XI. What are the Environmental Benefits of the Proposed Revisions?

A. Non-Water Quality Environmental Impacts

The regulatory options developed for this proposed rule are intended to ensure the protection of surface water in and around animal feeding operations. However, one or more of the requirements included in these options may also have an impact on the amount and form of compounds released to air, as well as the energy that is required to operate the feedlot. Under sections 304(b) and 306 of the CWA, EPA is to consider the non-water quality environmental impacts (NWQI) when setting effluent limitations guidelines and standards. This section describes the methodology EPA used to estimate the NWQI for each of the options considered for this proposed rule. These non-water quality environmental impacts include:

- Air emissions from the feedlot operation, including animal housing and animal waste storage and treatment areas;
- Air emissions from land application activities;
- Air emissions from vehicles, including the off-site transport of waste and on-site composting operations; and
- Energy impacts from land application activities and the use of digesters.

For each regulatory option, EPA estimated the potential for new water pollution control requirements to cause cross-media pollutant transfers. Consistent with the approach used to estimate compliance costs, EPA used a model-facility approach to estimate NWQIs and to define baseline conditions. Industry-level non-water quality impacts for each animal sector (i.e., beef, dairy, swine, and poultry) were then estimated by multiplying the model farm impacts by the number of facilities represented by that model farm. These results are presented in Tables 11-1 through 11-4 for the population of operations defined as CAFOs under the two-tier structure (operations with more than 500 AU) and Tables 11-5 through 11-8 for the population defined as CAFOs under the three tier structure. For details on the derivation of the model farms, including definitions of geographic location, method of determining model farm populations, and data on waste generation, see the *Technical Development Document*.

1. Sources of Air Emissions

Animal feeding operations generate various types of animal wastes, including manure (feces and urine), waste feed, water, bedding, dust, and wastewater. Air emissions are generated from the decomposition of these wastes from the point of generation through the management and treatment of these wastes on site. The rate of generation of these emissions varies based on a number of operational variables (e.g., animal species, type of housing, waste management system), as well as weather conditions (temperature, humidity, wind, time of release). A fraction of the air emissions from AFOs are subsequently redeposited on land or in surface waters. This atmospheric redeposition in turn can be a source for water quality impacts.

a. Air Emissions from the Feedlot Operation

Animal housing and manure management systems can be a significant source of air emissions. Little data exist on these releases to allow a complete analysis of all possible compounds. For this proposed rule, EPA has focused on the release of greenhouse gases (methane, carbon dioxide, and nitrous oxide), ammonia, and certain criteria air pollutants (carbon monoxide, nitrogen oxides, volatile organic compounds, and particulate matter).

i. Greenhouse Gas Emissions from Manure Management Systems

Manure management systems, including animal housing, produce methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O) emissions. Methane and carbon dioxide are produced by the anaerobic decomposition of manure. Nitrous oxide is produced as part of the agricultural nitrogen cycle through the denitrification of the organic nitrogen in livestock manure and urine. Greenhouse gas emissions for methane and nitrous oxide were estimated for this proposed rule based on methodologies previously used by EPA's Office of Air and Radiation. Emission estimates for carbon dioxide are based on the relationship of carbon dioxide generation compared to methane generation.

Methane

Methane production is directly related to the quantity of waste, the type of waste management system used, and the temperature and moisture of the waste. Some of the regulatory options evaluated for animal feeding operations are based on the use of different waste management systems which may increase or decrease methane emissions from animal operations. In general, manure that is handled as a liquid or in anaerobic management systems tends to produce more methane, while manure that is handled as a solid or in aerobic management systems produces little methane. The methane producing capacity of animal waste is related to the maximum quantity of methane that can be produced per kilogram of volatile solids. Values for the methane producing capacity are available from literature and are based on animal diet. EPA estimated methane emissions for each type of waste management system included in the cost models. These values vary by animal type, geographic region (the methane conversion factor is a function of the mean ambient temperature), and type of waste management system (e.g., anaerobic lagoon, composting, drylot, stacked solids, or runoff storage pond).

Methane is also produced from the digestive processes of ruminant livestock due to enteric fermentation. Certain animal populations, such as beef cattle on feedlots, tend to produce more methane because of higher energy diets that produce manure with a high methane-producing capacity. However, since the proposed regulatory options do not impose requirements forcing CAFOs to use specific feeding strategies, potential impacts on enteric fermentation methane emissions are speculative and were not estimated.

Carbon Dioxide

Carbon dioxide is a naturally occurring greenhouse gas and is continually emitted to and removed from the atmosphere. Certain human activities, such as fossil fuel burning, cause additional quantities of carbon dioxide to be emitted to the atmosphere. In the case of feedlot operations, the anaerobic degradation of manure results not only in methane emissions, but also carbon dioxide emissions. These carbon dioxide emissions due to anaerobic degradation were estimated for each regulatory option. In addition, under Option 6, large dairies and swine operations would install and operate anaerobic digestion systems with energy recovery units. The biogas produced in the digester is burned in an engine to recover energy. EPA's emission estimates for Option 6 include the carbon dioxide produced during this combustion process.

Nitrous Oxide

The emission of nitrous oxide from manure management systems is based on the nitrogen content of the manure, as well as the length of time the manure is stored and the specific type of system used. In general, manure that is handled as a liquid tends to produce less nitrous oxide than manure that is handled as a solid. Some of the regulatory options evaluated for animal feeding operations are based on the use of waste management systems which may increase nitrous oxide emissions from animal operations. Values for total Kjeldahl nitrogen (TKN), a measure of organic nitrogen plus ammonia nitrogen, vary by animal type and are typically available in the literature for animal waste. EPA estimated nitrous oxide emissions by adjusting these literature values with an emission factor that accounts for the varying degree of nitrous oxide production, based on the type of manure management system.

ii. Ammonia Emissions and Other Nitrogen Losses from Housing and Manure Management Systems

Much of the nitrogen emitted from animal feeding operations is in the form of ammonia. Ammonia is an important component responsible for acidification and overnutrification of the environment. The loss of ammonia occurs at both the point of generation of manure, typically from urine, as well as during the storage and treatment of animal waste. As the pH of a system rises above 7, nitrogen in the form of ammonium is transformed into ammonia. A number of variables affect the volatilization of ammonia from animal waste, including the method in which the waste is stored, transported, and treated on site and the environmental conditions present (e.g., temperature, pH, wind).

Animals at the feedlot operation may be housed in a number of different ways that have an impact on the type and amount of nitrogen emissions that will occur. Some animals are housed in traditional confined housing (e.g., tie stall barns, freestall barns), while others are housed in outdoor areas (e.g., drylots, paddocks). Studies have shown that the type of housing used has a great effect on the emission of ammonia. Management of waste within the housing area also affects emissions (e.g., litter system, deep pit, freestall).

