DAIRY AIR EMISSIONS AND ANALYSIS

ODA would like to acknowledge the Oregon Department of Environmental Quality’s review of this report.
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Executive Summary

During the 2017 Oregon Legislative Session, the Oregon Department of Agriculture (ODA), in consultation with Oregon State University (OSU), was asked to evaluate and report on the air emission mitigation best management practices (BMP) used on two Oregon dairy farms, Threemile Canyon Farms and Lost Valley Farm.

Each of the dairy farm’s BMPs were evaluated against the Idaho Dairy Ammonia Control Practices Program and the Yakima (WA) Regional Clean Air Agency’s (YRCAA) Air Quality Management Policy and Best Management Practices for Dairy Operations. Results of the evaluation showed that each of the dairy farms were in compliance with each program.

Research of dairy air emission mitigation strategies is happening worldwide, however, adoption of new practices and technologies will depend on factors such as affordability, availability and ease of implementation.

Unlike other emission sources, farm cropping systems create opportunities to capture atmospheric nitrogen and act as a sink for emissions. Crops such as alfalfa can biologically fix atmospheric nitrogen.

Market based opportunities will also influence the rate of adopting new on-farm BMPs and technology as well as national discussions and policy decisions.
Section 1. History

Senate Bill (SB) 197 was introduced in the 2017 legislative session. In short, the bill would have required the Environmental Quality Commission (EQC) to adopt by rule a program regulating air emissions from dairy confined animal feeding operations based off of recommendations from the 2008 Oregon Dairy Air Quality Task Force final report. The bill did not move out of the assigned committee, Senate Committee on Environment and Natural Resources.

Since SB 197 did not pass, ODA was asked to prepare a report on the air emission mitigation best management practices (BMPs) implemented at Three Mile Canyon Farms (TMCF) and newly operating Lost Valley Farm (LVF), look at new and developing BMPs, evaluate benefits of cropping systems to mitigate emissions, and identify opportunities for incentives to promote the development and implementation of BMPs by Oregon dairy sector. This information is below.

Section 2. Comparison of On-Farm BMPs to Existing Dairy Air Quality Programs

After review of existing dairy air quality programs, ODA and Oregon State University (OSU) selected two different programs for this comparison:

- Idaho’s Dairy Ammonia Control Practices

TMCF and LVF are both located in Boardman, OR. This high-desert setting offers many similarities in terms of geography, climate, and dairy production practices to that of Idaho and Yakima WA.

ODA and OSU independently evaluated TMCF and LVF BMPs during the summer of 2017 using the above dairy air quality programs. After individual farm assessments were completed, ODA and OSU compared results. The vast majority of the results were in agreement. If evaluators had scored a BMP differently, an average was assumed.

Idaho Dairy Farm Best Management Practices for the Control of Ammonia

In 2006, Idaho Board of Environmental Quality adopted Rules for the Control of Ammonia From Dairy Farms (IDAPA 58.01.01, 760-764). The rule sets forth the requirements for the control of ammonia through BMPs for certain size dairy farms licensed by the Idaho Department of Agriculture to sell raw milk for human consumption.\(^1\) The threshold that requires registration to this rule depends on animal housing and liquid manure management practices. A dairy farm with 1,638 mature cows is the lowest threshold that requires registration to the program.

To ensure compliance, dairy farms must ensure at least 27 points worth of BMPs are being implemented. Points are assigned based upon practices related to manure storage/treatment, land application, animal nutrition and more.

\(^1\) R. Sheffield and B. Louks, Dairy Ammonia Control Practices, University of Idaho College of Agricultural Life Sciences, 2007.
A full description of the Rules for the Control of Ammonia From Dairy Farms and BMPs, is available in Appendix A.

