ATTACHMENT B

NATIONAL AIR EMISSIONS MONITORING STUDY PROTOCOL
Overview & Summary

EXECUTIVE SUMMARY

This document provides an overview and summary of a monitoring study protocol for collecting air emissions data from the egg, broiler chicken, turkey, dairy and swine industries. This protocol was developed through a collaborative effort of industry experts, university scientists, government scientists, and other stakeholders knowledgeable in the field. Although the effort was facilitated by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Agriculture (USDA), this product represents the opinions of the scientists, government experts, and stakeholders involved. In addition, there was extensive internal review and input by representatives from U.S. EPA's Office of Enforcement and Compliance Assurance, Office of Air and Radiation, and Office of Research and Development.

This protocol is designed to provide a framework for development of a comprehensive field sampling plan for collecting quality-assured air emission data from representative livestock and poultry farms in the U.S. As recommended in the National Academy of Sciences (NAS) 2003 report[1], and paraphrased here, . . . EPA and USDA should for the short term, initiate and conduct a coordinated research program designed to produce a scientifically sound basis for measuring and estimating air emissions from AFOs. Specific recommendations being addressed with this protocol are related to direct measurements at sample farms; utilizing information on the relationships between air emissions and animal types, nutrient outputs, manure handling practices, animal numbers, climate, and other factors, conducting these studies to evaluate the extent to which ambient atmospheric concentrations of the various pollutants of interest are consistent with estimated farm emissions; and using scientifically sound and practical protocols for measuring pollutant emission rates. The research program will involve additional recommendations from the NAS, which entails developing a process-based model that considers the entire animal production process. The data collected in the monitoring study will lay the groundwork for developing these more process-related emission estimates. However, as with any large and complex effort, this work must be conducted over a period of years.

In the development of this protocol, several alternate techniques were considered. The Science Advisor, in

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1 NAS, "Air Emissions From Animal Feeding Operations: Current Knowledge, Future Needs," National Research Council, 2003.

designing the monitoring study, may choose to use an alternate technique that is deemed most appropriate for a particular study unit. (A listing of alternate techniques can be found later in this protocol.) Thus, this protocol does not exclude use or consideration of any measurement methods or technologies that have been demonstrated to be scientifically sound and/or widely accepted for application to collecting air emissions data from the relevant farm sectors. However, the use of alternate techniques is dependent upon EPA approval of a comprehensive study design and budget.

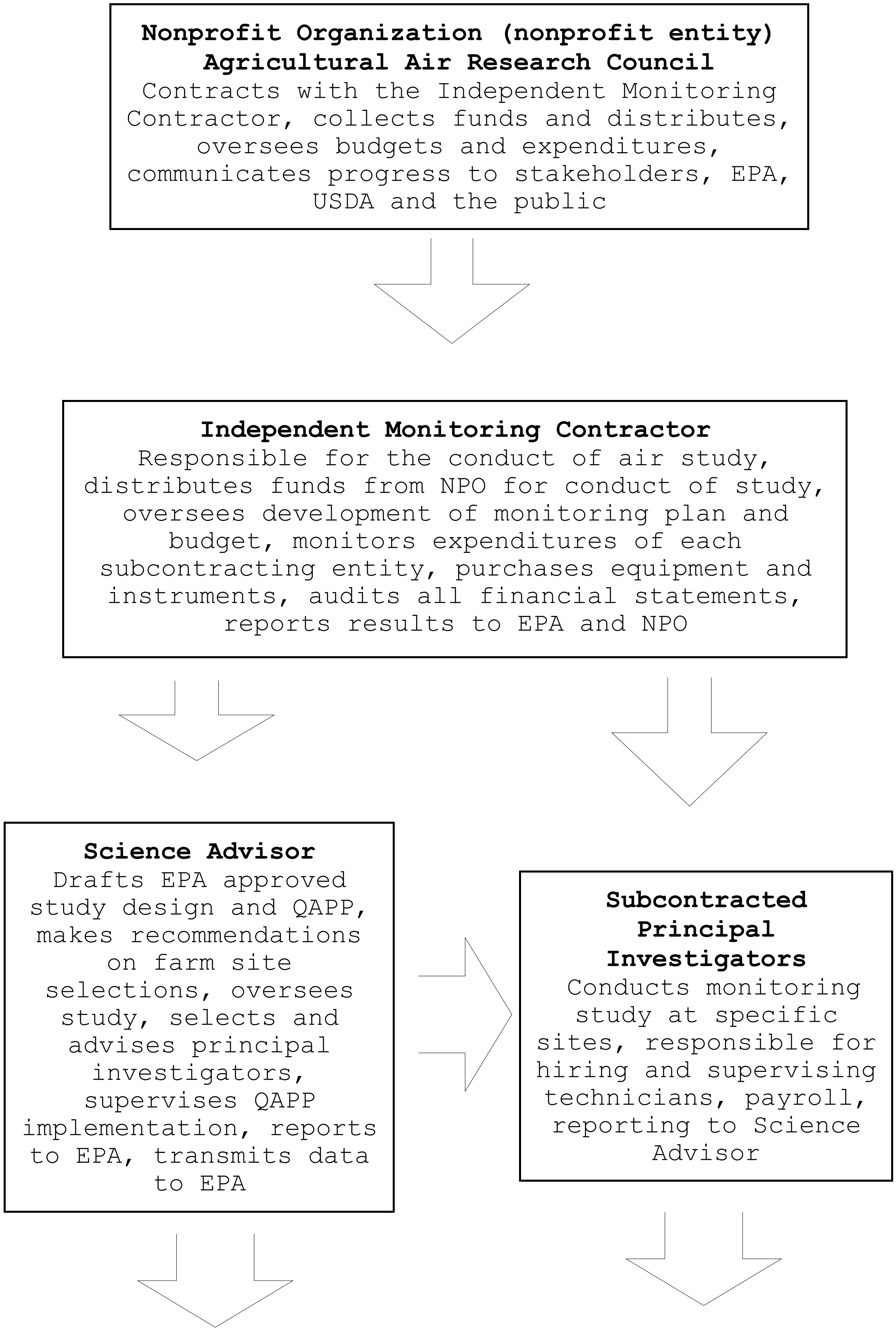
The benchmark data collected and subsequent analyses and interpretation will allow EPA and livestock and poultry producers to reasonably determine which farms are subject to the regulatory provisions of the Clean Air Act and reporting requirements of CERCLA and EPCRA. Following sound scientific principles and using accepted instrumentation and methods, the monitoring study will collect new data from a number of farms across the country and will also evaluate existing emissions data from other selected studies that may meet EPA quality assurance criteria. Together, they will form a database to which additional studies of air emissions and the effectiveness control technologies can be compared.

