where cost per pound is based on long-term performance data. The 1986 FRN Industry Cost Benchmark is 1.29 (a unitless ratio). These benchmarks were developed using only BOD_5 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 and 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 notes that when 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 the cost-reasonableness of BCT controls for FC, as described in Section 15.2.3.

15.2.2 BCT Cost Test Calculations for BOD_5 and TSS

Establishing BCT effluent limitations for an industrial category or subcategory begins by identifying feasible technology options that provide additional conventional pollutant control beyond the level of control provided by the application of BPT effluent limitations. In setting BCT, the CWA requires EPA to consider all the BAT factors. Any such candidate technologies are thus first evaluated to determine if they are technologically feasible and economically achievable. A technology must meet these requirements to be considered as a basis for BCT limitations.

The next step in determining BCT is to evaluate any candidate technology that is both technically feasible and economically achievable for cost reasonableness. EPA determines the incremental costs and incremental pollutant reductions for remaining candidate technologies. EPA then evaluates the cost-reasonableness by applying the BCT cost test.

After identifying the candidate technologies for each subcategory, EPA evaluates the cost-reasonableness of each candidate technology by applying the two-part BCT cost test. The first part of the BCT cost test is the POTW Test and the second part is the Industry Cost Test. These tests are described below in detail, and each section outlines the equations that have been historically used to calculate the cost-reasonableness of technologies designed to remove BOD_5 and TSS.

15.2.2.1 POTW Test for BOD_5 and TSS

The POTW Test requires "a comparison of the cost of removing additional pounds of conventional pollutants by industrial dischargers to the cost of conventional pollutant removals by a POTW" (51 FRN 24980). Specifically, the POTW Test compares two factors: the incremental cost per pound of conventional pollutant removal for the industry to increase treatment from BPT to BCT; and the incremental cost of conventional pollutant removal for a POTW with advanced secondary treatment and only secondary treatment (i.e., the POTW Benchmark). If the industrial incremental cost of removal exceeds the POTW Benchmark, the industrial treatment technology candidate fails the POTW cost test.

In the 1986 FRN, EPA used the incremental costs and removals of upgrading from secondary treatment to advanced secondary treatment at POTWs to calculate the POTW Benchmark for only BOD_5 and TSS. No other conventional pollutants, including FC, were included in the developed POTW Benchmark. As stated in the 1986 FRN, the following assumptions were "the basis for the choice of the secondary to advanced secondary increment as the foundation of the POTW Test" for BOD_5 and TSS (51 FRN 24980):

- "Calculation of the costs per pound of conventional pollutant removal based on the increment from secondary to advanced secondary yields the best approximation of marginal costs."

- The calculation represents the "point where incremental costs begin to exceed incremental benefits" with respect to POTW costs.

- "The level of treatment for a POTW to upgrade from secondary to advanced secondary treatment roughly parallels the industrial increment under consideration."

EPA calculated the POTW Benchmark for BOD_5 and TSS using the following equation in the 1986 FRN:

$$\frac{\text{Cost of Advanced Secondary Treatment} - \text{Cost of Secondary Treatment}}{\text{Pollutant Removal of Advanced Secondary Treatment} - \text{Pollutant Removal of Secondary Treatment}}$$

EPA concluded that this calculation is appropriate for BOD_5 and TSS because advanced secondary treatment, as described in the 1986 FRN, is specific to removing BOD_5 and TSS. Costs associated with upgrading a POTW from secondary to advanced secondary treatment were based on adding treatment with polymer addition to the existing activated sludge system. The purpose of the polymer addition was to enhance removal of BOD_5 and TSS and achieve final effluent concentrations of 20 mg/L BOD_5 and 20 mg/L TSS. Therefore, the cost increment between secondary and advanced secondary treatment represents the removal of additional BOD_5 and TSS.

To establish costs and removals for the 1986 FRN, EPA created five model POTWs to represent five different flow ranges of POTWs, as shown in Table 15-2. Multiple engineering firms developed costs 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).

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.

Using these data, EPA estimated the 1986 POTW Benchmark to be $0.25 (in 1976 dollars) per pound of BOD_5 and TSS removed. To update this calculation for use in the BCT analysis for CAFOs, EPA used cost index data from RSMeans Historical Cost Indices to update this POTW Benchmark to 2001 dollars according to the following equation:

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

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

After establishing the POTW Benchmark, EPA must compare it to the industry's cost of removal to upgrade from BPT to BCT. EPA calculated this incremental removal cost per pound of BOD_5 and TSS removed ($/lb) for each candidate technology using the following equation:

$$\frac{\text{Cost of BCT} - \text{Cost of BPT}}{\text{Pollutant Removal of BCT} - \text{Pollutant Removal of BPT}}$$

The upgrade cost to industry must be less than the POTW Benchmark of $0.65 per pound of BOD_5 and TSS (in 2001 dollars) for each subcategory or the subcategory fails the POTW Test. If any subcategory passes the first part of the BCT cost test, the technology is further evaluated in the second part of the test.

15.2.2.2 Industry Cost Test for BOD_5 and TSS

The second part of the BCT cost test is known as the Industry Cost Test. The Industry Cost Test compares two calculated values: the Industry Cost Ratio and the Industry Cost Benchmark.

EPA computes the Industry Cost Ratio using two incremental costs. The first incremental cost is the cost per pound of conventional pollutant removed by the candidate BCT relative to BPT. The second incremental cost is the cost per pound of conventional pollutant removed by BPT relative to no treatment (i.e., raw wasteload). Historically, this Industry Cost Ratio has been calculated using the following equation:

$$\frac{\text{Cost of BCT} - \text{Cost of BPT}}{\text{Pollutant Removal of BCT} - \text{Pollutant Removal of BPT}} \div \frac{\text{Cost of BPT}}{\text{Pollutant Removal of BPT}}$$

Next, EPA calculates the Industry Cost Benchmark. The Industry Cost Benchmark is the ratio of two other incremental costs: the cost per pound to upgrade a POTW from secondary treatment to advanced secondary treatment (the POTW Benchmark) divided by the cost per pound to initially achieve secondary treatment. The Industry Cost Benchmark is calculated using the following equation:

$$\text{POTW Benchmark} \div \frac{\text{Cost of Secondary Treatment}}{\text{Pollutant Removal of Secondary Treatment}}$$

EPA calculated the Industry Cost Benchmark using the same model POTW data (presented in Table 15-2) and flow-based weighting factors that were used to calculate the POTW Benchmark. The Industry Cost Benchmark established in the 1986 FRN for BOD_5 and TSS is 1.29 (see 51 FR 24974).