Anaerobic lagoons and waste storage ponds are a major component of the waste management systems. EPA has estimated volatilization of total nitrogen and ammonia from lagoons and ponds based on emission factors published in the scientific literature.

iii. Criteria Air Emissions from Energy Recovery Systems

Option 6 requires the implementation of anaerobic digestion systems with energy recovery for large dairy and swine operations. The operation of the digestion system greatly reduces the emission of methane through the capture of the biogas. However, the use of the biogas in an energy recovery system does generate certain criteria air pollutants when burned for fuel. Literature values for emission factors for carbon monoxide (CO), oxides of nitrogen (NOx), and volatile organic compounds (VOCs) were used to estimate releases of criteria air pollutants.

b. Air Emissions from Land Application Activities

Animal feeding operations generate air emissions from the land application of animal waste on cropland. Air emissions are primarily generated from the volatilization of ammonia at the point the material is applied to land. Additional emissions of nitrous oxide are liberated from agricultural soils when nitrogen applied to the soil undergoes nitrification and denitrification. Loss through denitrification is dependent on the oxygen levels of the soil to which manure is applied. Low oxygen levels, resulting from wet, compacted, or warm soil, increase the amount of nitrate-nitrogen released to the air as nitrogen gas or nitrous oxide. The analysis of air emissions from land application activities for this proposed rule focused on the volatilization of nitrogen as ammonia because the emission of other constituents is expected to be less significant.

The amount of nitrogen released to the environment from the application of animal waste is affected by the rate and method in which it is applied, the quantity of material applied, and site-specific factors such as air temperature, wind speed, and soil pH. There is insufficient data to quantify the effect of site-specific factors.

Since regulatory options in this proposed rule do not dictate particular application methods, EPA assumed that the application methods used by animal feeding operations will not significantly change from baseline.

Because EPA expects application methods to remain stable, EPA assumed that only the quantity of waste applied to cropland will change. On-site nitrogen volatilization will decrease as the quantity of waste applied to cropland decreases. The reductions of nitrogen volatilization will be the result of reductions in the total amount of manure applied on site. However, when both on-site and off-site nitrogen volatilization are considered, total nitrogen volatilization from manure is expected to remain constant. The movement of waste off -site changes the location of the nitrogen releases but not the quantity released. On-site, however, the volatilization rate will decrease, reflecting the decrease in the quantity of applied waste.

EPA used the same assumptions that were used to estimate compliance costs for land application of animal waste in order to estimate the change in air emissions from the application of nitrogen under baseline conditions and for each regulatory option. The cost methodology defines three types of animal feeding operations: Category 1 facilities currently have sufficient land to apply all manure on site; Category 2 facilities currently do not have enough land to apply all manure on site; and Category 3 facilities currently apply no manure on site (this manure is already being spread offsite). Neither Category 1 nor Category 3 facilities will show a change in nitrogen emission rates from the land application of animal manure under the proposed regulatory options. However, Category 2 facilities will be required to apply their waste at the agricultural rate under the regulatory options, thus reducing the amount of manure applied on site and subsequently reducing air emissions from on-site land application.

Under a phosphorus-based application scenario, facilities will have to apply supplemental nitrogen fertilizer to meet crop nutrient needs. The cost model assumes facilities will apply commercial ammonium nitrate or urea. The application of commercial fertilizer represents an increase in applied nutrients on site. While losses from applied commercial nitrogen are expected to be less than those from applied manure, data from Ohio State Extension states that both of these fertilizers can experience losses through denitrification if placed on wet or compacted soils. There is also a possibility that urea will volatilize if it is dry for several days after soil application. Ammonium nitrate fertilizer (when injected) is less likely to volatilize because it quickly converts to nitrate nitrogen which will not volatilize.

EPA estimated a "worst-case scenario" for ammonia emissions due to commercial fertilizer application based on a 35% loss of applied nitrogen.

c. Air Emissions from Vehicles

i. Off-Site Transportation

All options are expected to result in increasing the amount of manure hauled off-site, at least for some operations. Consistent with the cost model, EPA has grouped operations into three possible transportation categories. Category 1 facilities currently land apply all manure on site and Category 3 facilities currently transport all manure off site. Neither Category 1 nor Category 3 facilities require additional transportation of manure and will not have an increase in criteria air emissions. Category 2 facilities do not have enough land to apply all waste on site and do not currently transport waste. These facilities are expected to transport manure off site and therefore will have an increase in the amount of criteria air pollutants generated by the facility.

Hauling emissions estimates are based on calculations of the annual amount of waste generated, the annual number of miles traveled, and truck sizes. The number of trucks, number of trips per truck, the amount of waste and transportation distance are all calculated within the cost model. Vehicle emissions are calculated based on emission factors for diesel-fueled vehicles presented in "Compilation of Air Pollution Emission Factors" (AP-42). Estimates were calculated for volatile organic compounds, nitrogen oxides, particulate matter, and carbon monoxide.

ii. On-Site Composting Activities

Farm equipment used for on-site composting activities also affect the generation of air emissions, although composting of waste may also result in a reduction in transportation air emissions. While composting waste prior to hauling offsite can increase the marketability of the manure and may decrease hauling costs per ton of waste for some operations, not all operations can be expected to realize such benefits. Under Option 5, beef and dairy operations would be required to compost their solid manure. The criteria air emissions from on-site composting of manure were estimated for beef and dairy operations under Option 5. The source of criteria air emissions from composting are tractors and associated windrow-turning equipment.

2. Summary of Air Emission Impacts

Option 1: Emissions of methane and carbon dioxide from beef and dairy operations decrease under Option 1 due to the addition of solids separation in the waste management system. The separated solids are stockpiled rather than held in waste storage ponds or anaerobic lagoons. Anaerobic conditions, and the potential of the volatile solids to convert to methane, decrease using this drier method of handling the waste. However, this method also results in greater conversion of nitrogen to nitrous oxide. An increase in nitrous oxide emissions from dairies occurs for this reason. Greenhouse gas emissions from dry poultry operations (broilers, turkeys, and dry layers) do not change under Option 1 since no change to the waste handling practices are expected. These operations are already handling the waste as a dry material. Although indoor storage of poultry litter is included in the options, it is not expected to significantly alter the air emissions from the litter. Emissions of greenhouse gases from swine and wet poultry operations also do not change since no change to the waste handling practices are expected.

Ammonia emissions occur primarily from liquid waste storage areas, including ponds and lagoons. Under Option 1, all facilities are required to contain surface runoff from the feedlot, thereby increasing ammonia emissions from smaller beef and dairy CAFOs that do not currently have runoff control ponds or lagoons. Ammonia emissions for the poultry and swine sectors are not expected to change under Option 1.

Option 1 requires the application of animal waste to cropland at agronomic rates for nitrogen. Animal feeding operations that have excess nitrogen for their crops will need to transport their waste to another location. The generation of criteria pollutants for all animal sectors are expected to increase from baseline to Option 1 due to the additional transportation of waste off-site.

Options 2-4 and 7: No change in emissions of methane, carbon dioxide, or nitrous oxide occurs for all sectors relative to Option 1 because no significant changes in waste management are anticipated. Likewise, no large changes are expected for ammonia emissions.

These options require the application of animal waste to cropland at agronomic rates for phosphorus. Animal feeding operations that have excess phosphorus for their crops will need to transport their waste to another location. The generation of criteria pollutants are expected to increase from Option 1 to these options because more waste will need to be transported off site to meet agronomic rates for phosphorus.

Option 5A: Option 5A does not apply to the beef and dairy sectors. Emissions of greenhouse gases at swine operations significantly decrease under Option 5A, due to covering lagoons. The swine operations are expected to flare the gas that is generated in the lagoon. The methane will be converted, although carbon dioxide emissions will increase. In addition, the emissions of NOx and SOx increase because of the flaring of biogas collected from the covered lagoon.

On-site ammonia emissions at swine operations will decrease because the lagoon cover prevents the ammonia from leaving solution. Ammonia in the effluent from the covered lagoon will volatilize, however, soon after it is exposed to air.