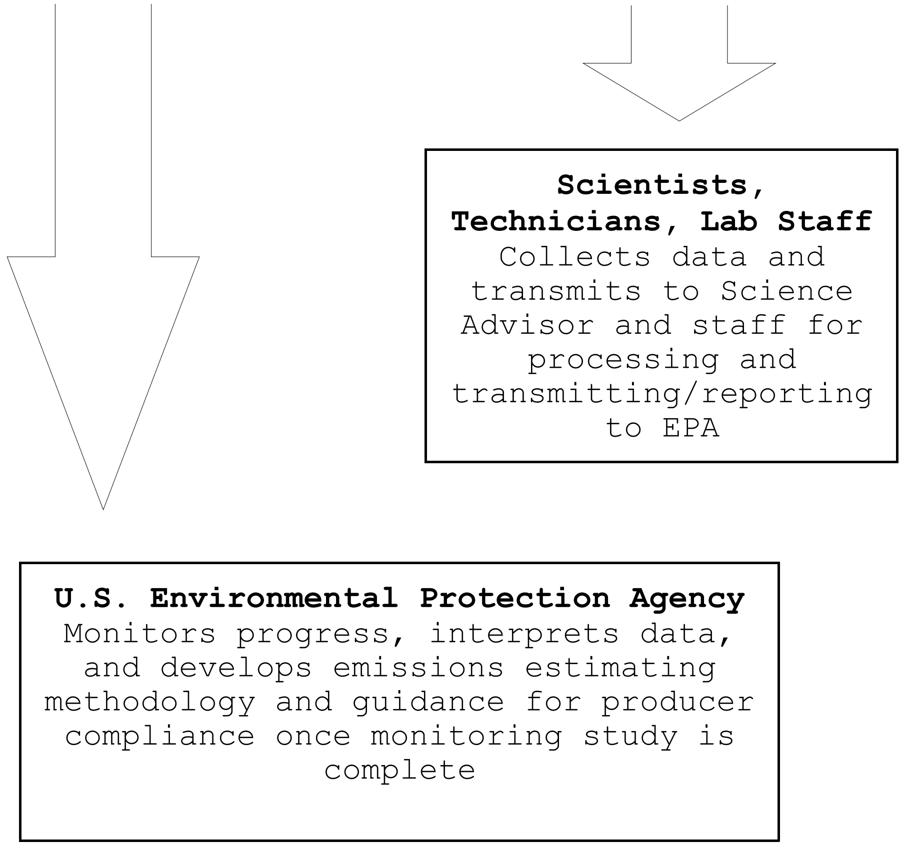
EPA will review and approve (as described in the Consent Agreement) a comprehensive study design and plan, including a Quality Assurance Project Plan (QAPP), and a budget for all aspects of the monitoring study. The QAPP will outline appropriate procedures to ensure acceptable accuracy, precision, representativeness, and comparability of the data; and will specify the use of properly maintained and reliable instrumentation, sampling schedules, ready supply of spare parts, approved analytical methodologies and standard operation procedures, description of routine quality control (QC) checks, external validation of data, well-trained analysts, field blanks, electrical backups, audits, documentation and format of data submission, and other procedural requirements. Chain of custody documentation will be used for samples of particulate matter. Wetted materials for gas sampling will be Teflon®, stainless steel or glass. All sampling flow rates will be calibrated.

MONITORING STUDY RESPONSIBILITIES

Several groups of management and technical staff will be responsible for success of the study. Their responsibilities are discussed here and graphically illustrated in the following flow chart.

RESPONSIBILITY FLOWCHART FOR COLLECTING AND ANALYZING DATA


Nonprofit Organization (nonprofit entity)
Agricultural Air Research Council
Contracts with the Independent Monitoring Contractor, collects funds and distributes, oversees budgets and expenditures, communicates progress to stakeholders, EPA, USDA and the public
Independent Monitoring Contractor
Responsible for the conduct of air study, distributes funds from NPO for conduct of study, oversees development of monitoring plan and budget, monitors expenditures of each subcontracting entity, purchases equipment and instruments, audits all financial statements, reports results to EPA and NPO
Science Advisor
Drafts EPA approved study design and QAPP, makes recommendations on farm site selections, oversees study, selects and advises principal investigators, supervises QAPP implementation, reports to EPA, transmits data to EPA
Subcontracted Principal Investigators
Conducts monitoring study at specific sites, responsible for hiring and supervising technicians, payroll, reporting to Science Advisor



The Nonprofit Organization (NPO)

Industry has established a nonprofit entity (Agricultural Air Research Council, or AARC, and referred to as the nonprofit organization or NPO in the Consent Agreement) to handle the funds contributed by individual participating organizations. The NPO will operate like a company with voting members who elect a board of directors. The board of directors will meet regularly, receive reports on the progress of the study, approve the budget, and review audits of expenditures.

The NPO will be responsible for:

- Selecting the Science Advisor and Independent Monitoring Contractor (IMC);
- Holding and disbursing to the Independent Monitoring Contractor the funds necessary to complete the study according to its approved schedule, protocol and budget; and
- Communicating progress of the study to livestock and poultry producers, the media and other interested parties.

Selection of the IMC and Science Advisor

The NPO will choose an IMC and a Science Advisor based on qualifications, experience and familiarity with all components of the subject matter. The IMC and the Science Advisor must be well staffed with accountants and contract managers who are well versed in fiduciary management. EPA will review the NPO's selection. If EPA believes the qualification criteria have not been met, the NPO will have to select an alternate candidate.

Role of Science Advisor

To be technically qualified, the Science Advisor must have an extensive background in animal agriculture, including expertise in air emissions from animal feeding operations, data processing, and engineering processes.

The Science Advisor will be responsible for drafting the comprehensive study design and QAPP and will submit these to EPA for approval. He/She will also coordinate with the IMC to oversee the work of the subcontracted Principal Investigators on the study. The Science Advisor will be employed by the IMC.

Roles of the Independent Monitoring Contractor (IMC)

Technical & Administrative Oversight

The IMC will be contractually responsible for the conduct of the study, and will:

- Be a separate organization from the industry that funds the study;
- Oversee the performance of the Science Advisor;
- Work closely with the Science Advisor in purchasing and assembling equipment and developing contracts for principal investigators; and
- Directly administer all subcontracts, supervise budgets and monitor expenditures, report progress and audit all financial statements.

Reporting on Study Progress

The IMC will:

- Report to EPA and the NPO on financial status of the study;
- Report to EPA and the NPO on the study progress; and
- Create a website specifically for the monitoring study

and regularly post updates so that the public can follow the study's progress.

Role of the Principal Investigators

Principal investigators will carry out the monitoring at each site. They will report to the Science Advisor and, in turn, to the IMC.