To pass the Industry Cost Test, the Industry Cost Ratio for the subcategory must be lower than the Industry Cost Benchmark. For BOD_5 and TSS, this means that the cost increase from BPT to BCT must be less than 1.29. EPA established an Industry Cost Benchmark only for BOD_5 and TSS in the 1986 FRN; no Industry Cost Benchmark for FC was developed prior to the 2006 proposed CAFO revisions.

15.2.3 BCT Analysis for FC

This section describes the BCT analysis that EPA performed for FC. The 1986 FRN established a BCT cost test methodology only for BOD5 and TSS and states that "there may be instances where, because of a lack of comparable industry data, a strict comparison to the benchmarks developed in this rulemaking would undermine Congressional intent on cost-reasonableness. In such instances, EPA will develop appropriate procedures to evaluate cost-reasonableness on an industry-specific basis" (51 FRN 24976).

To date, EPA has not established a BCT cost test methodology for FC. EPA excluded FC from the 1986 BCT cost test methodology for the following reasons (DCN 1-03073):

- EPA was unable to determine a FC load reduction in pounds; FC data were typically reported as most probable number (MPN) or colony forming units (CFU) per 100 mL of wastewater, rather than as a weight (pounds) like BOD_5 and TSS.

- No data were available on the overall reduction in FC through an entire POTW.

- EPA was unable to identify specific unit processes at POTWs responsible for FC removals.

- EPA had difficulty developing a method to categorize POTWs as having either secondary or advanced secondary treatment with respect to FC removal: FC removal occurs throughout a POTW, not specifically during secondary treatment or advanced secondary treatment.

- The BCT cost test methodology published in the 1986 FRN included dischargers from a variety of industries that do not have FC bacteria in their process wastewater (e.g., cement manufacturing). Therefore, developing a BCT cost test methodology for all conventional pollutants provided little benefit at that time.

EPA has more recently promulgated rules that are relevant to FC, such as the rule for the meat and poultry products point source category. For this category, EPA performed the BCT cost-reasonableness analysis using only those conventional pollutants that could be measured in pounds (e.g., BOD_5 and TSS) (EPA 2004).

For the proposed revisions to the CAFOs rule, EPA suggested a modified BCT cost test for FC. However, based on comments, EPA identified a number of problems with the proposed test. First, although the revised test used a different cost-effectiveness calculation from the traditional test, it still relied indirectly on a comparison of the cost-effectiveness of BCT candidate technologies to the cost-effectiveness of advanced secondary treatment, even though, as just noted, advanced secondary treatment is not designed to remove FC. Second, the revised test did not compare the incremental cost-effectiveness of the candidate technologies to the incremental cost-effectiveness of FC removals at POTWs and therefore did not allow a comparison of "the cost and level of reduction of [FC] from the discharge from publicly owned treatment works to the cost and level of reduction of [FC] from…industry sources…". As a result, EPA chose not to use the revised test to evaluate cost reasonableness; however, it is presented for reference only in Section 15.2.4

EPA considered other possible approaches for evaluating cost reasonableness. One approach would have been to identify a technology that is used at POTWs specifically for FC removal and develop a test similar to the traditional cost test but based on this technology. EPA considered disinfection as one possible benchmark technology for FC removal, but determined that there is significant variability in the manner in which disinfection is used in combination with other technologies at different POTWs and it would thus be extremely difficult, both theoretically and logistically, to develop a revised benchmark based on this technology.

For CAFOs, EPA has applied a simplified cost reasonableness test designed to specifically address FC. This approach is consistent with section 304(b)(4) of the CWA and is one EPA has used in the past. While the traditional cost test compares reductions from BCT candidate technologies to those of POTWs, EPA has rejected BCT technologies without comparing them to POTW performance, even for BOD_5 and TSS. For example, where EPA lacked sufficient data to quantitatively evaluate BOD_5 and TSS reductions under the traditional test, EPA rejected more stringent BCT limitations solely on the basis of an evaluation of the incremental costs of further reductions (51 FR 24,974, 24,991).

15.2.3.1 BCT Analysis for FC

In its evaluation of candidate BCT technologies, EPA reviewed data on different types of CAFO manure management systems. These systems employed treatment technologies, best management practices (BMPs) for pollution prevention, and management practices for the handling, storage, treatment, and land application of wastes. Sources of information included 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. Please see Section 8.6 for a discussion of the considered technologies.

In considering FC removal technologies for BCT for CAFOs, EPA evaluated the following three criteria:

1. **The technology must be economically achievable *and* technically feasible.** In setting BCT, the CWA requires EPA to consider all the BAT factors. Any such candidate technologies are thus first evaluated to determine if they are technologically feasible and economically achievable. A technology must meet these requirements to be considered as a basis for BCT limitations. *See* 33 U.S.C. 1311(b)(2)(A).

2. **The technology must reduce FC beyond BPT.** Section 304 of the Clean Water Act specifies that BCT must control conventional pollutants at or above BPT. Therefore, a technology that removes less of a conventional pollutant, such as FC, than BPT cannot be considered for BCT.

3. **The technology must be demonstrated at CAFO operations for reducing pathogens.** Technologies that are not demonstrated at CAFO for reducing pathogens should not be considered for BCT.

To evaluate economic achievability, EPA reviewed available cost data for the technologies in comparison to the costs estimated in the 2003 final CAFOs rule. For Subpart D (i.e., swine, poultry, and veal calf) facilities, EPA determined in the 2003 rule that Option 5 was not economically achievable. The *Waterkeeper* court sustained the Agency's determination that CAFOs cannot reasonably bear the cost associated with Option 5 (399 F.3d at 516). Option 5 would have cost Subpart D facilities $167 million (68 FR 7218).

For Subpart C facilities (i.e., beef, dairy), EPA did not have a previously identified option that it had already determined to be economically unachievable against which to compare the costs of candidate BCT technologies. To do an economic achievability analysis of candidate technologies for Subpart C, EPA would have had to conduct an analysis of the economic conditions of individual CAFOs in order to estimate potential closures and evaluate appropriate financial ratios, as it traditionally does for economic achievability analysis. EPA determined that conducting such an analysis was not practical; the technologies were instead evaluated for cost reasonableness, without considering economic achievability. To determine cost reasonableness the costs were compared to the 2003 rule cost of the BPT technology for Subpart C, which was $214 million per year,

EPA evaluated available cost data for the BCT candidate technologies, as presented in Section 8.6.3. Many of the technologies identified and researched under the North Carolina State University (NCSU) Program for the Development of Environmentally Superior Technologies (ESTs) for Swine Waste Management; cost estimates for these technologies are presented in Section 8.6.3.5.