Option 5B: Emissions of greenhouse gases from beef and dairy operations increase under Option 5B (i.e., mandated technology of composting), relative to Options 1 and 2. Compost operations include the addition of organic material to the waste pile to aid in the decomposition of the waste. This additional material also decomposes and contributes to increased methane emissions compared to other options. In addition, compost operations liberate more methane than stockpiles because the windrows are turned regularly. Stockpiles tend to form outer crusts that reduce the potential for air emissions to occur.

Emissions of greenhouse gases for swine operations under Option 5B are less than Option 2 due to the conversion of liquid manure handling systems (e.g., flush lagoons) to dry manure handling systems. Dry manure generates less methane than liquid systems. However, the emissions are higher than either Options 5A or 6, which allow liquid manure systems, but include destruction of the biogas generated from those systems.

Ammonia emissions at beef and dairy operations are expected to increase. During composting operations, the aeration of the compost pile liberates nitrogen in the form of ammonia. Ammonia emissions at swine operations are expected to decrease compared to Option 2, because of liquid manure systems converting to dry operations.

Option 5B generates the least criteria air pollutants compared to any other option for beef operations. Although composting operations include the operation of turning equipment which uses fuel and generates additional tractor air emissions, the process reduces the overall volume of waste to be transported. However, for dairy, additional organic material is added to the compost pile, which results in slightly higher transportation emissions than Option 2. Option 5B emissions of criteria pollutants for poultry operations are equal to the emissions for Options 2-4 and 7, since there is no difference in the amount of waste transported off site. The emissions from swine operations are significantly lower than Option 2 because the conversion of flush operations to dry housing significantly decreases the volume of waste to be transported off site.

Option 6: Relative to Option 2, only the dairy and swine sectors see any changes in air emissions. Emissions of methane from swine and dairy waste under Option 6 significantly decrease due to the addition of the anaerobic digester. A significant portion of the methane generated is collected as biogas and converted to energy. Drylot areas at dairies, however, will continue to generate methane that is uncollected. Carbon dioxide emissions significantly increase as methane is converted during the combustion process.

Although waste at large swine and dairy CAFOs will be digested, no significant changes to ammonia emissions are expected. The ammonia nitrogen, which is highly soluble, remains in solution in the digester. When the digester effluent is stored in an open lagoon, the ammonia will then be released.

Emissions of criteria pollutants from swine and dairy operations increase due to the addition of anaerobic digestion for large dairy operations. The digester collects biogas, which is subsequently combusted and converted into VOCs, NOx, and CO. Hydrogen sulfide contained in swine waste will be converted to Sox.

Table 11-1. Air Emissions and Energy Use for Beef (Including Heifer) Operations Under the Two-Tier Structure ($500 AU)

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5A	Option 5B	Option 6	Option 7
Air Emissions									
Methane (CH_4) (Gg/yr)	72	69	69	69	69		93	69	69
Carbon Dioxide (CO_2) (Gg/yr)	31	30	30	30	30		40	30	30
Nitrous Oxide (N_2O) (Gg/yr)	34	34	34	34	34		49	34	34
Ammonia (NH_3) (1000 Tons/yr)	581	582	582	582	582		902	582	568
Volatile Organic Compounds (VOCs) (Tons/yr)	NC	Baseline + 235	Baseline + 284	Baseline + 284	Baseline + 284		Baseline + 75	Baseline + 284	Baseline + 284
Nitrogen Oxides (NOx) (Tons/yr)	NC	Baseline + 905	Baseline + 1,091	Baseline + 1,091	Baseline + 1,091		Baseline + 291	Baseline + 1,091	Baseline + 1,091
Particulate Matter (PM) (Tons/yr)	NC	Baseline + 18	Baseline + 22	Baseline + 22	Baseline + 22		Baseline + 6	Baseline + 22	Baseline + 22
Carbon Monoxide (CO) (Tons/yr)	NC	Baseline + 2,800	Baseline + 3,400	Baseline + 3,400	Baseline + 3,400		Baseline + 900	Baseline + 3,400	Baseline + 3,400
Energy Usage									
Electricity Usage (1000 kW-hr/yr)	NC	Baseline + 11,082	Baseline + 45,109	Baseline + 45,109	Baseline + 45,109		Baseline + 45,109	Baseline + 45,109	Baseline + 45,109
Fuel Usage (1000 gallons/yr)	NC	Baseline + 1,917	Baseline + 2,311	Baseline + 2,311	Baseline + 2,311		Baseline + 420	Baseline + 2,311	Baseline + 2,311

Table 11-2. Air Emissions and Energy Use for Dairy Operations Under the Two-Tier Structure ($500 AU)

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5A	Option 5B	Option 6	Option 7
Air Emissions									
Methane (CH_4) (Gg/yr)	216	138	138	138	138		163	11	138
Carbon Dioxide (CO_2) (Gg/yr)	93	59	59	59	59		70	1,289	59
Nitrous Oxide (N_2O) (Gg/yr)	4	8	8	8	8		28	8	8
Ammonia (NH_3) (1000 Tons/yr)	217	220	220	220	220		257	207	218
Volatile Organic Compounds (VOCs) (Tons/yr)	NC	Baseline + 222	Baseline + 201	Baseline + 201	Baseline + 201		Baseline + 213	Baseline + 262	Baseline + 201
Nitrogen Oxides (NOx) (Tons/yr)	NC	Baseline + 855	Baseline + 772	Baseline + 772	Baseline + 772		Baseline + 821	Baseline + 4,454	Baseline + 772
Particulate Matter (PM) (Tons/yr)	NC	Baseline + 17	Baseline + 15	Baseline + 15	Baseline + 15		Baseline + 17	Baseline + 15	Baseline + 15
Carbon Monoxide (CO) (Tons/yr)	NC	Baseline + 2,700	Baseline + 2,400	Baseline + 2,400	Baseline + 2,400		Baseline + 2,500	Baseline + 2,900	Baseline + 2,400
Energy Usage									
Electricity Usage (1000 kW-hr/yr)	NC	Baseline + 8,759	Baseline + 9,899	Baseline + 9,899	Baseline + 9,899		Baseline + 9,899	Baseline + (1,139,200)	Baseline + 9,899
Fuel Usage (1000 Gallons/yr)	NC	Baseline + 1,811	Baseline + 1,635	Baseline + 1,635	Baseline + 1,635		Baseline + 1,646	Baseline + 1,605	Baseline + 1,635

Table 11-3. Air Emissions and Energy Use for Swine Operations under the Two-Tier Structure ($500 AU)

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5A	Option 5B	Option 6	Option 7
Air Emissions									
Methane (CH_4) (Gg/yr)	281	281	281	281	281	118	188	164	281
Carbon Dioxide (CO_2) (Gg/yr)	120	120	120	120	120	147	80	73	120
Nitrous Oxide (N_2O) (Gg/yr)	0.5	0.5	0.5	0.5	0.5	0.3	0.5	0.4	0.5
Ammonia (NH_3) (1000 Tons/yr)	128	128	128	128	128	113	93	126	135
Hydrogen Sulfide (H_2S) (1000 Tons/yr)	70	70	70	70	70	0	12	0	101
Volatile Organic Compounds (VOCs) (Tons/yr)	NC	Baseline + 12	Baseline + 31	Baseline + 31	Baseline + 31	Baseline + 50	Baseline + 16	Baseline + 11	Baseline + 31
Nitrogen Oxides (Tons/yr)	NC	Baseline + 43	Baseline + 115	Baseline + 115	Baseline + 115	Baseline + 15,300	Baseline + 63	Baseline + 9,600	Baseline + 115
Particulate Matter (PM) (Tons/yr)	NC	Baseline + 0.9	Baseline + 2	Baseline + 2	Baseline + 2	Baseline + 4	Baseline + 1	Baseline + 1	Baseline + 2
Carbon Monoxide (CO) (Tons/yr)	NC	Baseline + 130	Baseline + 360	Baseline + 360	Baseline + 360	Baseline + 590	Baseline + 200	Baseline + 130	Baseline + 360
Sulfur Oxides (1000 Tons/yr)	NC	Baseline	Baseline	Baseline	Baseline	Baseline + 59	Baseline	Baseline + 37	Baseline
Energy Usage									
Electricity Usage (1000 kW-hr/yr)	NC	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline + (848,900)	Baseline
Fuel Usage (1000 Gallons/yr)	NC	Baseline + 65	Baseline + 121	Baseline + 121	Baseline + 121	Baseline + 290	Baseline + 4	Baseline + 45	Baseline + 121