SITE SELECTION

The NPO will be comprised of representatives from the various animal husbandry industries who are knowledgeable of actual farming operations as related to the farm sites proposed for monitoring. They will compile a list of candidate farms from those operations participating in the Consent Agreement and submit the list to the Science Advisor. The Science Advisor will then facilitate a process to select farms for monitoring based on a set of pertinent factors (e.g., differing regional and climatic conditions, number of animals, different manure handling practices, and types of ventilation (natural vs. forced air)). In addition, logistical issues will be considered to reduce problems associated with egress and convenience; such as, is there a principal investigator located within 3 hours of the site, are there housing accommodations available within 1 hour of the site, is there internet access at the farm, and is 220 V power available? After comprehensive site plans are approved by EPA, the Science Advisor will supervise the set up of equipment at those farms selected, advise the cooperating farmers of their responsibilities, verify utilities, arrange for high speed computer data transmission service, initiate the study and implement the quality assurance project plan. As the study progresses, some investigators may want to alter their approved plans due to interim findings (such as, collecting redundant data or discovering a need to change equipment location). Any changes must be sent to the Science Advisor, with EPA notification and concurrence, for approval or disapproval.

MONITORING PLANS BY SPECIES

On the following pages, the swine, egg layer, meat bird (broiler and turkey) and dairy air emissions study components are summarized. These were developed over several months by a peer review team of scientists, industry and other stakeholders. While the study scope varies from species to species in line with their data needs, available funding, and industry characteristics, the technologies and measurement methodologies selected by the team are consistent across species.

1. Air Emission Monitoring Plan for Swine

Introduction: Swine production phases include sows (breeding, gestation, and farrowing), nursery pigs, and finishing pigs. The buildings are either naturally ventilated or mechanically ventilated but many buildings have a combination of the two ventilation types. Manure treatment and/or storage generally consists of either basins (earthen, clay or synthetic lined earthen, concrete, glass lined steel) that store manure collected from the barn, or clay/synthetic lined earthen anaerobic treatment lagoons that treat and store manure. Manure collection systems with external manure storage/treatment are generally scrape, flush or pull-plug.

Overall, the U.S. hog inventory is located in three general regions. The five top Midwest swine states, IA, MN, IL, MO, and IN represent about 54 percent of the total inventory in the U.S. In the Southeast, NC, AR, VA, KY, and MS represent about 19 percent, and in the West, OK, NE, KS, SD, and TX represent about 15 percent.

<u>Farm Selection for New Measurements</u>: Swine production farm types are identified by region, production phase, ventilation type, and manure storage/treatment in Table 1. Farms selected will be characterized by criteria such as facility age, size, design and management, local topography and meteorology, swine diet and genetics. The farm should be reasonably isolated from other potential air pollution sources. Producers/farm managers must be willing to attend a training session, make changes as needed to accommodate the project, and maintain and share certain production records to facilitate data analysis and interpretation.

Farms to be monitored will be further characterized using farm management data and samples collected for analysis of water, feed and manure. Farms will provide vital management information regarding ventilation controls/management and scheduling of barn activities such as manure management, animal load out, animal treatment, or feeding. At a minimum, water, feed and manure samples will be collected and analyzed for total nitrogen and total sulfur content.

Table 1. Farm Sites Identified and Proposed for Monitoring

(G = gestation, F = farrowing, FI = finishing, MV = mechanically ventilated)

Production Phase	Ventilation Type	Number of Units	Location of Measurements	
			Barns or Rooms	Storage/ Lagoon Treatment
SOUTHEAST				
Sow	MV	4	G & F	
		single or double		lagoon
Finisher	MV	4	FI	
		single or double		lagoon
MIDWEST				
Sow	MV	4	G & F	
		2		deep pit
Finisher	MV	4	FI	
		1		basin
WEST				
Sow	MV	4	G & F	

		single or double		**lagoon**

Methods: The mass balance technique will be used for measuring emissions from mechanically ventilated barns. Micrometeorological techniques will be used for manure storage/treatment systems located outside the barn. Table 2 summarizes the methods and emissions that will be measured from barns and manure storage/treatment systems. A maximum of five farms will be selected for barn measurements and six farms for manure storage/treatment system measurements. If possible, at least one farm will have measurements conducted at both the barns and the manure storage/treatment system.

Table 2. Summary of Emissions Measurements and Methodologies

Source Units	**Methodology**	**Targeted Emissions**	**Number of Farms**	**Number of Units to Monitor**
Barn	Mass balance	NH3, PM10, PM2.5 VOC, H2S, TSP, CO2	5 (see Table 1)	20
Manure storage/ treatment system	Micromet and Water 9	VOC, H2S, NH3	6 (see Table 1)	6

Barn Measurements: An on-farm instrumentation shelter (OFIS) will house the equipment for measuring pollutant concentrations at representative air inlets and outlets (primarily by air extraction for gases), barn airflows, operational processes and environmental variables. Sampling will be conducted for 24 months with data logged every 60 seconds. Data will be retrieved with network-connected PCs, formatted, validated, and delivered to EPA for subsequent calculations of emission factors. A multipoint air sampling system in the shelter will draw air sequentially from representative locations (including outdoor air) at the barns and deliver selected streams to a manifold from which on-line gas monitors draw their subsamples. Concentration of constituents of interest will be measured using the following methods:

- Ammonia will be measured using chemiluminescence or photoacoustic infrared.
- Hydrogen sulfide will be measured with pulsed fluorescence.
- Carbon dioxide will be measured using photoacoustic infrared or equivalent.
- TSP will be measured using an isokinetic multipoint gravimetric method.
- PM2.5 will be measured gravimetrically with a federal reference method for PM2.5 at least for 1 month per site. It will be shared among sites.
- PM10 will be measured in real time using the tapered element oscillating microbalance (TEOM) at

representative exhaust locations in the barn and ambient air.

- An initial characterization study of barn volatile organic compounds (VOC) will be conducted on 1 day during the first month at the first site (site 1). While total nonmethane hydrocarbons (NMHC) are continuously monitored using a dual-channel FID analyzer (Method 25A) along with building airflow rate, VOC will be sampled with replication at two barns using Silcosteel canisters, and all-glass impingers (EPA Method 26A). Each sample will be evaluated using concurrent gas chromatography-mass spectrometry (GC-MS) and GC/FID for TO 15 and other FID-responding compounds. VOC mass will be calculated as the sum of individual analytes. The 20 analytes making the greatest contribution to total mass will be identified during the initial characterization study. A sampling method that captures a significant fraction of the VOC mass will be chosen for the remainder of the study.
- The Method 26A sampling train is suitable for collecting samples for analysis of formaldehyde and acetaldehyde using NCASI 94.02, requiring only the addition of spectrophotometry for the detection of formaldehyde. These compounds will be measured during the initial characterization study and, if not found,

will not be analyzed during subsequent measurements.