None of the technologies and systems approaches cost less than $167 million for Subpart D facilities. The least costly of the technologies—gasification recycle, digester based systems, Super Soils composting, aerobic digestion, and aerobic blanket system—cost 1.3 times the cost of Option 5. Other technologies reviewed cost as much as seven times the total national costs of Option 5. Having determined that the costs of Option 5 were unachievable for Subpart D facilities, EPA did not evaluate further those treatment technologies that had similar or greater total costs. After rejecting the economically unachievable technologies identified by commenters, EPA reviewed the remaining technologies with respect to technical feasibility. EPA found that none of these technologies were technically feasible for all CAFOs in Subpart D (please see Section 8 for descriptions of the technologies and their technical feasibilities).

As mentioned earlier, for Subpart C facilities, EPA did not have a previously identified option that it had already determined to be economically unachievable so EPA instead evaluated technologies for cost reasonableness. EPA first evaluated the candidate technologies for technical feasibility for Subpart C, and on this basis, rejected all but two of the technologies for BCT limitation for FC. Please see Section 8 for discussions of the technical feasibility of the technologies. The two remaining candidate technologies (composting and constructed wetlands) were then evaluated directly for cost reasonableness, without considering economic achievability. (EPA evaluated cost reasonableness even though EPA believes these may not be technically available candidates due to the lack of data indicating how many CAFOs lack sufficient land base on which to construct and operate the technology.)

The cost of the BPT technology for Subpart C was $214 million per year, while the cost of composting was estimated to be $1.4 billion per year, and the cost of constructed wetlands was $2.9 billion. The annual operating costs for composting would be more than six times as much as the full BPT level of control at Subpart C facilities (see Chapter 4 and Table A-15 of the Final Cost Methodology, EPA-821-R-03-004), while constructed wetlands would cost Subpart C facilities more than an order of magnitude (13) times the cost of the BPT level of control. EPA has determined that these costs are too high relative to the additional removals. EPA thus concludes that the incremental costs of the additional removals alone support a determination that these technologies are not cost reasonable. EPA notes these costs are likely understated, as the two candidate technologies both require a sizable land base on which to construct and operate the technologies; the land may need to be purchased and may not be available, or the CAFO may need to take existing cropland out of production.

EPA has employed the evaluation of cost reasonableness of the technologies using the simplified approach described above in the past when a full data base to evaluate different BCT technologies was lacking. A simplified approach fits the circumstances here for two reasons. First, as noted, EPA has developed no standardized BCT cost test for FC. Second, EPA lacks the data to provide a comparison of incremental FC removals that is the basis for the BCT cost test for TSS and BOD.

To further evaluate this conclusion, EPA conducted a modeling analysis of POTW removal costs for FC (see Section 15.2.4.2). As discussed above, the available data do not permit an empirical cost comparison between CAFO candidate technologies and POTW FC performance. However, EPA was able to model POTW FC removal costs using reasonable approximating assumptions. EPA recognizes that the resulting calculation lacks the rigor of the determination of the 1986 POTW benchmark for TSS and BOD removal costs. What this assessment shows is that POTW average costs of removals of FC are very low ($0.33 per trillion CFU; see Section 15.2.4.2). This is not surprising, given that most POTW permits require achievement of FC reduction near 99 percent. In contrast, the two technologies being evaluated for cost reasonableness (composting and constructed wetlands) have higher costs for FC removal ($0.51 per trillion CFU for composting, and $1.02 per trillion CFU for constructed wetlands).

Recognizing the imprecision associated with EPA’s calculations and lack of hard data, EPA has determined that this limited POTW cost comparison further supports its determination that the costs of these two BCT candidate technologies are not cost reasonable. This is fully consistent with EPA’s findings in the proposed rule that POTWs are very cost effective at FC removals (71 FR 37,772). The assessment confirms what logic suggests: given a POTW’s requirement to virtually eliminate the extremely high FC discharges in its influent (basically raw sewage), POTWs, on a national basis, achieve FC removal on a cheaper basis than CAFOs.

Finally, EPA notes that Congress intended the BCT level of control to be somewhere between the BPT and the BAT levels of control, as established in the statute. As noted in the conference report to the 1977 amendments establishing BPT:

> "The result of the cost test could be a 1984 requirement which is no more than that which would result from best practicable technology but also could result in effluent reductions equal to that required in the application of best available technology." Joint Explanatory Statement of the Committee of Conference, 95th Cong. 1st Sess., H.R. No. 95-830 at 85**,** *Legislative History* at 269.

Thus, candidate technologies with costs between 6 and 13 times the costs of technologies that have been determined to be BAT would not generally be appropriate as the basis for BCT.

EPA concludes that there are no available and economically achievable technologies that are cost reasonable that would result in greater removal of FC than the technologies on which EPA based the 2003 BPT and BCT ELG.

15.2.4 Development of the Alternative BCT Cost Test for FC.

For the proposed revisions to the CAFOs rule, EPA suggested a modified BCT cost test for FC, also referred to as the alternative BCT cost test. However, based on comments and further review of the data available, EPA identified a number of problems with the proposed test. The analysis is presented in this Section for reference only,

EPA's methodology to perform the modified BCT cost test for FC comprised the following steps:

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

2. Calculate an Industry Cost Benchmark for FC.

3. Obtain industry costs and FC reductions from CAFO regulatory options explored in the original rulemaking and calculate industry costs and FC removals for newly explored technologies.

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

5. Perform the second part of the BCT cost test (the Industry Cost Test) by comparing the Industry Cost Benchmark to the candidate technology Industry Cost Ratio.

The remainder of this subsection describes the data sources and development of the POTW and Industry Cost Benchmarks for FC removal. Section 15.2.4. presents the results of the traditional and modified BCT cost tests.