A. Comparison of TMCF BMPs to Idaho’s Ammonia Control Rule

The assessment was based on 28,000 lactating (milking) cows housed in a freestall flush barn. The results are as follows:

<table>
<thead>
<tr>
<th>System</th>
<th>Component</th>
<th>Point Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Waste Storage</td>
<td>Manure solids separation</td>
<td>3</td>
</tr>
<tr>
<td>and Treatment</td>
<td>Direct utilization/parlor water (partial)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Direct utilization/flush water (partial)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Continuous mix digester</td>
<td>15</td>
</tr>
<tr>
<td>3. Freestall Barns</td>
<td>Scrape built up manure</td>
<td>3</td>
</tr>
<tr>
<td>5. Animal Nutrition</td>
<td>Manage dietary protein</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Incorporation of manure w/in 48 hrs (partial)</td>
<td>1</td>
</tr>
<tr>
<td>7. Land Application</td>
<td>Low energy/Low pressure application system</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Freshwater dilution</td>
<td>8</td>
</tr>
</tbody>
</table>

**Total Point Value**

B. Comparison of LVF BMPs (existing and proposed) to Idaho’s Ammonia Control Rule

Since LVF is a recently new operating dairy farm, the assessment was based on the maximum number of animals allowed under the Confined Animal Feeding Operation (CAFO) permit with 50 percent of the cows housed in a flush freestall barn and 50 percent of the cows housed in an open lot. In addition, the evaluation was also based on current management practices and proposed management practices. The results are as follows:

<table>
<thead>
<tr>
<th>System</th>
<th>Component</th>
<th>Point Value</th>
<th>Point Value with proposed digester</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Waste Storage</td>
<td>Manure solids separation</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>and Treatment</td>
<td>Direct utilization /collected slurry (partial)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Direct utilization/parlor water (partial)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Direct utilization/flush water (partial)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Digester (proposed)</td>
<td></td>
<td>10-15</td>
</tr>
<tr>
<td>2. General Practices</td>
<td>Vegetative buffers (establishing)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3. Freestall Barns</td>
<td>Scrape built up manure</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>4. Open Lots</td>
<td>Rapid manure removal</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Harrowing/mounding</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>In lot storage/stockpiling</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5. Animal Nutrition</td>
<td>Manage dietary protein</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>7. Land Application</td>
<td>Incorporation of manure w/in 48</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

2 A minimum of 27 points worth of BMPs are needed for compliance with Idaho’s Ammonia Control Rule.

3 At the time of the assessment, LVF CAFO Permit: 13,000 milking, 2,000 dry cows, 13,000 heifers, and 2,000 calves.
Yakima Regional Clean Air Agency (YRCAA) Air Quality Management Policy and Best Management Practices for Dairy Operations

In 2013, YRCAA adopted a policy to provide guidance and establish requirements for effective prevention and control of air emissions from dairy operations (RCW 34.05.313 and WAC 173-400-040(3)). Pollutants targeted in this program include particulate matter, ammonia, volatile organic compounds, oxides of nitrogen, hydrogen sulfide, odor, methane and nitrous oxide. YRCAA approves the plan and conducts compliance inspections at the dairy farm.

Dairy operations in Yakima, WA, that confine animals, must develop and implement an Air Quality Management Plan (AQMP). The plan must identify three BMPs to address the source (e.g. feed) based on a three-tier system with Tier 1 being the least expensive and easiest BMP to implement and Tier 3 being the most advanced and most expensive BMP to implement.

A full description of the YRCAA Air Quality Management Policy and Best Management Practices for Dairy Operations is available in Appendix B.

A. Comparison of TMCF BMPs to the YRCAA Air Quality Management Policy and BMP for Dairy Operations Program

<table>
<thead>
<tr>
<th>Source</th>
<th>Tier 1 BMP</th>
<th>Tier 2 BMP</th>
<th>Tier 3 BMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrition</td>
<td>Manage dietary protein and sulfur</td>
<td>Stage of lactation feeding</td>
<td>Feed additives</td>
</tr>
<tr>
<td>Implementation (%)</td>
<td>100</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Feed Management</td>
<td>Regular clean up</td>
<td>Cover/manage ensiled feed</td>
<td>Store feed in shelter</td>
</tr>
<tr>
<td>Implementation (%)</td>
<td>50</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>Milking Parlor</td>
<td>Recycle wash H₂O Proper ventilation</td>
<td>Clean manure from parlor frequently</td>
<td>Treat recycle flush water</td>
</tr>
<tr>
<td>Implementation (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Freestall Housing</td>
<td>Remove manure frequently Proper ventilation</td>
<td>Manure removal efficiency and technology I</td>
<td>Manure removal efficiency and technology II Floor texture</td>
</tr>
<tr>
<td>Implementation (%)</td>
<td>100</td>
<td>100</td>
<td>60</td>
</tr>
<tr>
<td>Open Lot Housing</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