- Total VOC mass may be estimated (scaled) by multiplying the total carbon as determined by Method 25A by the molecular weight/carbon weight ratio derived from GC-MS or GC-FID speciation. This should account for the VOC that are not identified by GC methods due either to sampling bias or the analytical procedures used, although some error is anticipated due to the imprecise response of the Method 25A FID to oxygenated compounds. Acceptance of a scaling factor will depend on whether the Method 25A analyzer response is reasonable based on the manufacturer's stated response factors, bench-scale verification, or judgmental estimation of the mass of unaccounted for VOC.
- By the middle of the second month, the Science Advisor will report results of the initial VOC characterization to EPA with recommendations on the appropriateness and validity of the selected methodologies.
- Quarterly VOC samples using the selected VOC sampling method will occur at all sites, along with continuous Method 25A monitoring at site 1 throughout the study.
- Method 25A measurements will be corrected from an "as carbon" basis to a total VOC mass basis by multiplying them by the mean molecular weight per carbon atom established by GC-MS evaluations during applicable

intervals of time.

Mechanically ventilated barn airflows will be estimated by continuously measuring fan operational status and building static pressure to calculate fan airflow from field-tested fan performance curves and by directly measuring selected fan airflows using anemometers. Specific processes that directly or indirectly influence barn emissions will be measured including pig activity, manure management/handling, feeding, and lighting. Environmental parameters including heating and cooling operation, floor and manure temperatures, inside and outside air temperatures and humidity, wind speed and direction, and solar radiation will be continuously monitored. Feed and water consumption, manure production and removal, swine mortalities, and animal production will also be monitored. As noted above, samples of feed, water, and manure will be collected and analyzed for total nitrogen and total sulfur. These data will enable the development and validation of process-based emission models in the future.

Table 1 identifies those types of farms where barn measurements will be taken to provide the needed data to complete the objectives of the monitoring study. A total of five farms will be selected as measurement sites. Two farms in the Southeast representing the sow and finishing phases of production with lagoon manure treatment will be selected.

Two farms in the Midwest representing a finishing farm using an in-ground manure storage basin and a sow farm with a deep pit gestation barn will be selected. Finally, one farm in the West representing a sow farm with lagoon treatment will be selected. On each of the farms, four barns will have measurements taken simultaneously. Where applicable, the sow farms will have two farrowing rooms and two gestation barn emissions measured and on finishing farms, up to four barns will have emission measurements.

Lagoons: Micrometeorological techniques will be used to estimate emissions of NH3, H2S, and a limited number of VOC from lagoons. Fundamentally, this approach will use optical remote sensing (ORS) downwind and upwind of the lagoon coupled with 3-dimensional (3D) wind velocity measurements at heights of 2 and 12 meters (m). The concentrations of NH3 and the various hydrocarbons will be made using open path Fourier transform infrared spectroscopy (FTIR). Measurements of H2S (and NH3) will be made using collocated open path UV differential optical absorption spectroscopy (UV-DOAS) systems. A team of two persons with two scanning FTIR systems, two single-path UV-DOAS systems, and two 3D sonics with supplementary meteorological instruments will move sequentially from farm to farm.

Each of two ORS systems will be oriented parallel to the storage side and approximately 10m from the lagoon edge.

Each monostatic FTIR system will scan five retroreflectors; three mounted at 1m height equally dividing the length of the open path along the lagoon side and two mounted on a tower at heights of 6 and 12m located at the corners down the adjacent sides of the lagoon, resulting in scan lines down each of the four sides of the lagoon. Two bistatic single-path UV-DOAS systems will be located at a nominal 2m height within 2m laterally of the FTIR scan lines on the two sides of the lagoon oriented most closely with prevailing winds.

Emissions will be determined from the difference in upwind and downwind concentration measurements using two different methods - a Eulerian Gaussian approach and a Lagrangian Stochastic approach. The Lagrangian approach is based on an inverse dispersion analysis using a backward Lagrangian stochastic method (bLS). This approach will be used to estimate NH_3 emissions from concentration measurements made using the FTIR and UV-DOAS systems and the H_2S emissions from concentration measurements made using the UV-DOAS systems. The emission rate for NH_3 will be the ensemble average of the estimated emissions for each of the five FTIR scans with a corresponding error of the emission estimate. The Eulerian approach is based on a computed tomography (CT) method using Eulerian Gaussian statistics and a fitted wind profile from the two 3D sonics.

Measurements of air and lagoon temperatures, wind speed and direction, humidity, atmospheric pressure, and solar radiation will also be conducted.

The bLS and CT emission estimates will be quality assured using tests of instrument response, wind direction and wind speed, stability, turbulence intensity, differences between the lagoon and the surrounding surface temperatures, differences in the mean and turbulent wind components with height, and the temporal variability in emissions. Emission estimates using the CT method will be qualified by the measured fraction of the estimated plume. To estimate VOC emissions from lagoons, samples of the lagoon liquid will be collected and analyzed for VOC, and the EPA model WATER9 will be used to estimate emissions based on measured VOC concentrations, pH, and other factors.

Quality Assurance/Quality Control (QA/QC): QA/QC processes will be established before data collection commences. The QA/QC procedures will be based on EPA guidelines and will include the use of properly maintained and reliable instrumentation, ready supply of spare parts, approved analytical methodologies and standard operating procedures, external validation of data, well-trained analysts, field blanks, electrical backups, audits, and documentation. Calibration and maintenance logs will be maintained for each instrument.

2. Air Emission Monitoring Plan for Laying Hens

Introduction: Most U.S. layer housing types and manure management schemes fall under one of four categories: 1) high-rise houses with manure stored in the lower level and removed every 1 to 2 years, 2) belt houses with quasi-continuous manure transfer to an external storage/treatment facility, 3) shallow-pit houses with regular manure removal by scraping and temporary storage in uncovered piles, and 4) liquid-manure houses with manure flushed daily into a lagoon. The locations for four sites with specific housing types were recommended for the monitoring study with consideration of these four housing categories along with the potential impact of climatic differences and the geographical density of egg production (Table 3). Final site selections will also depend on site-specific factors including representativeness of facility age, size, design and management, and flock diet and genetics. The facility should be reasonably isolated from other air pollution sources and have potential for testing mitigation strategies. Producers/farm managers must be willing to attend a training session, make changes as needed to accommodate the project, and maintain and share certain production records to facilitate data analysis and interpretation.