15.2.4.1 Data Sources Used in the Modified BCT Cost Test Calculations

EPA evaluated numerous sources of data on CAFO manure management systems, including treatment technologies and 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 modified 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 across both the production area and land application areas, considering facilities that use lime treatment of dairy manure, anaerobic digestion of swine and dairy manure for pathogen reduction, and composting of poultry manure/litter. The Agency used a variety of data sources 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 POTW and CAFO industries. Chapter 8 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 (Cost Report), and *Pollutant Loading Reductions for the Effluent Limitations Guidelines for Concentrated Animal Feeding Operations,* December 2002 (Loads Report). In general, EPA assumed that each production area technology considered can achieve an upper bound of 99 percent FC reductions across the production and the land application areas. The literature suggests such high removals will not be achieved in all cases, but the 99 percent reduction does provide an upper level limit of treatment that is obtainable in some cases. However, EPA assumes that if no technology passes the cost test at the upper bound of 99 percent FC removals, then any technology of similar cost will also not pass the cost test. Mathematically, the logic employed can be stated as follows:

IF Technology “A” Costs > Benchmark “X”
AND Technology “B” Costs > Technology “A” Costs
THEN Technology “B” Costs > Benchmark “X”

Similarly, a technology with costs comparable to the costs of the technologies evaluated here but achieving less FC reductions would fail the cost test:

IF Technology “C” Costs ÷ Pollutant Reductions “D” > Benchmark “Y”
AND Pollutant Reductions “D” > Pollutant Reductions “E”
THEN Technology “C” Costs ÷ Pollutant Reductions “E” > Benchmark “Y”

This logic based approach allows EPA to expeditiously assess numerous technologies without having to conduct a thorough cost reasonable test on each and every technology. None of the additional technologies cost less than the technologies considered here.

15.2.4.2 Calculation of POTW Benchmark for FC

EPA developed a new POTW Benchmark for FC for use in the modified BCT analysis of the CAFOs industries. EPA had to adjust the 1986 calculation methodology to calculate a POTW Benchmark for FC, since the 1986 methodology only accounted for BOD_5 and TSS.

The 1986 FRN calculation is appropriate for BOD_5 and TSS because the incremental costs to achieve advanced secondary treatment beyond secondary treatment are associated specifically with incremental additional removal of BOD_5 and TSS. Costs associated with upgrading a POTW from secondary to advanced secondary treatment were based on polymer addition to the activated sludge basin. The purpose of the polymer addition was to enhance removal of BOD_5 and TSS in the secondary clarifier, and achieve final effluent concentrations of 20 mg/L BOD_5 and 20 mg/L TSS. Therefore, the cost increment between secondary and advanced secondary treatment represents the removal of additional BOD_5 and TSS (51 FR 24,981).

Unlike BOD_5 and TSS, advanced secondary treatment is not specifically designed to target additional removal of FC beyond secondary treatment. When both secondary and advanced secondary treatment systems include disinfection, the total FC removal is the same, over 99.9 percent.[1] The polymer addition in advanced secondary treatment is not intended for additional FC removal since both secondary and advanced secondary POTWs use disinfection treatments to prevent FC releases to surface water.

Therefore, because the object of the BCT cost test is to ensure that the costs of additional removals of conventional pollutants associated with BCT limitations do not exceed POTW conventional removal costs, distinguishing FC removals between advanced secondary treatment and secondary treatment is essentially not relevant. Because advance secondary treatment is not more effective than secondary treatment at removing FC, it is not appropriate and reasonable to apply the same POTW cost test used for evaluating BOD_5 and TSS BCT limitations to the evaluation of FC limitations. Consequently in assessing POTW FC removals, the cost associated with the upgrade of a POTW from secondary treatment to advanced secondary treatment for FC removal should not be evaluated in the same way as it is for BOD_5 and TSS.

As explained above, when the Agency promulgated the BCT methodology (including descriptions of how to apply the cost test), EPA envisioned the need for adjustments to the BCT cost test methodology in future rulemakings to account for lack of comparable data or other industry-specific factors (51 FR 24974, 24976). Moreover, section 304(b)(4)(B) authorizes EPA to consider other appropriate factors in establishing BCT.

The Second Circuit directed EPA to make an affirmative finding that the BCT-based ELGs adopted in the 2003 CAFO rule do *in fact* represent the best conventional pollutant control technology for reducing pathogens, specifically FC. To respond to the Second Circuit's direction, EPA has developed a new BCT cost test to evaluate BCT cost-reasonableness for FC removal for this industry. While EPA's approach is similar to its two-part cost-reasonableness test for BOD_5 and TSS, it is a different test.

As part of the modified test, EPA established a new methodology to estimate a POTW Benchmark that is specific to FC and reflects the costs to reduce FC at a POTW over raw

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[1] The 99.9% removal rate is based on the influent and effluent FC values used in EPA's calculations of secondary and advanced secondary treatment systems: influent FC for both systems is 5,000,000 CFU per 100 mL; effluent FC from secondary treatment is 200 CFU per 100 mL based on typical state standards; and effluent FC from advanced secondary treatment is estimated at 21 CFU per 100 mL based on a small dataset of POTWs that could be identified in EPA's Permit Compliance System as achieving better than secondary treatment.

wasteloads. In doing so, EPA faced the challenge of properly accounting for the cost and removals of advanced secondary treatment, when, as explained above, secondary treatment alone removes 90 to 98 percent of FC on average and in some cases up to 99 percent. For FC, calculating the incremental cost per unit of pollutant removal in the same way as BOD_5 and TSS ignores the fact that the majority of the FC removal occurs in secondary treatment, and would provide an erroneously high POTW benchmark cost as a result.

EPA's modified methodology uses readily available secondary and advanced secondary treatment data as the basis for the FC costs and removals, but modifies the calculation of the incremental cost per pollutant removal. As described above, since FC removals cannot be attributed to a specific unit process at a POTW, this calculation considers the entire cost and the full FC removals of secondary treatment versus advanced secondary treatment, instead of considering only the incremental costs and removals attributable to secondary treatment as was done for the BOD_5 and TSS POTW Benchmark. EPA used the following equation to calculate the incremental cost of FC removal between secondary treatment and advanced secondary treatment:

$$\frac{\text{Cost of Advanced Secondary Treatment}}{\text{FC Removal of Advanced Secondary Treatment}} - \frac{\text{Cost of Secondary Treatment}}{\text{FC Removal of Secondary Treatment}}$$

EPA determined this calculation to be the most appropriate way to calculate a POTW Benchmark for FC using available data. It fulfills the intent of the BCT cost test and responds to the need for EPA to "develop appropriate procedures to evaluate cost-reasonableness" (51 FRN 24976) for the CAFO industry.