A minimum of 27 points worth of BMPs are needed for compliance with Idaho’s Ammonia Control Rule.
B. Comparison of LVF (existing) BMPs to the YRCAA Air Quality Management Policy and BMP for Dairy Operations Program

<table>
<thead>
<tr>
<th>Source</th>
<th>Tier 1 BMP</th>
<th>Tier 2 BMP</th>
<th>Tier 3 BMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrition</td>
<td>Manage dietary protein and sulfur</td>
<td>Stage of lactation feeding</td>
<td>Feed additives</td>
</tr>
<tr>
<td>Implementation (%)</td>
<td>100</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Feed Management</td>
<td>Regular clean up</td>
<td>Cover/manage ensiled feed</td>
<td>Store feed in shelter</td>
</tr>
<tr>
<td>Implementation (%)</td>
<td>50</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>Milking Parlor</td>
<td>Recycle wash H₂O</td>
<td>Clean manure from parlor frequently</td>
<td>Treat recycle flush water</td>
</tr>
<tr>
<td>Implementation (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Freestall Housing</td>
<td>Remove manure frequently</td>
<td>Manure removal efficiency and technology I</td>
<td>Manure removal efficiency and technology II Floor texture</td>
</tr>
<tr>
<td>Implementation (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Open Lot Housing</td>
<td>Harrow lots Moisture management</td>
<td>Fenceline &amp; bunk manure removal Straw when required</td>
<td>Water trough locations</td>
</tr>
<tr>
<td>Implementation (%)</td>
<td>100</td>
<td>50</td>
<td>35</td>
</tr>
</tbody>
</table>

Section 3. Continuing Research and Development of BMPs

Continuing research and development of BMPs that reduce or mitigate dairy air emissions is ongoing. Below is a list of management practices and technologies that could be explored as opportunities to mitigate dairy air emissions:

- Milk Urea Nitrogen (MUN): Can MUN sample results inform producers on optimum diets for reduction of enteric ammonia and hydrogen sulfide emissions?
- Optimizing bacteria in the digester for maximum efficiency in manure breakdown and reductions of ammonia and hydrogen sulfide.
- Optimizing digester operations with additions of off-farm feedstocks for maximum efficiency in manure breakdown and reductions of ammonia and hydrogen sulfide.
- Lagoon or manure storage covers/flares to destroy gasses.
- Bacterial or other substrate additions into the lagoon(s) to maximize lagoon treatment activity.
- Increase in production efficiency to lower the amount of emission/unit of milk produced.
- Installation of bio-filters to capture/treat emissions from closed spaces.
- Optimization of application equipment/techniques to further reduce emissions from land application activities.
• Participate in Western Region Odor and Air Quality group researching dairy air quality topics.

OSU continues to do projects that help us improve our understanding of potential air emissions from dairies. For example, one current project is looking at the effects of manure digester liquid applications to soil microbe populations. This work has the potential to fill in some gaps in our understanding of the role soils play on emissions from organic agriculture.

There are also some models available that predict BMP effectiveness and assist the producer when making a decision as to what BMP should be adopted. For example, Dairy Gas Emission Model (Dairy GEM) is a software tool that estimates ammonia, hydrogen sulfide and greenhouse gases based on climate and farm management practices.

The Environmental Protection Agency (EPA) Office of Air Quality Planning and Standards and the USDA Natural Resources Conservation Service (NRCS) recently released the “Agricultural Air Quality Conservation Measures: Reference Guide for Poultry and Livestock Production Systems”. This document provides a broad set of conservation practices for poultry and livestock operations that may address air resource concerns with a focus on NRCS conservation standards and other demonstrated practices.

Scientifically proven BMPs that are effective, affordable, and easily integrated into existing dairy production systems will result in a more rapid adoption. Access to information from scientifically-trusted sources as well as trusted advisors, like university extension staff or/and subject matter research experts, to help producers make informed decisions could also increase the rate of BMP adoption. However, it is important to be aware of cross-media impacts when air emission mitigation BMPs are implemented. BMPs for air emission mitigation could impact other natural resources, like water quality.