Table 11-4. Air Emissions and Energy Use for Poultry Operations Under the Two Tier Structure ($500 AU)

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5A	Option 5B	Option 6	Option 7
Air Emissions									
Methane (CH_4) (Gg/yr)	70	70	70	70	70	26	27	70	70
Carbon Dioxide (CO_2) (Gg/yr)	30	30	30	30	30	255	12	30	30
Nitrous Oxide (N_2O) (Gg/yr)	16	16	16	16	16	16	17	16	16
Ammonia (NH_3) (1000 Tons/yr)	17	17	17	17	17	15	14	17	19
Volatile Organic Compounds (VOCs) (Tons/yr)	NC	Baseline + 3	Baseline + 9	Baseline + 9	Baseline + 9	Baseline + 9	Baseline + 9	Baseline + 9	Baseline + 9
Nitrogen Oxides (Tons/yr)	NC	Baseline + 13	Baseline + 36	Baseline + 36	Baseline + 36	Baseline + 3,000	Baseline + 36	Baseline + 36	Baseline + 36
Particulate Matter (PM) (Tons/yr)	NC	Baseline + 0	Baseline + 1	Baseline + 1	Baseline + 1	Baseline + 1	Baseline + 1	Baseline + 1	Baseline + 1
Carbon Monoxide (CO) (Tons/yr)	NC	Baseline + 41	Baseline + 110	Baseline + 110	Baseline + 110	Baseline + 110	Baseline + 110	Baseline + 110	Baseline + 110
Energy Usage									
Electricity Usage (kW-hr/yr)	NC	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Fuel Usage (1000 Gallons/yr)	NC	Baseline + 427	Baseline + 1,253	Baseline + 1,253	Baseline + 1,253	Baseline + 1,253	Baseline + 1,253	Baseline + 1,253	Baseline + 1,253

Table 11-5. Air Emissions and Energy Use for Beef Operations Under the Three-Tier Structure (Includes Heifers)

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5A	Option 5B	Option 6	Option 7
Air Emissions									
Methane (CH_4) (Gg/yr)	70.20	67.32	67.32	67.32	67.32		90.52	67.32	67.32
Carbon Dioxide (CO_2) (Gg/yr)	30.08	28.85	28.85	28.85	28.85		38.79	28.85	28.85
Nitrous Oxide (N_2O) (Gg/yr)	32.55	32.54	32.54	32.54	32.54		47.56	32.54	32.54
Total Kjeldhl Nitrogen (TKN) (Tons/yr)	660580	657464	653382	653382	653382		653382	653382	649063
Ammonia (NH_3) (Tons/yr)	562404	563461	563461	563461	563461		872675	563461	550052
Volatile Organic Compounds (VOCs) (Tons/yr)	NC	Baseline + 234	Baseline + 282	Baseline + 282	Baseline + 282		Baseline + 74	Baseline + 282	Baseline + 282
Nitrogen Oxides (NOx) (Tons/yr)	NC	Baseline + 901	Baseline + 1086	Baseline + 1086	Baseline + 1086		Baseline + 286	Baseline + 1086	Baseline + 1086
Particulate Matter (PM) (Tons/yr)	NC	Baseline + 18	Baseline + 22	Baseline + 22	Baseline + 22		Baseline + 6	Baseline + 22	Baseline + 22
Carbon Monoxide (CO) (Tons/yr)	NC	Baseline + 2794	Baseline + 3367	Baseline + 3367	Baseline + 3367		Baseline + 889	Baseline + 3367	Baseline + 3367
Energy Usage									
Electricity Usage (kW-hr/yr)	NC	Baseline + 26801558	Baseline + 21706406	Baseline + 21706406	Baseline + 21706406		Baseline + 21706406	Baseline + 21706406	Baseline + 21706406
Fuel Usage (gallons/yr)	NC	Baseline + 1909749	Baseline + 2300912	Baseline + 2300970	Baseline + 2300970		Baseline + 409593	Baseline + 2300996	Baseline + 2300912

Table 11-6. Air Emissions and Energy Use for Dairy Operations Under the Three-Tier Structure

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5A	Option 5B	Option 6	Option 7
Air Emissions									
Methane (CH_4) (Gg/yr)	213.87	136.19	136.19	136.19	136.19		161.64	11.12	136.19
Carbon Dioxide (CO_2) (Gg/yr)	91.66	58.37	58.37	58.37	58.37		69.27	1290	58.37
Nitrous Oxide (N_2O) (Gg/yr)	4.17	7.56	7.56	7.56	7.56		23.07	7.56	7.56
Total Kjeldhl Nitrogen (TKN) (Tons/yr)	159703	153360	151810	151810	151810		151810	151810	151810
Ammonia (NH_3) (Tons/yr)	218368	221407	221407	221407	221407		258543	207969	218397
Volatile Organic Compounds (VOCs) (Tons/yr)	NC	Baseline + 211	Baseline + 178	Baseline + 178	Baseline + 178		Baseline + 192	Baseline + 242	Baseline + 178
Nitrogen Oxides (NOx) (Tons/yr)	NC	Baseline + 811	Baseline + 691	Baseline + 691	Baseline + 691		Baseline + 741	Baseline + 4377	Baseline + 691
Particulate Matter (PM) (Tons/yr)	NC	Baseline + 16	Baseline + 14	Baseline + 14	Baseline + 14		Baseline + 15	Baseline + 14	Baseline + 14
Carbon Monoxide (CO) (Tons/yr)	NC	Baseline + 2516	Baseline + 2143	Baseline + 2143	Baseline + 2143		Baseline + 2296	Baseline + 2647	Baseline + 2143
Energy Usage									
Electricity Usage (kW-hr/yr)	NC	Baseline + 11074220	Baseline + 16066951	Baseline + 16066951	Baseline + 16066951		Baseline + 16066951	Baseline + (1,139,200,000)	Baseline + 16066951
Fuel Usage (Gallons/yr)	NC	Baseline + 17192511	Baseline + 1464917	Baseline + 1464917	Baseline + 1464917		Baseline + 1477361	Baseline + 1440274	Baseline + 1464917

Table 11-7. Air Emissions and Energy Use for Swine Operations Under the Three-Tier Structure