After establishing the benchmark calculation, EPA needed to identify POTW cost and FC removal data for secondary and advanced secondary treatment. EPA determined that the cost data from the model POTWs presented in the 1986 FRN could be used to calculate the benchmark because the 1986 FRN costs include biological treatment and disinfection; no additional treatment would be needed to remove FC. EPA updated the 1986 FRN annual costs for each model POTW from 1976 dollars to 2001 dollars, using the RSMeans Historical Cost Indices. EPA inflated to 2001 dollars to allow direct comparison to the costs of the 2003 final CAFOs rule, which were expressed in 2001 dollars.

EPA then calculated annual influent and effluent FC loads, based on the following data:

- For influent FC concentrations for all model POTWs, EPA estimated a value of 5,000,000 CFU of FC per 100 mL of untreated wastewater, based on published domestic wastewater values (EPA Docket OW-2005-0037, DCNs 1-01001, 1-01002, and 1-01220). The published data stated that domestic wastewater typically contains FC concentrations of between 1 and 10 million CFU per 100 mL; EPA calculated the midpoint of the range to estimate the influent FC. EPA compared this range of FC concentrations with other data sources and considers this to be a representative estimate.[2]

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[2] Other FC data sources include EPA's *Technical Development Document for the Final Effluent Limitations Guidelines and Standards for the Meat and Poultry Products Point Source Category* (EPA-821-R-04-011), *Onsite Wastewater Treatment Systems Manual* (EPA Docket OW-2005-0037, DCN 1-01006), and *Small and Decentralized Wastewater Management Systems* (EPA Docket OW-2005-0037, DCN 1-01001).

EPA considered using measured POTW data from EPA’s Permit Compliance System (PCS) data, but there were insufficient data reported in PCS for influent FC concentrations at POTWs.[3]

- For POTWs with secondary treatment, EPA estimated effluent FC concentrations of 200 CFU per 100 mL, based on the standard water quality criterion for FC according to EPA’s Ambient Water Quality Criteria for Bacteria.

- For POTWs with advanced secondary treatment, EPA estimated effluent FC concentrations of 21 CFU per 100 mL, based on the median FC concentrations of POTWs reporting to PCS.

EPA multiplied the influent and effluent 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. Tables 15-3 and 15-4 show EPA’s estimated costs and FC removal of secondary treatment and advanced secondary treatment, respectively, 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 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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[3] Both influent and effluent data are needed to calculate FC reductions.

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 (CFU/Year)** (c)	**Effluent FC Load (CFU/Year)** (d)	**FC Removal (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/100 mL.
(d) Based on effluent FC concentration of 200 CFU/100 mL.

Table 15-4. Cost of Advanced 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 (CFU/Year)** (c)	**Effluent FC Load (CFU/Year)** (d)	**FC Removal (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	2.2798E+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)	$21,034,000	$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/100 mL.
(d) Based on effluent FC concentration of 21 CFU/100 mL.

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	2,395	0.0720
3.3	1.06–10.5	8,983	0.2701
25	10.6–50.2	8,644	0.2599
140	>50.2	12,939	0.3890
All	All	33,264	1

(a) The "Total Flow for All POTWs" column reflects CWNS data.

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 modified POTW Benchmark value for FC, determined to be $0.33 per trillion CFU removed (in 2001 dollars). Table 15-6 presents the incremental costs and weighting factors used to calculate the POTW Benchmark for FC.

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**	**Weighted Incremental Cost per Trillion CFUs Removed**
0.052	0.0091	$0.00	$0.000
0.38	0.0720	$0.00	$0.000
3.3	0.2701	$0.53	$0.144
25	0.2599	$0.36	$0.094
140	0.3890	$0.24	$0.092
		Flow-weighted incremental cost ($/trillion CFU)	**$0.33**

15.2.4.3 Calculation of the Industry Cost Benchmark for FC

As described in Section 15.2.2.2, the Industry Cost Test is the second part of the BCT cost test. For the FC cost test, EPA has used FC CFU's rather than pounds of BOD_5 and TSS. The first incremental cost in the Industry Cost Ratio is therefore the cost per CFU removed by the candidate technology relative to BPT. This is divided by the cost per trillion CFU removed by BPT relative to no treatment (i.e., raw wasteload).

The Industry Cost Benchmark is the ratio of two other incremental costs: the cost per CFU to upgrade a POTW from secondary treatment to advanced secondary treatment (the POTW Benchmark) divided by the cost per CFU to initially achieve secondary treatment. Table 15-3 presents the cost per CFU to initially achieve secondary treatment for each model POTW. EPA calculated the cost ratio for each model POTW using the following equation:

$$\frac{\text{Cost per Trillion CFU to Upgrade from Secondary Treatment to Advanced Secondary Treatment}}{\text{Cost per Trillion CFU to Initially Achieve Secondary Treatment}}$$

The cost ratio for each model POTW is multiplied by a flow-weighting factor and the weighted ratios are summed to determine the flow-weighted Industry Cost Benchmark. Table 15-7 presents the flow-weighted cost of secondary treatment for the entire POTW industry and the Industry Cost Benchmark calculation. For the FC BCT cost test, the Industry Cost Benchmark is 0.04.

After the Industry Cost Ratio and the Industry Cost Benchmark and calculated, the values are compared. If the Industry Cost Ratio is lower than the Industry Cost Benchmark, then the candidate technology passes the Industry Cost Test.

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)	Industry Cost Benchmark	Weighting Factor	Weighted Industry Cost Benchmark
0–0.105	$28.92	$0.00	0.0000	0.0091	0.00
0.106–1.05	$15.43	$0.00	0.0000	0.0720	0.00
1.06–10.5	$15.39	$0.53	0.0348	0.2701	0.01
10.6–50.2	$8.20	$0.36	0.0440	0.2599	0.01
>50.2	$5.41	$0.24	0.0438	0.3890	0.02
Flow-weighted industry cost benchmark					**0.04**

15.2.4.4 BCT Cost Test Calculations for BOD_5 and TSS Removals

EPA’s BCT cost test evaluated the following technologies:

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

In the traditional BCT cost test evaluation of BOD_5 and TSS, EPA calculated incremental costs for all candidate BCTs compared to the BPT option. Table 15-8 summarizes the costs and BOD_5 and TSS reductions across the production and land application areas for the 2003 CAFO rule BPT by species. Table 15-9 presents the costs and pollutant reductions across the production and land application areas for 2003 CAFO rule BPT by subcategory. Pollutant removals were determined using the 2003 final CAFO rule methodology, as described in Section 8.6.3.