Table 3. Recommended Types and Locations of Laying Hen

Houses to be Monitored in the Monitoring Study

Region/Location	House 1 - Type	House 2 - Type
Midwest	High-rise with inside manure storage (2)	Manure belt (2) with manure storage
West	Shallow pit with open manure storage	Manure belt with open manure storage
South	High-rise with inside manure storage	High-rise with inside manure storage
East	High-rise with inside manure storage	Flushing with anaerobic treatment lagoon

<u>Methods</u>: An on-farm instrument shelter (OFIS) will house the equipment for monitoring pollutant concentrations at representative air inlets and outlets (primarily by air extraction for gases), barn and manure shed airflows, and operational processes and environmental variables. Sampling will be conducted for 24 months with data logged every 60 seconds. Data will be retrieved with network-connected PCs, formatted, validated, and delivered to EPA for subsequent calculations of emission factors. A multipoint air sampling system in the OFIS will draw air sequentially from representative locations (including outdoor air) at the hen houses and manure sheds and deliver selected streams to a manifold from which gas analyzers draw their samples. Selected pollutants will be evaluated as follows:

- Ammonia will be measured using chemiluminescence or photoacoustic infrared.

- Hydrogen sulfide will be measured with pulsed fluorescence.
- Carbon dioxide will be measured using photoacoustic infrared or equivalent.
- TSP will be measured using an isokinetic multipoint gravimetric method.
- PM2.5 will be measured gravimetrically with a federal reference method for PM2.5 at least for 1 month per site. It will be shared among sites.
- PM10 will be measured in real time using the tapered element oscillating microbalance (TEOM) at representative exhaust locations in the barn, ambient air, and at manure storage exhaust (if manure is disturbed).
- An initial characterization study of barn VOC will be conducted on 1 day during the first month at the first site (site 1). While total nonmethane hydrocarbons (NMHC) are continuously monitored using a dual-channel FID analyzer (Method 25A) along with building airflow rate, VOC will be sampled with replication at two barns using Silcosteel canisters, and all-glass impingers (EPA Method 26A). Each sample will be evaluated using concurrent gas chromatography - mass spectrometry (GC-MS) and GC/FID for TO 15 and other FID-responding

compounds. VOC mass will be calculated as the sum of individual analytes. The 20 analytes making the greatest contribution to total mass will be identified during the initial characterization study. A sampling method that captures a significant fraction of the VOC mass will be chosen for the remainder of the study.

- The Method 26A sampling train is suitable for collecting samples for analysis of formaldehyde and acetaldehyde using NCASI 94.02, requiring only the addition of spectrophotometry for the detection of formaldehyde. These compounds will be measured during the initial characterization study and, if not found, will not be analyzed during subsequent measurements.
- Total VOC mass may be estimated (scaled) by multiplying the total carbon as determined by Method 25A by the molecular weight/carbon weight ratio derived from GC-MS or GC-FID speciation. This should account for the VOC that are not identified by GC methods due either to sampling bias or the analytical procedures used, although some error is anticipated due to the imprecise response of the Method 25A FID to oxygenated compounds. Acceptance of a scaling factor will depend on whether the Method 25A analyzer response is reasonable based on the manufacturer's stated response factors, bench-scale verification, or judgmental estimation of unaccounted

for VOC mass.

- By the middle of the second month, the Science Advisor will report results of the initial VOC characterization to EPA with recommendations on the appropriateness and validity of the selected methodologies.
- Quarterly VOC samples using the selected VOC sampling method will occur at all sites, along with continuous Method 25A monitoring at site 1 throughout the study.
- Method 25A measurements will be corrected from an "as carbon" basis to a total VOC mass basis by multiplying them by the mean molecular weight per carbon atom established by GC-MS evaluations during applicable intervals of time.

Mechanically ventilated barn airflows will be estimated by continuously measuring fan operational status and building static pressure to calculate fan airflow from field-tested fan performance curves and by directly measuring selected fan airflows using anemometers. Specific processes that directly or indirectly influence air emissions will be measured including hen activity, feeding, and lighting. Measured environmental parameters include cooling system status, manure temperatures, inside and outside air temperatures and humidities, wind speed and direction, and solar radiation. Feed and water consumption, egg production, manure production and removal, and bird mortalities will also be monitored with producer assistance. Samples of feed, eggs, water, and manure will be collected and analyzed for total nitrogen and total sulfur. These data will enable the development and validation of process-based emission models in the future.

Quality assurance/quality control (QA/QC): QA/QC processes will be established before data collection commences. The QA/QC procedures will be based on EPA guidelines and will include the use of properly maintained and reliable instrumentation, ready supply of spare parts, approved analytical methodologies and standard operating procedures, external validation of data, well-trained analysts, field blanks, electrical backups, audits, and documentation. Instrument calibration and maintenance logs will be maintained.

3. Air Emission Monitoring Plan for Meat Birds (Broiler Chickens and Turkeys)

Introduction: Meat birds include broilers and turkeys and are raised in confinement barns on dirt or concrete floors covered with litter. Broiler barns are typically mechanically ventilated and turkey barns are typically naturally ventilated. The locations for three sites with specific housing types were recommended for the monitoring study with consideration of the potential impact of climatic differences and the geographical density of poultry meat production (Table 4). The final site selections will depend on site-specific emission generating factors including representativeness of facility age, size, design and management; and flock diet and genetics. The facility should be reasonably isolated from other air pollution sources and have potential for testing mitigation strategies. Producers/farm managers must be willing to attend a training session, make changes as needed to accommodate the project, and maintain and share certain production records to facilitate data analysis and interpretation.

Table 4. Recommended Types and Locations of Meat Bird Houses to Be Monitored

Region	Type	Ventilation Type	Manure Handling
Midwest	Turkey	Mechanical	Litter on floor
West Coast	Broiler	Mechanical	Litter on floor
Southeast	Broiler	Mechanical	Litter on floor

Methods: An on-farm instrument shelter (OFIS) will house the equipment for monitoring pollutant concentrations at representative air inlets and outlets (primarily by air extraction for gases), barn airflows, and operational processes and environmental variables. Sampling will be conducted for 24 months with data logged every 60 seconds.