NWQI	Regulatory Option								
	Baseline	Option 1	Option 2	Option 3	Option 4	Option 5A	Option 5B	Option 6	Option 7
Air Emissions									
Methane (CH_4) (Gg/yr)	256.32	256.32	256.32	256.32	256.32	100.84	167.74	139.59	256.32
Carbon Dioxide (CO_2) (Gg/yr)	109.85	109.85	109.85	109.85	109.85	141.79	71.89	62.90	109.85
Nitrous Oxide (N_2O) (Gg/yr)	0.46	0.46	0.46	0.46	0.46	0.28	0.46	0.32	0.46
Total Kjeldhl Nitrogen (TKN) (Tons/yr)	57143	56753	56663	56663	56663	56831	23779	41891	56663
Ammonia (NH_3) (Tons/yr)	115346	115346	115346	115346	115346	101312	82276	115346	122363
Hydrogen Sulfide (H_2S) (Tons/yr)	64511	64511	64511	64511	64511	0	10570	0	93477
Volatile Organic Compounds (VOCs) (Tons/yr)	NC	Baseline + 11	Baseline + 28	Baseline + 28	Baseline + 28	Baseline + 28	Baseline + 16	Baseline + 11	Baseline + 28
Nitrogen Oxides (NOx-N) (Tons/yr)	NC	Baseline + 42	Baseline + 109	Baseline + 109	Baseline + 109	Baseline + 14143	Baseline + 61	Baseline + 9554	Baseline + 109
Particulate Matter (PM) (Tons/yr)	NC	Baseline + 0.88	Baseline + 2	Baseline + 2	Baseline + 2	Baseline + 2	Baseline + 1	Baseline + 0.84	Baseline + 2
Carbon Monoxide (CO) (Tons/yr)	NC	Baseline + 129	Baseline + 338	Baseline + 338	Baseline + 338	Baseline + 338	Baseline + 189	Baseline + 126	Baseline + 338
Sulfur Oxides (Sox-S) (Tons/yr)	NC	Baseline	Baseline	Baseline	Baseline	Baseline + 54525	Baseline	Baseline + 36961	Baseline

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5A	Option 5B	Option 6	Option 7
Energy Usage									
Electricity Usage (kW-hr/yr)	NC	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline + (848,900,000)	Baseline
Fuel Usage (Gallons/yr)	NC	Baseline + 61940	Baseline + 111033	Baseline + 111033	Baseline + 111033	Baseline + 110122	Baseline + 3577	Baseline + 41082	Baseline + 111033

Table 11-8. Air Emissions and Energy Use for Poultry Operations Under the Three-Tier Structure

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5A	Option 5B	Option 6	Option 7
Air Emissions									
Methane (CH_4) (Gg/yr)	67.19	67.19	67.19	67.19	67.19	25.79	26.63	67.19	67.19
Carbon Dioxide (CO_2) (Gg/yr)	28.79	28.79	28.79	28.79	28.79	239.24	11.41	28.79	28.79
Nitrous Oxide (N_2O) (Gg/yr)	16.30	16.30	16.30	16.30	16.30	16.27	16.80	16.30	16.30
Total Kjeldhl Nitrogen (TKN) (Tons/yr)	341627	340325	329444	329444	329444	329444	45285	329444	329444
Ammonia (NH_3) (Tons/yr)	16507	16507	16507	16507	16507	14191	14485	16507	18003
Volatile Organic Compounds (VOCs) (Tons/yr)	NC	Baseline + 3	Baseline + 7	Baseline + 7	Baseline + 7	Baseline + 7	Baseline + 7	Baseline + 7	Baseline + 7
Nitrogen Oxides (NOx-N) (Tons/yr)	NC	Baseline + 10	Baseline + 27	Baseline + 27	Baseline + 27	Baseline + 2343	Baseline + 27	Baseline + 27	Baseline + 27
Particulate Matter (PM) (Tons/yr)	NC	Baseline + 0.21	Baseline + 1	Baseline + 1	Baseline + 1	Baseline + 1	Baseline + 1	Baseline + 1	Baseline + 1
Carbon Monoxide (CO) (Tons/yr)	NC	Baseline + 32	Baseline + 82	Baseline + 82	Baseline + 82	Baseline + 82	Baseline + 82	Baseline + 82	Baseline + 82
Energy Usage									
Electricity Usage (kW-hr/yr)	NC	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Fuel Usage (Gallons/yr)	NC	Baseline + 314265	Baseline + 893365	Baseline + 893365	Baseline + 893365	Baseline + 893365	Baseline + 893365	Baseline + 893365	Baseline + 893365

3. Energy Impacts

The proposed regulatory options may result in increased energy use for operations that currently do not capture their runoff or other process wastewater. These operations would need to capture the feedlot runoff, divert it to a waste management system, and use this wastewater for irrigation or dispose of it by some alternative means.

For the land application areas, the proposed regulatory options assume all CAFOs will apply their manure and wastewater using agricultural application rates. In many instances this means that facilities would have to limit the amount of manure applied to the land which may result in decreased energy usage at the CAFO. However, total energy requirements for land application increase under all options due to the increased transportation of waste off-site. Additional energy is also required to operate composting equipment, and at swine CAFOs to operate recirculating pumps to reuse lagoon effluent as flush water.

Option 6 includes the use of anaerobic digesters with energy recovery to manage animal waste for large dairy and swine operations. Digesters require a continuous input of energy to operate the holding tank mixer and an engine to convert captured methane into energy. The energy required to continuously operate these devices, as well as the amount of energy generated by the system, have been determined from the *FarmWare* model, which was also used for estimating compliance costs. Under Option 6, EPA anticipates a net decrease in electricity use due to the energy savings from methane recovery.

B. Quantitative and Monetized Benefits

In addition to costs and impacts, EPA also estimated the environmental and human health benefits of today's proposed requirements. Benefits identified as a result of this proposed rule are associated with improvements in water quality.

EPA is not currently able to evaluate all human health and ecosystem benefits associated with water quality improvements quantitatively. EPA is even more limited in its ability to assign monetary values to these benefits. The economic benefit values described below and in the "Environmental and Economic Benefits of the NPDES/ELG CAFO Rules" (Benefit Report) should be considered a subset of the total benefits of this rule and should be evaluated along with descriptive assessments of benefits and the acknowledgment that even these may fall short of the real-world benefits that may result from this rule. For example, the economic valuation considers the effects of nitrogen, phosphorous, pathogens and sediment but does not evaluate the economic impacts of metals or hormones which can produce significant adverse environmental impacts.

Within these confines, EPA analyzed the effects of current water discharges and assessed the benefits of reductions in these discharges resulting from this proposed regulation. The CAFO industry waste effluents contain pollutants that, when discharged into freshwater and estuarine ecosystems, may alter aquatic habitats, affect aquatic life, and adversely affect human health.

For this proposed rule, EPA conducted four benefit studies to estimate the impacts of controlling CAFO manure. The first study is a national water quality model (National Water Pollution Control Assessment Model) that estimates runoff from land application areas to rivers, streams, lakes and impoundments in the U.S. This study estimates the value society places in improvements in surface water quality associated with the different regulatory scenarios. Another study examines the expected improvements in shellfish harvesting as a result of CAFO regulation. A third study looks at incidences of fish kills that are attributed to animal feeding operations and estimates the cost of replacing the lost fish stocks. A fourth study estimates the benefits associated with reduced groundwater contamination. Each of these studies is described below.