Table 15-8. 2003 CAFO Rule BPT Costs and BOD_5 and TSS Removals

Animal Sector	Annualized Costs ($2001, Millions, Pre-Tax)	BOD_5 Removed (Million Pounds)	TSS Removed (Million Pounds Sediment)	Total Pounds Removed (Million Pounds)
Beef	86	0	1,201	1,201
Dairy	128	0	99	99
Swine	25	0	113	113
Poultry	41	6	181	187

Table 15-9. 2003 CAFO Rule BPT Costs and Pollutant Removals by Subcategory

Subcategory	Annualized Costs ($2001, Millions, Pre-Tax)	BOD_5 Removed (Million Pounds)	TSS Removed (Million Pounds Sediment)	Total Pounds Removed (Million Pounds)
C: Beef/dairy	214	0	1,300	1,300
D: Swine/poultry	66	6	294	300

Table 15-10 presents incremental costs and incremental pollutant removals of candidate technologies for each species 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 are the sum of BOD_5 and TSS removals. EPA calculated the incremental cost per pound of conventional pollutants (BOD_5 and TSS) removed by the candidate technology by dividing the incremental costs by the total incremental removals. EPA evaluated the pollutant loadings of each technology across both the production and land application areas.

Table 15-10. Incremental Costs and Conventional Pollutant Removals of Candidate Technologies

Candidate Technology	Animal Sector	Incremental Costs ($2001, Millions, Pre-Tax)	Incremental BOD_5 Removed (Million Pounds)	Incremental TSS Removed (Million Pounds Sediment)	Total Incremental Removals (Million Pounds)	Incremental Cost per Pound Removed (2001$/lb)
Ground-water controls (a)	Beef	145	0	0	0	NC
	Dairy	188	0	0	0	NC
	Swine	36	0	0	0	NC
No discharge	Swine	108	7	1	8	13.55
Composting	Beef	1,281	3	25	28	46.39
	Dairy	149	1	7	8	17.84
	Poultry	467	0	0	0	NC
Anaerobic digestion	Dairy	237	2	9	11	21.46
	Swine	56	6	0	7	8.16
Land application timing restrictions	Beef	26	0	0	0	366.65
	Dairy	190	2	7	9	20.90
	Swine	12	7	1	8	1.55

(a) Only reduced discharges to surface waters via a hydrologic connection are included in this analysis.
NC: Values were not calculated because no additional pollutant reductions to surface waters were expected for these options.

For this analysis, EPA determined the costs and pollutant removals for each candidate technology on species-specific basis, and then combined species-specific candidate technologies to represent costs and removals for Subcategories C and D. EPA approached the evaluation in this manner because (1) EPA could not identify any candidate technologies that are feasible across all CAFOs and (2) even if such a candidate technology could be found, the costs and loads are sufficiently variable across differing types of CAFOS that species-specific calculations would have to be determined anyway.

The Agency selected the most cost-reasonable technologies for each species to develop a candidate technology option that is applicable to the subcategory. For example, for Subcategory C, the most cost-effective candidate technology for dairy is combined with the most cost-effective candidate technology for beef. This method provides an evaluation of cost-reasonableness for the entire subcategory and is, therefore, both appropriate and necessary for applying the BCT cost-reasonableness methodology to CAFOs.

To pass the POTW Test, the cost to upgrade from BPT to BCT for each subcategory must be less than the POTW Benchmark of $0.65 per pound of BOD_5 and TSS in 2001 dollars. To evaluate subcategories in the POTW Test, EPA considered the most cost-effective technology for each species:

- For the beef/dairy subcategory, EPA combined beef composting and dairy composting.
- For the swine/poultry subcategory, EPA combined poultry composting and swine land application timing restrictions.

EPA calculated the cost per pound of BOD_5 and TSS removed by these technologies for each subcategory using the incremental costs and incremental load removals in Table 15-11. The costs per pound of BOD_5 and TSS removal for each subcategory exceed the POTW Benchmark and, therefore, fail the POTW Test.

Table 15-11. BOD_5 and TSS Cost Test Part One—POTW Test Results

Subcategory	Candidate Technologies' Incremental Cost per Pound BOD_5 and TSS Removed (2001$)	POTW Benchmark (2001$)	POTW Test Result
C: Beef/dairy	39.75	0.65	Fail
D: Swine/poultry	61.92	0.65	Fail

Since the most cost-effective candidate technologies for each species fail the POTW Test for each subcategory evaluated, any technology option developed for subcategories C or D utilizing a combination of these candidate technologies would also fail the POTW Test. Mathematically, this conclusion may be expressed as:

IF Technology "A" Costs > Benchmark "X"
AND Technology "B" Costs > Technology "A" Costs
THEN Technology "B" Costs > Benchmark "X"

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 similar to those used by beef feedlots. EPA notes that veal calf and heifer operations reflect approximately two percent of all Large CAFOs. Therefore, assuming that candidate technologies have similar costs and pollutant reductions, including additional models to reflect these facilities would not affect the overall cost-reasonableness test results.

Once a candidate technology fails the POTW Test, it fails the cost-reasonableness test. Although the Industry Cost Test is only relevant if the POTW Test is passed, it is discussed below for completeness.

The Industry Cost Test (see Section 15.2.2.2) is the second test that the candidate BCT must pass to be considered cost-reasonable. The Industry Cost Benchmark for BOD_5 and TSS is 1.29. Table 15-12 shows the Industry Cost Ratio calculated for each candidate technology options and the results of the second part of the BCT cost test.

Table 15-12. BOD_5 and TSS Cost Test Part Two—Industry Cost Test Results

Subcategory	BPT Cost per Pound BOD_5 and TSS Removed (2001$)	Candidate Technologies' Incremental Cost per Pound BOD_5 and TSS Removed (2001$)	Candidate Technologies' Industry Cost Ratio	Industry Cost Benchmark	Industry Test Results
C: Beef/dairy	0.16	39.75	241.54	1.29	Fail
D: Swine/poultry	0.22	61.92	283.28	1.29	Fail

In both subcategories, the candidate technologies' Industry Cost Ratios are higher than the Industry Cost Benchmark, and the technologies fail the second test. EPA concludes that since the most cost-effective candidate technologies for each species fail the Industry Cost Test for each subcategory evaluated, any technology option developed for subcategories C or D utilizing a combination of these candidate technologies would also fail the Industry Cost Test. This analysis clearly shows that even if the candidate technologies were both economically achievable and available, these technologies fail the BCT cost test.