**Section 4. Farm Source / Sink Relationship**

Unlike other air emission sources (e.g. automobiles), dairy farms provide opportunities for air sequestration/sink through crop production.

Both of these dairy farms have crop production systems that require nutrients, such as nitrogen and sulfur, for crop growth. Legume crops, such as alfalfa, can biologically fix nitrogen from the atmosphere to use for plant growth. Fixation of nitrogen by legumes is one element of the nitrogen cycle (see diagram below).

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The cropping system also sequesters carbon in the soil/plant system.

**Section 5. Market Based Opportunities and Incentives**

The market place for Oregon agriculture and food is prevalent in local, domestic, and global markets. In order to stay competitive, Oregon agriculture, including dairy farms, will need to remain nimble and able to adapt to the market’s ever-changing needs. Project Gigaton is an example of this. Project Gigaton, is an effort by Walmart to remove 1 billion metric tons of greenhouse gases from their supply chain by 2030. Therefore, in order to enter in, or even maintain this market space, producers will need to adapt to meet this new market expectation for this customer.

In addition to market based opportunities, local, state, and federal incentives can further increase the rate at which BMPs and new technologies are adopted. As conversations regarding ‘cap and invest’ begin, Oregon does not have to look far to see the role agriculture can play to meet environmental goals. For example, California has relied on agriculture for opportunities of investment as that state looks to meet its emission goals. California developed an investment fund that provides incentives for agricultural practices to implement BMPs that mitigate greenhouse gases.
Section 6. Animal Air Emissions – National updates

Emergency Planning and Community Right to Know Act (EPCRA) Reporting of Ammonia and Hydrogen Sulfide Emissions

The Emergency Planning and Community Right to Know Act (EPCRA) requires, that whenever there is a known release of hazardous substances, the person in charge of a facility must notify state and local emergency responders. In April 2017, the DC Circuit Court invalidated a rule that exempted most animal agricultural farms from reporting air emissions under EPCRA. EPCRA reporting applies to large Concentrated Animal Feeding Operations (CAFOs) who must make “good faith emissions estimates” and report those data to the state coordinator. For most types of animal feeding operations, ammonia emissions are likely to trigger a reporting requirement, with reporting of hydrogen sulfide being much less likely. Farms must begin reporting by November 15, 2017. EPA is currently developing guidance for farmers to assist with this reporting requirement.

National Air Emissions Monitoring Study (NAEMS)

Since there was a lack of reliable methods to estimate animal emissions, in 2005 EPA and animal feeding operations, like dairy farms, across the country entered into a voluntary compliance agreement. In general, as part of this agreement, animal agriculture agreed to fund an air emission monitoring study, National Air Emissions Monitoring Study (NAEMS), and EPA would not seek regulatory actions for past violations provided that the animal feeding operation complied with the agreement’s conditions. The study measured emissions of particulate matter, ammonia, hydrogen sulfide and volatile organic compounds on animal feeding operations.

Although the study was completed more than seven years ago, EPA had not yet finalized the development of any emission estimating methodologies. On September 19, 2017, the EPA Office of Inspector General issued a report titled, Eleven Years After Agreement, EPA Has Not Developed Reliable Emission Estimation Methods to Determine Whether Animal Feeding Operations Comply With Clean Air Act and Other Statutes. The report concluded that EPA should conduct systematic planning for future development of emission estimating methodologies. In short, EPA should determine whether it can develop accurate emission estimating methodologies for emission source and pollutant combination collected during the study. If this can be done, a publically available timeline should be established. If EPA determines that it cannot develop accurate emission estimating methodologies, the compliance agreement signed in 2005 should be terminated.

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Appendix A

Idaho: Rules for the Control of Ammonia From Dairy Farms

Reference materials for Idaho’s Rules for the Control of Ammonia from Dairy Farms have been included. This includes:

- Idaho Department of Environmental: Fact Sheet Docket 58-0101-0502: Rules for the Control of Ammonia from Dairy Farms
- Idaho Department of Environmental Quality: Scientific Basis for the Control of Ammonia From Dairy Farms Best Management Practices (July 18, 2006)
Fact Sheet
Docket 58-0101-0502:
Rules for the Control of Ammonia from Dairy Farms

What do these rules require?
The rules require dairy farms above specified threshold numbers of cows or animals units* to implement industry best management practices (BMPs) to control ammonia emissions through a permit by rule.