Data will be retrieved with network-connected PCs, formatted, validated, and delivered to EPA for subsequent calculations of emission factors. A multipoint air sampling system in the OFIS will draw air sequentially from representative locations (including outdoor air) at the barns and deliver selected streams to a manifold from which gas analyzers draw their subsamples. The pollutants targeted for measurement will be evaluated as follows:

- Ammonia will be measured using chemiluminescence or photoacoustic infrared.
- Hydrogen sulfide will be measured with pulsed fluorescence.
- Carbon dioxide will be measured using photoacoustic infrared or equivalent.
- TSP will be measured using an isokinetic multipoint gravimetric method.
- PM2.5 will be measured gravimetrically with a federal reference method for PM2.5 at least for 1 month per site. It will be shared among sites.
- PM10 will be measured in real time using the tapered element oscillating microbalance (TEOM) at representative exhaust locations in the barn, and ambient air.
- An initial characterization study of barn VOC will be conducted on 1 day during the first month at the first

site (site 1). While total nonmethane hydrocarbons (NMHC) are continuously monitored using a dual-channel FID analyzer (Method 25A) along with building airflow rate, VOC will be sampled with replication at two barns using Silcosteel canisters, and all-glass impingers (EPA Method 26A). Each sample will be evaluated using concurrent gas chromatography - mass spectrometry (GC-MS) and GC/FID for TO 15 and other FID-responding compounds. VOC mass will be calculated as the sum of individual analytes. The 20 analytes making the greatest contribution to total mass will be identified during the initial characterization study. A sampling method that captures a significant fraction of the VOC mass will be chosen for the remainder of the study.

- The Method 26A sampling train is suitable for collecting samples for analysis of formaldehyde and acetaldehyde using NCASI 94.02, requiring only the addition of spectrophotometry for the detection of formaldehyde. These compounds will be measured during the initial characterization study and, if not found, will not be analyzed during subsequent measurements.
- Total VOC mass may be estimated (scaled) by multiplying the total carbon as determined by Method 25A by the molecular weight/carbon weight ratio derived from GC-MS or GC-FID speciation. This should account for the VOC

that are not identified by GC methods due either to sampling bias or the analytical procedures used, although some error is anticipated due to the imprecise response of the Method 25A FID to oxygenated compounds. Acceptance of a scaling factor will depend on whether the Method 25A analyzer response is reasonable based on the manufacturer's stated response factors, bench-scale verification, or judgmental estimation of the mass of unaccounted for VOC.

- By the middle of the second month, the Science Advisor will report results of the initial VOC characterization to EPA with recommendations on the appropriateness and validity of the selected methodologies.
- Quarterly VOC samples using the selected VOC sampling method will occur at all sites, along with continuous Method 25A monitoring at site 1 throughout the study.
- Method 25A measurements will be corrected from an "as carbon" basis to a total VOC mass basis by multiplying them by the mean molecular weight per carbon atom established by GC-MS evaluations during applicable intervals of time.

Mechanically ventilated barn airflows will be estimated by continuously measuring fan operational status and building static pressure to calculate fan airflow from field-tested fan performance curves and by directly measuring selected fan airflows using anemometers. Specific processes that directly or indirectly influence barn emissions will be measured including bird activity, manure handling, feeding, and lighting. Measured environmental parameters include heating and cooling operation, floor and manure temperatures, inside and outside air temperatures and humidity, wind speed and direction, and solar radiation. Feed and water consumption, manure production and removal, bird mortalities and bird production will also be monitored with producer assistance. Samples of feed, water, and manure will be collected and analyzed for total nitrogen and total sulfur. These data will enable the development and validation of process-based emission models in the future.

Quality Assurance/Quality Control (QA/QC): QA/QC processes will be established before data collection commences. The QA/QC procedures will be based on EPA guidelines and will include the use of properly maintained and reliable instrumentation, ready supply of spare parts, approved analytical methodologies and standard operating procedures, external validation of data, well-trained analysts, field blanks, electrical backups, audits, and documentation. Instrument calibration and maintenance logs will be maintained.

Open Manure Piles: Micrometeorological techniques will be used to estimate emissions of NH3, H2S, and a limited number of VOC from open manure piles. Fundamentally, this approach will use optical remote sensing (ORS) downwind and upwind of the source coupled with 3-dimensional (3D) wind velocity measurements at heights of 2 and 12m. The concentrations of NH3 and the various hydrocarbons will be made using open path Fourier transform infrared spectroscopy (FTIR). Measurements of H2S (and NH3) will be made using collocated open path UV differential optical absorption spectroscopy (UV-DOAS) systems. A team of two persons with two scanning FTIR systems, two single-path UV-DOAS systems, and two 3D sonics with supplementary meteorological instruments will move sequentially from farm to farm.

Each of two ORS systems will be oriented parallel to the storage side and approximately 10m from the storage edge. Each monostatic FTIR system will scan five retroreflectors; three mounted at 1m height equally dividing the length of the open path along the storage side and two mounted on a tower at heights of 6 and 12m located at the corners down the adjacent sides of the source, resulting in scan lines down each of the four sides of the storage. Two bistatic single-path UV-DOAS systems will be located at a nominal 2m height within 2m laterally of the FTIR scan lines on the two sides of the manure storage area oriented most closely with prevailing winds.

Emissions will be determined from the difference in upwind and downwind concentration measurements using two different methods - an Eulerian Gaussian approach and a Lagrangian Stochastic approach. The Lagrangian approach is based on an inverse dispersion analysis using a backward Lagrangian stochastic method (bLS). This approach will be used to estimate NH3 emissions from concentration measurements made using the FTIR and UV-DOAS systems and the H2S emissions from concentration measurements made using the UV-DOAS systems. The emission rate for NH3 will be the ensemble average of the estimated emissions for each of the five FTIR scans with a corresponding error of the emissions estimate. The Eulerian approach is based on a computed tomography (CT) method using Eulerian Gaussian statistics and a fitted wind profile from the two-3D sonics. Measurements of air and storage temperatures, wind speed and direction, humidity, atmospheric pressure, and solar radiation will also be conducted.

The bLS and CT emission estimates will be quality assured using tests of instrument response, wind direction and wind speed, stability, turbulence intensity, differences between the storage and the surrounding surface temperatures, differences in the mean and turbulent wind components with height, and the temporal variability in emissions. Emission estimates using the CT method will be qualified by the measured fraction of the estimated plume.

4. Air Emissions Monitoring Plan for Dairy

Introduction: Dairy operations are naturally ventilated buildings with different manure handling systems. Measurement of the emissions from these operations is to be conducted with a series of measurement systems that provide a concentration measurement along a path that would be representative of the emission plume from the building. In order to estimate the emissions rate, it is necessary to couple the concentration with a measurement of the wind flow through the building or facility.

Manure storage sites could be either liquid (lagoons or slurry store) or piles of solid materials. These sites represent a different source area for emissions than buildings and will have to be considered separately in the measurement scheme.

The protocols that are developed for these studies are based on the following assumptions.

- The buildings are naturally ventilated and require a measurement method that captures the entire plume leaving the building. Mechanically ventilated facilities are beginning to enter the industry.
- Manure storage is separate from the building and will have to be measured as a distinct entity as part of the farm emission factor.