15.2.4.5 Modified BCT Cost Test Calculations for FC Removals

Since none of the candidate technologies are technically and economically achievable, EPA need not proceed further to the cost reasonableness test. The following analysis is provided for information purposes.

In the BCT cost test for FC, EPA calculated incremental industry costs for all candidate BCTs compared to the BPT option. Table 15-13 presents the costs and FC removals of the 2003 CAFO rule (BPT) by species; Table 15-4 presents the costs and FC removals of the 2003 CAFO rule (BPT) by subcategory. FC removals were determined using the 2003 final CAFO rule methodology, as described in Section 8.6.3.

Table 15-13. 2003 CAFO Rule BPT Costs and FC Removals by Species

Animal 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 15-14. 2003 CAFO Rule BPT Costs and FC Removals by Subcategory

Subcategory	Annualized Costs ($2001, Millions, Pre-Tax)	FC Removed (Million CFU)
C: Beef/dairy	214	11.5×10^{13}
D: Swine/poultry	66	7.13×10^{13}

Table 15-15 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 test, EPA again evaluated the candidate technologies first on a species-specific basis. EPA then combined the most cost-effective technology for each species to form candidate technology options used to conduct the cost-reasonableness test on a subcategory basis.

As described in Section 15.2.3.1, EPA developed a new benchmark to use for this alternative POTW Test, which reflects the cost to reduce FC at a POTW. The resulting POTW Benchmark was $0.33 per trillion CFU FC removed (in 2001 dollars).

To pass the POTW Test for FC, the upgrade cost from BPT to BCT for each subcategory must be less than the POTW Benchmark of $0.33 per trillion CFU FC removed in 2001 dollars. To evaluate subcategories in the POTW Test, EPA considered the most cost-effective technology for each species:

- For the beef/dairy subcategory, EPA combined beef composting and dairy composting.
- For the swine/poultry subcategory, EPA combined poultry composting and swine land application timing restrictions.

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

Candidate Technology	Animal Sector	Incremental Annualized Cost ($2001, Millions, Pre-Tax)	Incremental FC Removed (Million CFU)	Cost per Trillion CFU Removed by Technology ($2001 per Trillion CFU)
Ground-water controls	Beef	145	ND	NC
	Dairy	188	ND	NC
	Swine	36	ND	NC
No discharge	Swine	108	137×10^{13}	0.08
Composting	Beef	1281	250×10^{13}	0.51
	Dairy	149	30.4×10^{13}	0.49
	Poultry	467	0.460×10^{13}	101.52
Anaerobic digestion	Dairy	237	33.3×10^{13}	0.71
	Swine	56	170×10^{13}	0.03
Land application timing restrictions	Beef	26	0.557×10^{13}	4.67
	Dairy	190	22.9×10^{13}	0.83
	Swine	12	136×10^{13}	0.01

ND: Values were non-zero, but too small to report in the indicated units.
NC: Values were not calculated because no additional pollutant reductions to surface waters were expected for these options.

EPA calculated the incremental costs between BPT and BCT for each CAFO subcategory using the incremental costs and incremental load removals in Table 15-15 and the following equation, as presented in the 1986 FRN methodology:

$$\frac{\text{Cost of BCT} - \text{Cost of BPT}}{\text{Pollutant Removal of BCT} - \text{Pollutant Removal of BPT}}$$

The equation used to calculate the incremental cost between BPT and BCT is not the modified equation developed by EPA to calculate the POTW Benchmark for FC removal. The POTW FC benchmark calculation applies to the incremental cost of FC removal between secondary treatment and advanced secondary treatment at POTWs, considering the entire POTW process and not a specific treatment unit. Because the entire POTW treatment process is considered for FC removals, the POTW FC equation must take into account removals and costs for the entire POTW.

The candidate treatment technologies selected for the CAFO subcategories will provide different levels of FC removal. Therefore, FC removals and costs for the BCT and BPT technologies can be compared on a process unit basis, similarly to the 1986 FRN methodology. EPA then calculated an incremental FC removal cost between BCT and BPT that could be compared to the POTW Benchmark cost.

Table 15-16 shows the comparison of BCT costs for candidate technologies with the POTW benchmark. For all subcategories, the FC POTW benchmark is lower than the cost per CFU removed by the BCT candidate technology. Because the cost per trillion CFU removed for each subcategory exceeds the POTW benchmark, all the technologies would fail the POTW cost test and therefore the BCT cost reasonableness test.

Table 15-16. FC Cost Test Part One—POTW Test Results

Subcategory	Candidate Technologies' Incremental Cost per Trillion CFU FC Removed (2001$)	POTW Benchmark for FC (2001$)	POTW Test Result
C: Beef/dairy	0.51	0.33	Fail
D: Swine/poultry	0.35	0.33	Fail

Once it fails the POTW Test, the candidate technology fails the BCT cost-reasonableness test. Although the Industry Cost Test is only relevant if the POTW Test is passed, the following discussion of the Industry Cost Test is provided for completeness.

The second test that the candidate BCT must pass to be considered cost-reasonable is the Industry Cost Test. As described previously, EPA first computes a ratio of two incremental costs to form the Industry Cost Ratio. The first incremental cost is the cost per CFU FC removed by the BCT candidate technology relative to BPT. The second incremental cost is the cost per CFU FC removed by BPT relative to no treatment (i.e., raw wasteload).