1 Benefit scenarios

There are eight benefit scenarios under consideration, four scenarios(1, 2/3, 4a and 4b) using a nitrogen application rate and the same 4 scenarios using a phosphorus application rate. Scenarios 1 and 2/3 have a three-tiered structure similar to the current rule. Tier 1 is 1,000 AU and greater; Tier 2 is 300 - 999 AU; Tier 3 is less than 300 AU. Scenarios 4a and 4b have a two-tiered structure. Under Scenario 4a, Tier 1 is 500 AU and greater; Tier 2 is less than 500 AU. Under Scenario 4b, Tier 1 is 300 AU and greater; Tier 2 is less than 300 AU. EPA is co-proposing a two-tier and a three-tier structure (phosphorus - Scenario 2/3 and Phosphorus - Scenario 4a). Table 11-9 summarizes the regulatory scenarios considered in the benefits analysis.

Table 11-9. Regulatory Scenarios Considered in the Benefits Analysis

Regulatory Scenario	NPDES Revisions	Effluent Guidelines Revisions
Baseline	CAFOs include any AFO with over 1,000 AUs, as well as AFOs with 300 or more AUs that meet certain requirements.	Manure application not regulated
Nitrogen - Scenario 1	Baseline scenario plus dry poultry and immature swine and heifer operations.	Nitrogen-based manure application
Nitrogen - Scenario 2/3	New NPDES conditions for identifying CAFOs among AFOs with 300 - 1000 AUs, plus dry poultry and immature swine and heifer operations.	Nitrogen-based manure application
Nitrogen - Scenario 4a	CAFOs include all AFOs with 500 or more AUs, plus dry poultry, immature swine and heifer operations.	Nitrogen-based manure application
Nitrogen - Scenario 4b	CAFOs include all AFOs with 300 or more AUs, plus dry poultry, immature swine and heifer operations.	Nitrogen-based manure application
Phosphorus Scenario 1	Baseline scenario plus dry poultry and immature swine and heifer operations.	Phosphorus-based manure application

Regulatory Scenario	NPDES Revisions	Effluent Guidelines Revisions
Phosphorus Scenario 2/3*	New NPDES conditions for identifying CAFOs among AFOs with 300 - 1000 AUs, plus dry poultry and immature swine and heifer operations.	Phosphorus-based manure application
Phosphorus Scenario 4a*	CAFOs include all AFOs with 500 or more AUs, plus dry poultry, immature swine and heifer operations.	Phosphorus-based manure application
Phosphorus Scenario 4b	CAFOs include all AFOs with 300 or more AUs, plus dry poultry, immature swine and heifer operations.	Phosphorus-based manure application

* proposed scenarios

EPA has developed a model facility analysis to assess changes in pollutant loadings under baseline conditions and proposed regulatory scenarios. First, the analysis disaggregates the universe of AFOs according to a suite of characteristics directly affecting manure generation, manure management, and pollutant loadings. AFOs are then grouped into five geographic regions. Within each geographic region, EPA defines model facilities by production sector, subsector, and size (number of animals).

EPA then calculates manure production and the associated production of pollutants for each model facility. EPA multiplies the number of animal units per model facility by the manure production per animal unit to determine total manure production. EPA then calculates total generation of nutrients based on the typical pollutant concentrations per unit of recoverable manure for each animal type.

The core modeling analysis focuses on land application practices for each model facility and the capacity for soil and crop removal of nutrients applied to the land.[2] EPA divides the total nitrogen and phosphorus generated in manure by the average total acreage available for land application for an operation in the given region, size class, and production sector. The ratio of nutrients applied to crop nutrient requirements provides a measure of the excess nutrients applied in the manure. This in turn forms the foundation for loadings analyses of regulatory scenarios that call for adherence to agronomic rates of nutrient application.

EPA models "edge-of-field" loadings (i.e., pollutant loadings at the boundary of the model facility) using the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model. This field-scale model simulates hydrologic transport, erosion, and biochemical processes such as chemical transformation and plant uptake. The model uses information on soil characteristics and climate, along with nutrient production data, to model losses of nutrients in surface runoff, sediment, and groundwater leachate. Loadings are modeled for the pre- and post-regulatory scenarios to estimate changes in loadings attributable to the proposed standards.

[2] In addition to modeling loadings based on manure application, EPA develops two complementary analyses to examine loadings from storage structures and feedlots.

Finally, EPA extrapolates from the model facilities to develop national estimates of baseline and post-regulatory pollutant loadings from AFOs. Using the USDA Census of Agriculture, EPA determines the number of operations that raise animals under confinement. Then, EPA determines the number of CAFOs based on operations that are *defined* as CAFOs and smaller operations that are *designated* as CAFOs based on site-specific conditions, as established by the permitting authority. Finally, AFOs and CAFOs by region are placed into counties (and eventually watersheds) using published county level Census data. Therefore, the end product of the GLEAMS modeling is a spatial distribution of aggregated edge-of-field loadings that can be used in the water quality modeling and benefits monetization process described below.

National Surface Water Pollution Study

The National Water Pollution Control Assessment Model (NWPCAM) was employed to estimate national economic benefits to surface water quality resulting from implementation of various scenarios for regulating CAFOs. NWPCAM is a national-scale water quality model for simulating the water quality and economic benefits that can result from various water pollution control policies. NWPCAM is designed to characterize water quality for the Nation's network of rivers and streams, and, to a more limited extent, its lakes. Using GLEAMS output data, NWPCAM is able to translate spatially varying water quality changes resulting from different pollution control policies into terms that reflect the value individuals place on water quality improvements. In this way, NWPCAM is capable of deriving economic benefit estimates for scenarios for regulating CAFOs.

NWPCAM estimates pollutant loadings to the stream (nitrogen, phosphorous, metals, pathogens and sediment) for each regulatory scenario. These loadings by scenario (NWPCAM output) are used as input to the other studies. Thus, all stream loading estimates are derived from NWPCAM.

1. NWPCAM Loading reductions

Table 11-10 shows the estimated pollutant reduction for nitrogen, phosphorus, fecal coliform, fecal streptococci, and sediment for each of the five NPDES regulatory scenarios based on either nitrogen or phosphorus manure land application. Nitrogen reductions range from 14 million to 33 million kgs per year; phosphorus ranges from 35 million to 59 million kgs per year; fecal coliform from 26 billion to 38 billion colonies per year; fecal streptococci from 37 to 65 billion colonies per year; and sediment from 0 kgs to 38 million kgs per year.

The proposed Phosphorus - Scenario 2/3 shows a reduction of 30 M kg (66M lbs) of nitrogen, 54M kg (119M lbs) of phosphorus, 34 billion colonies of fecal coliform, 60 billion colonies of fecal strep, and 35B kg (77B lbs) of sediment. Phosphorus - Scenario 4a shows a reduction of 29 million kg (64M lbs)of nitrogen, 52 million kg (115 M lbs) of phosphorus, 32 billion and 58 billion colonies of fecal coliform and fecal streptococci, respectively and 34 billion kg (75B lbs) of sediment to our nation's waters each year.

Table 11-10. Pollutant Reduction based on Nitrogen or Phosphorus Manure Application Rates by NPDES Scenario

	Nitrogen (million kg)	Phosphorus (million kg)	Fecal Coliform (billion colonies)	Fecal Strep (billion colonies)	Sediment (billion kg)
Nitrogen - Scenario 1	14	35	26	37	0
Nitrogen - Scenario 2/3	16	45	31	45	0
Nitrogen - Scenario 4a	15	42	29	44	0
Nitrogen - Scenario 4b	18	48	34	47	0
Phosphorus - Scenario 1	25	42	29	50	26
Phosphorus - Scenario 2/3*	30	54	34	60	35
Phosphorus - Scenario 4a*	29	52	32	58	34
Phosphorus - Scenario 4b	33	59	38	65	38

* proposed scenarios

In addition, EPA estimated loadings reductions to surface waters for various metals found in manure: zinc, copper, cadmium, nickel and lead. The range of loadings reductions is shown in Table 11-11.