- The primary emissions sources are the housing and feeding areas and manure storage.
- There is a large diversity among dairy operations across the U.S., and although there are similar characteristics in general structure, the difference in building design, management, and climate require measurements of facilities that represent these factors.
- Measurements will be conducted at facilities which represent a diversity of systems in three general areas: California and Southern U.S., Northeast U.S., and Upper Midwest.

Milk production facilities include cattle (dry cows, lactating cows, and replacement heifers) and calves. The partially open barns range from those with windows and flaps to fully open free stalls. The buildings are most typically naturally ventilated except for some mechanically ventilated free stall and tie stall houses. The naturally ventilated barns range from partially open barns with windows and flaps to fully open free stalls. External manure storages generally consist of either earthen basins that store undiluted manure collected from the barn, or anaerobic treatment lagoons that treat manure that is diluted by a factor of about 5:1. Manure collection systems generally are either scrape or flush. Four dairy sites that consider climate and types of ventilation, manure collection, and manure storage have been identified by the dairy industry for collecting the comprehensive air emission data required by the monitoring study (Table 5). Final site selections will also depend on site-specific factors including representativeness of facility age, size, design and management; and cow diet and genetics. The facility should be isolated from other potential air pollution sources and have potential for testing mitigation strategies. Producers should be willing to make changes and keep extra records to facilitate a quality study.

Table 5. Recommended Types and Locations of Dairy Facilities to Be Monitored in this Study

Region	Site Type	Ventilation **	Manure Collection	Manure Storage
Midwest	Free stall	Natural	Flush or scrape	Lagoon
Northeast	Free stall	Natural	Scrape	Basin
West	Open* free stall	Natural	Flush	Lagoon
South	Open free stall	Natural	Scrape	Basin

*Cattle are free to walk outside in open free stall barns.
**If warranted by current or future use, mechanically ventilated barns may be monitored.

Methods:

Naturally Ventilated Buildings: To achieve the most representative measurements of the emissions of the gases, it is recommended that a FTIR system be used to quantify the concentration of NH3, CO2, and, at levels above 50 parts per billion (ppb), H2S in various paths through the atmosphere. A variation of the horizontal gradient method utilizing multiple paths through the airflow from the building, called radial plume mapping, measures the concentrations. The FTIR method is selected because of the extreme turbulence adjacent to the building and the lack of a defined plume in this area of the facility. A scanning system rotates among the paths to provide a serial measurement of the paths utilizing horizontally and vertically located retro-reflectors. A computer calculates the concentration gradients in real time. FTIR measurements are coupled to two sonic anemometers positioned at two locations along the length of the building to provide the wind flow measurements needed to estimate the flux from the measured concentrations.

Particulate load would be sampled using a series of particle samplers located with a sampling height of 5m adjacent to one of the sonic anemometer towers. These units would be designed to collect 2.5 µm, 10 µm and TSP values.

VOC would be sampled at the same position as the particulate samples for the building emissions. VOC emissions from the manure storage would be sampled with a system located both upwind and downwind of the manure storage system. These units would be positioned at heights of 2 and 12m.

Mechanically Ventilated Buildings: Mechanically ventilated buildings have begun to be used in the dairy industry. If warranted by current or future use, a mechanically ventilated facility will be included in this project. An on-site instrument shelter (OSIS) will house the equipment for monitoring pollutant concentrations at representative air inlets and outlets (primarily by air extraction), barn airflows, and operational processes and environmental variables. Sampling will be conducted for 24 months with data logged every 60 seconds. Data will be retrieved with network-connected PCs, formatted, validated, and delivered to EPA as hourly averages for subsequent calculations of emission factors. A multipoint air sampling system in the OSIS will draw air sequentially from representative locations (including ambient) at the barns and deliver selected streams to a manifold from which on-line gas monitors draw their subsamples. The pollutants targeted for measurement will be evaluated as follows:

- Ammonia will be measured using chemiluminescence or photoacoustic infrared.
- Hydrogen sulfide will be measured with pulsed fluorescence.
- Carbon dioxide will be measured using photoacoustic

infrared or equivalent.

- TSP will be measured using an isokinetic multipoint gravimetric method.
- PM2.5 will be measured gravimetrically with a federal reference method for PM2.5 at least for 1 month per site. It will be shared among sites.
- PM10 concentrations will be measured in real time using the tapered element oscillating microbalance (TEOM) at representative exhaust locations in the barn and ambient air.
- An initial characterization study of barn VOC will be conducted on 1 day during the first month at the first site (site 1). While total nonmethane hydrocarbons (NMHC) are continuously monitored using a dual-channel FID analyzer (Method 25A) along with building airflow rate, VOC will be sampled with replication at two barns using Silcosteel canisters, and all-glass impingers (EPA Method 26A). Each sample will be evaluated using concurrent gas chromatography - mass spectrometry (GC-MS) and GC/FID for TO 15 and other FID-responding compounds. VOC mass will be calculated as the sum of individual analytes. The 20 analytes making the greatest contribution to total mass will be identified during the initial characterization study. A sampling method that captures a significant fraction of the VOC

mass will be chosen for the remainder of the study.

- The Method 26A sampling train is suitable for collecting samples for analysis of formaldehyde and acetaldehyde using NCASI 94.02, requiring only the addition of spectrophotometry for the detection of formaldehyde. These compounds will be measured during the initial characterization study and, if not found, will not be analyzed during subsequent measurements.
- Total VOC mass may be estimated (scaled) by multiplying the total carbon as determined by Method 25A by the molecular weight/carbon weight ratio derived from GC-MS or GC-FID speciation. This should account for the VOC that are not identified by GC methods due either to sampling bias or the analytical procedures used, although some error is anticipated due to the imprecise response of Method 25A FID to oxygenated compounds. Acceptance of a scaling factor will depend on whether the Method 25A analyzer response is reasonable based on the manufacturer's stated response factors, bench-scale verification, or judgmental estimation of the mass of unaccounted for VOC.
- By the middle of the second month, the Science Advisor will report results of the initial VOC characterization to EPA with recommendations on the appropriateness and validity of the selected methodologies.

- Quarterly VOC samples using the selected VOC sampling method will occur at all sites, along with continuous Method 25A monitoring at site 1 throughout the study.
- Method 25A measurements will be corrected from an "as carbon" basis to a total VOC mass basis by multiplying them by the mean molecular weight per carbon atom established by GC-MS evaluations during applicable intervals of time.

Manure Storage Systems: Micrometeorological techniques will be used to estimate emissions of NH3, H2S, and a limited number of VOC from manure storage systems and storages. Fundamentally, this approach will use optical remote sensing (ORS) downwind and upwind of the storage coupled with 3-dimensional (3D) wind velocity measurements at heights of 2 and 12m. The concentrations of NH3 and the various hydrocarbons will be made using open path Fourier transform infrared spectroscopy (FTIR). Measurements of H2S (and NH3) will be made using collocated open path UV differential optical absorption spectroscopy (UV-DOAS) systems. A team of two persons with two scanning FTIR systems, two single-path UV-DOAS systems, and two 3D sonics with supplementary meteorological instruments will move sequentially from farm to farm.