The Industry Cost Benchmark is the ratio of two other incremental costs: the POTW Benchmark and the cost per CFU FC for a POTW to initially achieve secondary treatment. If the Industry Cost Ratio is lower than the Industry Cost Benchmark, then the candidate technology passes the cost test. The Industry Cost Benchmark for FC is 0.04. Table 15-17 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 15-17. FC Cost Test Part Two—Industry Cost Test Results

Subcategory	BPT Cost per Trillion CFU FC Removed (2001$)	Candidate Technologies' Incremental Cost per Trillion CFU FC Removed (2001$)	Candidate Technologies' Industry Cost Ratio	Industry Cost Benchmark	Industry Test Results
C: Beef/dairy	1.86	0.51	0.27	0.04	Fail
D: Swine/poultry	0.92	0.35	0.38	0.04	Fail

In both subcategories the Industry Cost Ratio is higher than the Industry Cost Benchmark. Therefore, none of the candidate technologies would pass this Industry Cost Test. Since the most cost-effective candidate technologies for each species would fail the BCT cost test for each category evaluated, any technology option developed for Subcategories C or D utilizing a combination of these candidate technologies would also fail the cost test. EPA notes that the reductions in FC achieved by the candidate technologies (i.e., greater than 99 percent FC removal in the case of digesters and composting) represent the upper bound attainable by any technology. Based on this example modified BCT cost analysis, no candidate technologies would pass the BCT cost test for either Subcategory C or D.

15.2.4.6 Sensitivity Analyses and Alternative Approaches

EPA performed a variety of sensitivity analyses and alternative approaches to test the modified BCT Cost Test methodology to determine the effect of various inputs and approaches. These analyses and approaches included varying FC concentration values, investigating model cost data, using 99 percent FC removal for the BCT candidate technologies, calculating the POTW benchmark for FC using the 1986 methodology designed for TSS and BOD, and incorporating cost offsets into the BCT costs.

FC Concentration

EPA performed a sensitivity analysis to determine the effect of the FC concentration in the POTW influent and effluent on the POTW benchmark. EPA found that increasing the FC concentration in the secondary treatment effluent to 10,000 CFU per 100 mL (from 21 CFU per 100 mL) decreases the POTW benchmark cost from $0.33 per trillion CFU FC to $0.31 per trillion CFU FC. However, increasing the FC concentration in the raw influent to the POTW from 5,000,000 CFU per 100 mL to 7,000,000 CFU per 100 mL decreases the POTW benchmark cost from $0.33 to $0.24 per trillion CFU FC. This sensitivity analysis shows that one of the key parameters needed to accurately calculate the POTW benchmark cost is the concentration of FC in the influent to the POTW. In the absence of other reliable measured influent FC concentration data, the 5,000,000 CFU per 100 mL reflects the best available data for use in the POTW benchmark calculation.

Model Cost Data

EPA evaluated the accuracy of the model cost data from the 1986 FRN. EPA contacted a number of POTWs to determine both their capital and annual operating costs. These cost data, along with FC removal information, are summarized in a memorandum titled *Results of POTW Contacts for*

Fecal Coliform Removal, dated November 29, 2006 (EPA Docket OW-2005-0037, DCN 1-03038). The POTW annualized costs collected by EPA compared well with the POTW annualized costs that were obtained from the 1986 FRN and indexed to 2001. Based on these data, EPA concluded that the model POTW costs obtained from the FRN are reasonable for use in the POTW Benchmark calculation.

FC Removal of 99 Percent

EPA assessed these candidate technologies using the conservative assumption that FC produced by CAFOs may be reduced by 99 percent using any of these candidate technologies. EPA's record shows the range of performance of these technologies is more often 90 to 98 percent, therefore the 99 percent removal rate is an assumption that EPA recognized would overstate likely removals.

Using BOD_5 and TSS BCT Methodology for FC

For FC, calculating the incremental cost per unit of pollutant removal in the same way as BOD_5 and TSS ignores the fact that the majority of the FC removal occurs in secondary treatment, and would provide an erroneously high POTW benchmark cost as a result. EPA performed this calculation and the resulting POTW benchmark using the incremental costs and incremental pollutant removals yielded a POTW benchmark exceeding $9,200. (By comparison, the 1986 POTW Benchmark Methodology for BOD_5 and TSS produces a benchmark of $0.65 per pound in 2001 dollars).

While this value does represent marginal costs for additional FC removal, it does not, in fact, represent the point where incremental costs begin to exceed incremental benefits, identification of which was the intended object of the Congress's mandated cost reasonableness inquiry for BCT limitations. In other words, as the disparity between the two benchmarks show, the assumption that the additional costs of moving from secondary to advance secondary treatment are a surrogate for what is likely to be the point where incremental costs exceed incremental benefits does not hold true for control of FC. Under this approach, by contrast, virtually any candidate technology, no matter how expensive, would always pass the first cost test, a result that is clearly at odds with Congressional intent.

Cost Offset Programs

Available cost-sharing and technical assistance, as well as manure sales, may provide potential offsets to compliance costs incurred by CAFOs under the proposed CAFO regulations. As a conservative measure, EPA did not consider such offsets as part of its analysis. As a result, the impacts of the economic impact analysis are likely overstated; however, EPA does not believe that including these offsets changes the results of the BCT analysis.

EPA evaluated digestion as an example BCT that could be eligible for a cost-sharing program. According to EPA's AgStar program, a total of approximately $25 million has been awarded for anaerobic digestion of livestock manures from 2003 through 2005, ranging from $12.9 million in 2003 to $5 million in 2005.

To be conservative for the BCT analysis, EPA assumed that the entire budget in 2003 of $12.9 million was available for cost-sharing the installation of anaerobic digesters at either all-swine or all-dairy operations considered in the analysis. Applying this credit to the BCT analysis increases the cost-reasonableness of digestion as shown in Table 15-18; however, the decrease in cost is not enough to change the results of the BCT cost test. That is, digestion is still not the least cost technology, even considering the maximum contribution from all cost-offset programs to just this portion of the livestock and poultry industry.

Table 15-18. Contribution of Cost-Offset Programs for Digestion Incremental Costs and Removals

Candidate Technology	Animal Sector	Incremental Annualized Cost ($2001, Millions, Pre-Tax)	Incremental FC Removed (Million CFU)	Cost per Trillion CFU Removed by Technology ($2001 per Trillion CFU)
Anaerobic digestion	Dairy	362	33.3×10^{13}	1.09
	Swine	54	170×10^{13}	0.03

These reduced costs result in a cost ratio that is greater than the cost ratio of the least expensive candidate technology for dairies and swine. The least expensive technology selected for the BCT analysis was composting for dairies ($0.49/trillion CFU) and additional land application restrictions for swine ($0.01/trillion CFU).

Because it is not certain which operations could take advantage of cost-share assistance or to what degree, EPA determined that cost-share assistance could not be reliably used as a cost offset in the impact analysis and thus did not incorporate any assumptions of cost share assistance into the economic impact methodology. See 2003 Final Economic Analysis.

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