Table 11-11. Range of Metal Loading Reductions Across Scenarios

Metal	low (kg)	high (kg)
Zinc	10 M	19 M
Copper	546 K	1,051 K
Cadmium	23 K	39 K
Nickel	219 K	418 K
Lead	395 K	777 K

Table 11-12 is a list of metals and load reductions per year for the proposed scenarios.

Table 11-12. Metal Loading Reductions for Scenario2/3-Scenario 4a

Metal	Kilograms*
Zinc	18million/17 million
Copper	1 million/895 thousand
Cadmium	37 thousand/35 thousand
Nickel	400 thousand/345 thousand
Lead	740/690 thousand

* rounded to the nearest 10

The methods used to develop these loading reduction estimates are outlined in detail in the *Environmental and Economic Benefits of the NPDES/ELG CAFO Rules*.

2. Monetized Benefits

a. National Water Pollution Control Assessment Model (NWPCAM)

Economic benefits associated with the various AFO/CAFO scenarios are based on changes in water quality use-support (i.e., boatable, fishable, swimmable) and the population benefitting from the changes. Benefits are calculated state-by-state at the State (local) scale as well as at the national level. For each State, benefits at the local-scale represent the value that the State population is willing to pay for improvements to waters within the State or adjoining the State. For each State, benefits at the national-scale represent the value that the State population is willing to pay for improvements to waters in all other states in the continental United States.

Based on the NWPCAM analysis, the total national willingness-to-pay (WTP) benefits at the local-scale for all water quality use-supports ranged from approximately $4.3 million (1999 dollars) for the least stringent scenario to $122.1 million for the most stringent scenario. The total national WTP benefits at the national-scale for all water quality use-supports ranged from approximately $0.4 million (1999 dollars) for the least stringent scenario to $22.7 million for the most stringent scenario. Total WTP benefits (i.e., sum of local-scale and national-scale) for all water quality use-supports ranged from approximately $4.9 million (1999 dollars) for the least stringent scenario to $145 million for the most stringent scenario.

Table 11-13 summarizes the resulting estimates of economic benefits for each of the six regulatory scenarios analyzed. EPA estimates that the annual benefits of Phosphorus - Scenario 2/3 is approximately $127 million per year; for Phosphorus - Scenario 4a is $108 million per year.

Table 11-13. Economic Benefit of Estimated Improvements in Surface Water Quality

Regulatory Scenario	Annual Benefits (1999 $)

Nitrogen - Scenario 1	$4.9 million
Nitrogen - Scenario 2/3	$6.3 million
Nitrogen - Scenario 4a	$5.5 million
Nitrogen - Scenario 4b	$7.2 million
Phosphorus - Scenario 1	$87.6 million
Phosphorus - Scenario 2/3*	$127.1 million
Phosphorus - Scenario 4a*	$108.5 million
Phosphorus - Scenario 4b	$145.0 million

*proposed scenarios

b. Shellfish Beds

Pathogen contamination of coastal waters is a leading cause of shellfish bed harvest restrictions and closures. Sources of pathogens include runoff from agricultural land and activities. Using The 1995 National Shellfish Register of Classified Growing Waters (shellfish register) published by the National Oceanic and Atmospheric Administration (NOAA), EPA estimated the possible improvements to shellfish bed harvesting due to expected pathogen reductions of each regulatory scenario.

First, EPA characterized the baseline annual shellfish bed loadings. Then, EPA estimated the area of shellfish-growing waters for which current loadings are harvested. For the third step, EPA calculated the average annual per-acre yield of shellfish form harvested waters. Next, EPA estimated the area of shellfish-growing waters that are currently unharvested as a result of pollution from AFOs. From this, EPA calculated the potential harvest of shellfish from waters that are currently unharvested as a result of pollution from AFOs. Estimates for all scenarios range from $1.8 million to $2.9 million. Phosphorus - Scenario3 is $2.7 million and Phosphorus - Scenario 4a is $2.4 million.

c. Fishkills

Episodic fish kill events resulting from spills, manure runoff, and other discharges of manure from animal waste feeding operations continue to remain a serious problem in the United States. The impacts from these incidents range from immediate and dramatic kill events to less dramatic but more widespread events. Manure dumped into and along the West Branch of the Pecatonica River in Wisconsin resulted in a complete kill of smallmouth bass, catfish, forage fish, and all but the hardiest insects in a 13 mile stretch of the river. Less immediate catastrophic impacts on water quality from manure runoff, but equally important, are increased algae growth or algae blooms which remove oxygen from the water and may result in the death of fish. Manure runoff into a shallow lake in Arkansas resulted in a heavy algae bloom which depleted the lake of oxygen, killing many fish.

Fish health and fish kills are an indication of water quality. If fish cannot survive or are sick in their natural habitat then the public may view the water as unsuitable for recreational activities and fish unfit for human consumption. Parts of the Eastern Shore of the United States have been plagued with problems related to pfiesteria, a dinoflagellate algae that exist in rivers at all times, but can transform itself into a toxin that eats fish. Fish attacked by pfiesteria have lesions or large, gaping holes on them as their skin tissue is broken down; the lesions often result in death. The transformation of pfiesteria to the toxic form is believed to be the result of high levels of nutrients. Fish kills related to pfiesteria in the Neuse River in North Carolina have been blamed on the booming hog industry and the associated waste spills and runoff from the hog farms.

There is preliminary evidence that suggests that there are human health problems associated with exposure to pfiesteria. As a result, people most likely would limit or avoid recreational activities in waters with pfiesteria-related fish kills. The town of New Bern, a popular summer vacation spot along the Neuse River in North Carolina, was concerned about a decline in tourism after several major fish kills in the summer of 1995. Not only were fish killed, people became sick after swimming or fishing in the waters. People swimming in the waters reported welts and sores on their body. Summer camps canceled boating classes and children were urged to stay out of the water. Fishing boats were concerned about taking people fishing on the river. People were warned not to eat fish that were diseased or sick. At one point, after seeing miles and miles of dead fish, a top environmental official issued a warning urging people not to swim, fish, or boat in the fish-kill zone. Many blame the heavy rainfall which pumped pollutants from overflowing sewage plants and hog lagoons into the river, creating algae blooms, low oxygen and pfeisteria outbreaks as the cause of the fish kills.

Reports on fish kill events in the United States were collected by the Natural Resources Defense Council and the Izaak Walton League. Nineteen states reported information on historical and current fish kills. Using these data, EPA estimated the benefits related to reduced fish being killed for each regulatory scenario. At a seven percent discount rate, benefits range from $2 million to $42 million. Benefots for Phosphorus - Scenario 3 range from $2.4 million to $30.6 million; for Phosphorus - Scenario 4a, from $2.8 million to $34.5 million.

d. Groundwater Contamination

CAFOs can contaminate groundwater and thereby cause health risks and welfare losses to people relying on groundwater sources for their potable supplies or other uses. Of particular concern are nitrogen and other animal waste-related contaminants (originating from manure and liquid wastes) that leach through the soils and the unsaturated zone and ultimately reach groundwaters. Nitrogen loadings convert to elevated nitrate concentrations at household and community system wells, and elevated nitrate levels in turn pose a risk to human health in households with private wells (nitrate levels in community wells are regulated to protect human health). The proposed regulation will generate benefits by reducing nitrate levels in household wells, and there is clear empirical evidence that households have a positive willingness to pay to reduce nitrate concentrations in their water supplies.