What is a permit by rule?
A permit by rule is a simplified and expedited process whereby a facility that emits air pollutant(s) may register with the Department of Environmental Quality (DEQ) and the permit conditions are addressed in the rule rather than a site-specific permit.

Why control ammonia emissions?
Ammonia is a common by-product of animal waste. The volume of ammonia emissions depends on manure characteristics and how the manure is managed.

Ammonia emissions are an environmental concern, because they can adversely impact water and air quality. Ammonia emissions can contribute to eutrophication of surface waters and nitrate contamination of ground water. In addition, when emitted ammonia is combined with acidic compounds in the upper atmosphere, fine dust particles (particulates) capable of being inhaled are formed. These particulates have been related to atmospheric haze, and also have been attributed to a variety of adverse human health effects, including premature mortality, chronic bronchitis, asthma, and other respiratory ailments.

Who does the PBR apply to?
The PBR applies to dairy farms with a capacity to produce 100 or more tons of ammonia emissions per year. (Dairy farms with fewer than the specified number of animal units or mature cows may opt into the PBR program as well.) The capacity to produce is based on the number of animal units or mature cows and the type of manure collection system. The table below shows the applicable thresholds prescribed in the rule:

<table>
<thead>
<tr>
<th>Animal Unit (AU) Basis</th>
<th>Drylot</th>
<th>Free Stall/Scrape</th>
<th>Free Stall/Flush</th>
</tr>
</thead>
<tbody>
<tr>
<td>AU (100 t NH₃) Threshold</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No land app</td>
<td>7089</td>
<td>3893</td>
<td></td>
</tr>
<tr>
<td>27% volatilization¹</td>
<td>6842</td>
<td>3827</td>
<td>2293</td>
</tr>
<tr>
<td>80% volatilization²</td>
<td>6397</td>
<td>3700</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Basis (1400 lbs)</th>
<th>Drylot</th>
<th>Free Stall/Scrape</th>
<th>Free Stall/Flush</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cows AU (100 t NH₃) Threshold</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No land app</td>
<td>5063</td>
<td>2781</td>
<td>1638</td>
</tr>
<tr>
<td>27% volatilization¹</td>
<td>4887</td>
<td>2733</td>
<td></td>
</tr>
<tr>
<td>80% volatilization²</td>
<td>4569</td>
<td>2643</td>
<td></td>
</tr>
</tbody>
</table>

¹Assumes expected level of N->NH₃ volatilization for drop-hose or ground level liquid manure application.
²Assumes expected level of N->NH₃ volatilization for center pivot or other conventional sprinkler irrigation liquid manure application.
How do dairy farms comply with the PBR?
To comply with the PBR, dairy farms that are subject to the rule must register with DEQ and the Idaho State Department of Agriculture (ISDA) within 15 days of the rule’s effective date of July 1, 2006, by providing the following information:

- Name, address, location of dairy farm, and telephone number;
- Information on the size and type of the dairy farm;
- Information on the type of BMPs that the dairy farm is employing to total 27 points.

What types of BMPs can dairies employ?
The rules prescribe various BMPs to control ammonia emissions, ranging from installing certain types of waste storage and treatment systems to implementing composting practices to exporting manure. A point value is assigned to each BMP. Dairy farms must employ BMPs totaling 27 points.

If a dairy farmer uses a certain BMP during six months of the year, because weather or seasonal conditions restricted implementation of that BMP year-round, will he receive the entire amount of points allocated to the BMP?
Yes. Seasonal or periodic implementation of BMPs has been factored into the points assigned to each BMP. State rules or adverse weather conditions prohibit implementation of certain BMPs during winter months. The points assigned to each BMP are scaled to represent the BMP’s effectiveness for ammonia emission reduction on an annual basis. Inspectors will be able to determine whether the BMP has been implemented when allowed or appropriate.