Each of two ORS systems will be oriented parallel to the storage side and approximately 10m from the storage edge. Each monostatic FTIR system will scan five retroreflectors; three mounted at 1m height equally dividing the length of the open path along the storage side and two mounted on a tower at heights of 6 and 12m located at the corners down the adjacent sides of the storage, resulting in scan lines down each of the four sides of the storage. Two bistatic single-path UV-DOAS systems will be located at a nominal 2m height within 2m laterally of the FTIR scan lines on the two sides of the storage oriented most closely with prevailing winds.

Emissions will be determined from the difference in upwind and downwind concentration measurements using two different methods - an Eulerian Gaussian approach and a Lagrangian Stochastic approach. The Lagrangian approach is based on an inverse dispersion analysis using a backward Lagrangian stochastic method (bLS). This approach will be used to estimate NH3 emissions from concentration measurements made using the FTIR and UV-DOAS systems and the H2S emissions from concentration measurements made using the UV-DOAS systems. The emission rate for NH3 will be the ensemble average of the estimated emissions for each of the five FTIR scans with a corresponding error of the emission estimate. The Eulerian approach is based on a computed tomography (CT) method using Eulerian Gaussian statistics and a fitted wind profile from the two 3D sonics.

Measurements of air and storage temperatures, wind speed and direction, humidity, atmospheric pressure, and solar radiation will also be conducted.

The bLS and CT emission estimates will be quality assured using tests of instrument response, wind direction and wind speed, stability, turbulence intensity, differences between the storage and the surrounding surface temperatures, differences in the mean and turbulent wind components with height, and the temporal variability in emissions. Emission estimates using the CT method will be qualified by the measured fraction of the estimated plume.

To estimate VOC emissions from lagoons, samples of the lagoon liquid will be collected and analyzed for VOC, and the EPA model WATER9 will be used to estimate emissions based on measured VOC concentrations, pH, and other factors.

ALTERNATE TECHNIQUES

1. For the circuit rider system, an instrumental system such as the DustTrak by TSI could be used for continuous particle data for PM2.5 and PM10. These systems provide optical light scattering measurements of the concentration in mg/m3 and cost about $5,000 per point including an environmental shelter.

2. A radial plume mapping approach could be applied to the manure storage systems using a TDL system that has been approved by EPA for use in the aluminum industry in a single

path mode. One upwind and three downwind paths provide the same type of data as the FTIR except for a single compound. The single laser is scanned via fiberoptic cables to the individual paths with a complete scan taking 40 seconds. It provides a fast, direct measurement of the flux of ammonia from these manure systems. A single 4-channel system costs $68,000.

3. It is recommended that one short-term (2-week) measurement of each facility be made with a LIDAR system to measure and quantify the plume dynamics of particles, water vapor, and ammonia surrounding the facility. This is recommended because the short-term measurements will be made at different times throughout the year and will be placed at a series of heights based on experience. These associated data of the plume structure will provide evidence of representativeness of the micrometeorological measurements for the emission rates.

4. It is recommended that each building site be instrumented with temperature and associated sensors to provide a continuous measurement record of the microclimate within and adjacent to the building. These systems can be linked with sensors to measure and record animal activity and floor temperature. A similar system would be located to measure the microclimate of the manure storage system and would include air temperature, wind speed, wind direction,

surface temperature, and relative humidity of the manure storage system. The continuous record from these manure storage units and buildings would provide a reference for the short-term measurements made with the FTIR systems.

5. A Dynamic Flux Chamber Technique could be used for performing emission measurements from lagoons and/or a manure pile. Ammonia flux is measured over a surface (lagoon and/or soil) using a dynamic flux chamber system interfaced to an environmentally controlled mobile laboratory. This flux chamber system is interfaced to an environmentally controlled mobile laboratory in which two ammonia chemiluminescence analyzers, gas dilution/titration calibration system, and data logger with lap-top computer are located. The flux calculation of ammonia using the flow-through chamber system is given by the mass balance for ammonia in the chamber.

TYPICAL FACTORS USED IN DETERMINING FARM SELECTION

Farm Characteristics

1. Did the producer sign up to the Consent Agreement and pay EPA?

2. Does the producer's farm fit the description of any of the farms listed?

3. Is there a principal investigator within 3 hours of the site?

4. Are there housing accommodations available within 1 hour

of the site?

5. Does your site have mechanical or natural ventilation for barns? Do the fans blow out directly over the lagoon/ manure storage area?

6. Is the producer/farm manager cooperative to attend a training session and provide needed production information?

7. Is there internet access at the farm? Is 220 V power available?

8. What is the general topography on the farm? Describe the surrounding terrain (rolling hills, flat, low lying, river bottom, etc.) specifically for areas near the barns and the manure storage/treatment system.

9. Is the farm free from large disturbances such as trees and other buildings?

10. What is the distance from a public road? Is it gravel?

11. Are there other potential air pollutant sources nearby? Explain type (other farms, industrial site, grain elevator/feedmill), distance and direction.

12. Are there other animal species housed on the site, or planned for housing on site?

13. How many barns are located on the site? How many animals in each barn? Please characterize the barns: barn number/identifier, production phase, rate your barn cleanliness (1-5; 1 being the cleanest), age of barns, and air exchange rate.

14. How far are the land application fields from the lagoons and barns?

15. How often is manure removed from the manure treatment/storage system and land applied?

16. How often is manure removed from the buildings and sent to the outdoor treatment/storage system?

17. Describe (in general terms) the rations fed to the animals.

18. Are the animals hand-fed or is feed delivered through an automatic delivery system?

19. Is fat (vegetable or animal) added to the rations?

20. Are feed rations pelleted or ground?

<u>Influences on Emissions</u>

Influences	**Producer Provided**	**Collected by Study**
Climate		X
Air temperature		X
Manure temperature		X
Barn temperature		X
Wind speed		X
Solar radiation		X
Rainfall		X
Relative humidity		X
Wind direction		X
Feed conversion/efficiency		X
Feed analysis (N & P & S)	X	X
Phases		X

Feeding to recommendations	X	
Manure production volume	X	X
Management cycle	X	
Storage duration	X	
Stocking density (actual)		X
Lagoon design	X	X
Swine genetics	X	
Animal inventory	X	
Feed usage	X	
Water usage	X	
Closeouts	X	
Feed analysis	X	X
Water analysis		X
Manure analysis	X	X
Animal/barn activity	X	X