The federal health-based National Primary Drinking Water Standard for nitrate is 10 mg/L, and this Maximum Contaminant Level (MCL) applies to all Community Water Supply systems. Households relying on private wells are not subject to the federal MCL for nitrate but levels above 10 mg/L are considered unsafe for sensitive subpopulations (e.g., infants). Several economic studies indicate a considerable WTP by households to reduce the likelihood of nitrate levels exceeding 10 mg/L (e.g.,$448 per year per household (Poe and Bishop, 1991)). There also is evidence of a positive household WTP to reduce nitrate levels even when baseline concentrations are considerably below the MCL (approximately $2 per mg/L of reduced nitrate concentration (Crutchfield et al, 1997, De Zoysa, 1995)).

Based on extensive U.S. Geologic Survey (USGS) data on nitrate levels in wells throughout the country, an empirical model was developed to predict how each regulatory option would affect the distribution of nitrate concentrations in household wells. Table 11-14 indicates the number of household wells that are estimated to have baseline (i.e., without regulation) concentrations above 10 mg/L and that will have these concentration reduced to levels below the MCL for each option. Also shown are the households with predicted nitrate levels that are below the MCL at baseline, but that will experience further reductions in nitrate levels due to the proposed regulation.

Table 11-14. Reduction in households exceeding MCL and mg/L of nitrate in wells

Regulatory Scenario	Reduction, from baseline, in # of households exceeding 10 mg/L	Total number of mg/L reduced in wells at 1-10 mg/L at baseline
Baseline # of households affected	1,277,137	6,195,332
Nitrogen - Scenario 1	152,204	961,741
Nitrogen - Scenario 2/3	152,204	1,007,611
Nitrogen - Scenario 4a	161,384	1,186,423
Nitrogen -Scenario 4b	161,384	1,186,423
Phos. - Scenario 1	161,384	1,103,166
Phos.- Scenario 2/3*	161,384	1,159,907
Phos.- Scenario 4a*	165,974	1,374,990
Phos. - Scenario 4b	165,974	1,374,990

*proposed scenarios

The monetized benefits of these nitrate concentration reductions is estimated to be $49.4 million per year for Phosphorus - Scenario 2/3, as shown in Table 11-15. The total benefits of this scenario consist of $47.8 million for the households that have nitrate levels reduced to below the MCL from baseline concentrations above 10 mg/L, plus an additional $1.5 million for those households with nitrate reductions relative to baseline levels below the MCL. The monetized benefits of these nitrate concentration reductions is estimated to be $51.0 million per year for Phosphorus - Scenario 4a. The total benefits of this option consist of $49.2 million for the households that have nitrate levels reduced to below the MCL from baseline concentrations above 10 mg/L, plus an additional $1.7 million for those households with nitrate reductions relative to baseline levels below the MCL. The household benefits of the other options are also shown in the table, and range from $46.4-$50.1 million per year.

Table 11-15. Annualized monetary benefits attributable to reduced nitrate concentrations

Regulatory Scenario	Total Benefits	Benefits from households exceeding MCL at baseline	Benefits from households between 1 and 10 mg/L at baseline
Nitrogen - Scenario 1	$46,372,457	$45,118,803	$1,219,763
Nitrogen - Scenario 2/3	$46,432,250	$45,118,803	$1,276,293
Nitrogen - Scenario 4a	$49,386,622	$47,840,089	$1,498,104
Nitrogen - Scenario 4b	$49,386,622	$47,840,089	$1,498,104
Phos. - Scenario 1	$49,278,094	$47,840,089	$1,396,043
Phos. - Scenario 2/3*	$49,352,058	$47,840,089	$1,465,648
Phos. - Scenario 4a*	$50,993,067	$49,200,732	$1,729,337
Phos. - Scenario 4b	$50,993,067	$49,200,732	$1,729,337

*proposed scenarios

e. Total Benefit of Proposed Regulatory Scenario

Table 11-16 shows the annualized benefits for each of the studies conducted. Table 11-17 shows the summary of annualized benefits for three discount rates (3,5,and 7 percent). The total monetized benefits for this proposed rule are, at a minimum, $163 million for Phosphorus - Scenario 2/3 and $146 million for Phosphorus - Scenario 4a, discounted at seven percent. At a three percent discount rate, the annualized benefits for Phosphorus - Scenario 3 are $180 million and for Phosphorus - Scenario 4a, $163 million. These represent the lower bound estimates for this analysis. The upper end of the range would include estimates for drinking water treatment plant cost savings, surface water improvements from nonboatable to boatable water quality conditions, and other benefits that we were unable to estimate at this time. We plan to include some of these monetized benefits in the final rule.

Table 11-16. Estimated Annualized Benefits of Revised CAFO Regulations (1999 dollars, millions)

Regulatory Scenario	Recreational and Non-use Benefits	Reduced Fish Kills	Improved Shellfishing	Reduced Private Well Contamination
Nitrogen- Scenario 1	$4.9	$0.1 - $0.2	$0.1 - $1.8	$33.3 - $49.0
Nitrogen- Scenario 2/3	$6.3	$0.1 - $0.3	$0.2 - $2.4	$33.3 - $49.1
Nitrogen- Scenario 4a	$5.5	$0.1 - $0.3	$0.2 - $2.2	$35.5 - $52.2
Nitrogen- Scenario 4b	$7.2	$0.1 - $0.3	$0.2 - $2.6	$35.5 - $52.2
Phosphorus- Scenario 1	$87.6	$0.2 - $0.3	$0.2 - $2.1	$35.4 - $52.1
Phosphorus- Scenario 2/3*	$127.1	$0.2 - $0.4	$0.2 - $2.7	$35.4 - $52.1
Phosphorus- Scenario 4a*	$108.5	$0.2 - $0.4	$0.2 - $2.4	$36.6 - $53.9
Phosphorus- Scenario 4b	$145.0	$0.2 - $0.4	$0.2 - $3.0	$36.6 - $53.9

*proposed scenarios

Table 11-17. Summary of Annualized Benefits (1999 dollars, millions)

	Discount Rates					
	3 Percent		5 Percent		7 Percent	
Regulatory Scenario	Low	High	Low	High	Low	High
Nitrogen-Scenario 1	$54.1	$55.9	$45.0	$46.9	$38.4	$40.2
Nitrogen-Scenario 2/3	$55.7	$58.0	$46.6	$48.9	$39.9	$42.3
Nitrogen-Scenario 4a	$58.0	$60.2	$48.3	$50.5	$41.2	$43.4
Nitrogen-Scenario 4b	$59.7	$62.3	$50.1	$52.6	$43.0	$45.5
Phosphorus-Scenario 1	$140.0	$142.1	$130.4	$132.4	$123.3	$125.4
Phosphorus-Scenario 2/3*	$179.7	$182.3	$170.0	$172.7	$163.0	$165.6
Phosphorus-Scenario 4a*	$162.8	$165.1	$152.8	$155.2	$145.5	$147.9
Phosphorus-Scenario 4b	$199.4	$202.2	$189.4	$192.2	$182.1	$185.0

* Proposed scenarios

XII. Public Outreach

A. Introduction and Overview

EPA has actively involved interested parties to assist it in developing a protective, practical, cost-effective regulatory proposal. EPA has provided many opportunities for input in this rulemaking