If a dairy farmer implements a BMP on only half the waste generated, will the point value assigned to the BMP recognize this?
Yes. If a 10-point value BMP is implemented on only half the waste, the dairy farmer will receive 5 points for its use.

If a dairy farmer implements a BMP for six months of the year and then chooses to implement another BMP in its place, how will the point value be determined for those BMPs?
The point value will be prorated between the BMPs. For example, a 10-point year-round BMP that is implemented for six months will receive 5 points and, if a different 10-point year-round BMP is implemented the next six months, it, too, will receive 5 points.

If a dairy farmer opts to have a third party export its dairy waste off site, will the third-party exporter become subject to these rules?
No. The rules do not give DEQ enforcement authority over third-party exporters. If it were determined that the third-party exporter had not implemented the BMP claimed by the dairy farmer, the dairy farmer would receive no points for that BMP.

If a dairy farmer who would not be subject to these rules based on size and type of dairy farm chooses to obtain a permit by rule under Section 762.02, will the dairy farm be required to comply with the permit by rule?
Yes. A dairy farmer who opts into the program and obtains a permit by rule will be subject to the requirements of the program. The dairy farmer can request termination of the permit by rule, which DEQ would agree to so long as the farm was in good standing. Termination of the permit by rule will not negate any violations, however, while subject to the program.

What is an example of an emergency as defined in Section 762.03?
An example of an emergency would be when a dairy farmer agrees to take a neighbor’s cows, because the neighbor’s barn burned down.

How do equipment upsets and breakdowns affect the point total assigned to the BMP?
In the event of unforeseen equipment upsets and breakdowns, DEQ will exercise enforcement discretion. So long as corrective action is taken within a reasonable time, which would depend on specific circumstances, the event will not reduce the BMP point value.
**How will the state ensure compliance?**
Within 30 days of receiving a dairy farm’s registrations, ISDA will conduct an inspection to ensure that the required number of BMPs is employed. ISDA will also provide compliance assistance if needed. If ISDA finds that BMPs are lacking, it may issue a warning letter.

Enforcement of the rule is DEQ’s responsibility. Enforcement methods include filing a notice of violation or referring the case to the Attorney General’s office for civil enforcement. In the event of unforeseen equipment upsets and breakdowns, DEQ will exercise enforcement discretion. So long as corrective action is taken within a reasonable time, which would depend on specific circumstances, the event will not reduce the BMP point value. In the event of an emergency, the farm could apply for and be granted an exemption for up to one year.

If a dairy farmer does not implement the required point total of BMPs, would the violation be considered a failure to obtain a permit by rule or a failure to comply with the permit by rule?

The violation would be a failure to comply with the permit by rule.

**Who developed these rules?**
The rules were developed by DEQ in conjunction with a negotiating committee made up of representatives from the dairy industry, the environmental community, other state agencies, and other interested persons.

**When did these rules take effect?**
The effective date is July 1, 2006.

**Where can I get a copy of the scientific basis for the 100 tons per year ammonia estimates?**

**Where can I get a copy of the Scientific Basis for the Control of Ammonia from Dairy Farms Best Management Practices?**

**Who can I contact at DEQ for more information?**
Contact Mike Simon, Stationary Source Program Manager, DEQ Air Quality Division, at (208) 373-0502.
This bulletin is to assist dairy farmers in understanding the terms used and the scientific basis for the best management practices (BMP) listed in the Idaho Department of Environmental Quality’s Rules for the Control of Ammonia from Dairy Farms located at IDAPA 58.01.01.760 through 764 (hereinafter “the Rule”). This bulletin will be reviewed annually and revised if necessary to reflect any new information, including any changes to the Rule.

The Rule was developed for dairy farms that emit an estimate of 100 tons per year or more of ammonia. The threshold values were derived from manure excretion tables prepared by the American Society of Agricultural and Biological Engineers and the USDA – Natural Resources Conservation Service and were agreed upon by the Idaho Dairymen’s Association (IDA) and Idaho Conservation League (ICL). In addition to manure excretion, the IDA and ICL took into account their best professional judgment to account for differences in ammonia losses from various dairy housing types, manure storage systems, and land application practices. The table below, located at IDAPA 58.01.01.761, represents the scientific findings established in The Dairy Air Emissions Analysis: Focus: Ammonia Emissions for Typical Dairy Management Systems in Idaho, February 10-11, 2005.

**SUMMARY:** Animal Unit (AU) or mature cow threshold to produce 100 ton NH₃/year

<table>
<thead>
<tr>
<th>Animal Unit (AU) Basis</th>
<th>Drylot</th>
<th>Free Stall/Scrape</th>
<th>Free Stall/Flush</th>
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<tr>
<td>No land app</td>
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<tr>
<td>27% volatilization</td>
<td>6842</td>
<td>3827</td>
<td>2293</td>
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<tr>
<td>80% volatilization</td>
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<table>
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<th>Cow Basis (1400 lbs)</th>
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<td>1638</td>
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<tr>
<td>27% volatilization</td>
<td>4887</td>
<td>2733</td>
<td></td>
</tr>
<tr>
<td>80% volatilization</td>
<td>4569</td>
<td>2643</td>
<td></td>
</tr>
</tbody>
</table>

1. Assumes: Expected level of N->NH₃ volatilization for: drop-hose or ground level liquid manure application
2. Assumes: Expected level of N->NH₃ volatilization for: center pivot or other conventional sprinkler irrigation liquid manure application

**Best Management Practices**

The Rule recognizes that dairy farms are unique and that no specific BMP is appropriate for all dairy farms. Therefore, Section 764 of the Rule contains a table of BMP options. The dairy farmer must implement at least 27 points worth of BMPs under its permit by rule.

During the development of the Rule, various manure treatment systems and handling practices were evaluated for their effectiveness in reducing ammonia emissions. Many scientific studies, extension bulletins, NRCS handbooks and EPA guidance documents were referred to in preparing the professional judgment toward relative effectiveness in reducing ammonia and the allocation of points. An arbitrary point system, with a maximum of 20 points, was assigned to each practice; whereas, a practice receiving...
20 points would equate to a system or practice that would result in a major reduction, approximately 70 percent, in ammonia emissions for that specific process. Each practice was rated on a year-round basis and as if all of the manure practically available for the practice was handled by the practice and variations due to normal seasonal use of each practice was taken into account in the points awarded to each BMP. Variations due to seasonal practices (such as corral harrowing or direct land application of liquid manure) and expected weather conditions have been factored into these ratings. Points awarded to land application practices assume that the practice is utilized on all manure that is applied. Points are allowed to be pro-rated to reflect actual waste treatment or handling that is occurring on each farm.

The emissions related to the management of exported manure are also addressed in the Rule. Dairy farmers, under the Rule, can “take credit” for the management of ammonia conservation practices that occur on farms (3rd parties) that receive their manure. For example, if a dairy exports all the vacuumed slurry (feces and urine) from a freestall dairy to a neighboring farm which injects the manure, a total of 25 points would be awarded: 15 for “Direct Utilization of Collected Slurry” and 10 points for “Soil Injection – Slurry,” if used year-round or pro-rated to reflect the percentage of the year used. In order to take credit for activities conducted by 3rd parties, dairy farmers must keep records on the amount of exported material that left the farm and the BMP the 3rd party intends to employ.

The list of BMPs was developed to give the maximum amount of flexibility for producers to select the appropriate ammonia control practices for their farm. Producers should review the description of BMPs found in this bulletin as well as discuss their proposed plan with their Nutrient Management Planner to ensure that the proposal is not contrary to the provisions of their nutrient management plan.
Section 764 states:

### Ammonia Control Practices for Idaho Dairies

<table>
<thead>
<tr>
<th>System</th>
<th>Component</th>
<th>Ammonia Control Effectiveness</th>
<th>Compliance Method</th>
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</thead>
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<tr>
<td>Waste Storage and Treatment Systems</td>
<td>Synthetic Lagoon Cover</td>
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<tr>
<td></td>
<td>Geotextile Covers</td>
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<tr>
<td></td>
<td>Solids Separation</td>
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<td></td>
<td>Composting</td>
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<tr>
<td></td>
<td>Separate Slurry and Liquid Manure Basins</td>
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<td>1</td>
</tr>
<tr>
<td></td>
<td>In-House Separation</td>
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<td>1</td>
</tr>
<tr>
<td></td>
<td>Direct Utilization of Collected Slurry</td>
<td>6 10  -</td>
<td>1 3 4</td>
</tr>
<tr>
<td></td>
<td>Direct Utilization of Parlor Wastewater</td>
<td>10 10 10</td>
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</tr>
<tr>
<td></td>
<td>Direct Utilization of Flush Water</td>
<td>8 0 13</td>
<td>3 4</td>
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<tr>
<td></td>
<td>Anaerobic Digester</td>
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<td>Anaerobic Lagoon</td>
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<tr>
<td></td>
<td>Aerated Lagoon</td>
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<tr>
<td></td>
<td>Sequencing-Batch Reactor</td>
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<td>Lagoon Nitrification/Denitrification Systems</td>
<td>15 20 20</td>
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<td>Fixed-Media Aeration Systems</td>
<td>15 20 20</td>
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<td>General Practices</td>
<td>Vegetative or Wooded Buffers (established)</td>
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<td>Vegetative or Wooded Buffers (establishing)</td>
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<tr>
<td></td>
<td>Alternatives to Copper Sulfate</td>
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<tr>
<td>Freestall Barns</td>
<td>Scrape Built Up Manure</td>
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<tr>
<td></td>
<td>Frequent Manure Removal</td>
<td>UD UD UD</td>
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<td></td>
<td>Tunnel Ventilation</td>
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<tr>
<td></td>
<td>Tunnel Ventilation w/Biofilters</td>
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<tr>
<td></td>
<td>Tunnel Ventilation w/Washing wall</td>
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<td>Open Lots and Corrals</td>
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<td>In-Corral Composting / Stockpiling</td>
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<tr>
<td></td>
<td>Summertime Deep Bedding</td>
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### Scientific Basis for the Control of Ammonia from Dairy Farms
Best Management Practices 7/18/06

<table>
<thead>
<tr>
<th>System</th>
<th>Component</th>
<th>Ammonia Control Effectiveness</th>
<th>Compliance Method</th>
</tr>
</thead>
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<tr>
<td></td>
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<td>Open Lot</td>
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<td>Composting Practices</td>
<td>Alum Incorporation</td>
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<td>Carbon:Nitrogen Ratio (C:N) Ratio Manipulation</td>
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<td>Composting with Windrows</td>
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<td>Composting Static Pile</td>
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<td>Forced Aeration Composting</td>
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<td>Forced Aeration Composting with Biofilter</td>
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<td>Land Application</td>
<td>Soil Injection - Slurry</td>
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<td>Incorporation of manure within 24 hrs</td>
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<td>Incorporation of manure within 48 hrs</td>
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<td>Nitrification of lagoon effluent</td>
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<td>Low Energy/Pressure Application Systems</td>
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<td>Freshwater Dilution</td>
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<tr>
<td></td>
<td>Subsurface Drip Irrigation</td>
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</table>

**Notes:**
1. The ammonia emission reduction effectiveness of each practice is rated numerically based on practical year-round implementation. Variations due to seasonal practices and expected weather conditions have been factored into these ratings. Not implementing a BMP when it is not practicable to do so, does not reduce the point value assigned to the BMP, nor does it constitute failure to perform the BMP. UD indicates that the practice is still under development.
2. Land application practices assume practice is conducted on all manure; points will be pro-rated to reflect actual waste treatment; points can be obtained on exported material with sufficient documentation.
3. Method used by inspector to determine compliance:
   1=Observation by Inspector
   2=On-Site Recordkeeping Required
   3, 4=Deviation Reporting Required. Equipment upsets and/or breakdowns shall be recorded in a deviation log and if repaired in a reasonable timeframe does not constitute non-compliance with this rule.

A description of each ammonia control BMP is attached hereto as Appendix A.

**How do I calculate how many BMP points I have?**
Dairy farmers subject to this Rule should review the list of accepted BMPs and denote which practices they use throughout the year to manage and land apply the manure on their farm. The plan should reflect the “year-around” implementation of practices, rather than a plan for summer BMPs and another for winter BMPs. The following three examples, using the same example dairy farm, will help in determining the amount of points that should be awarded for each farm.

**Example Dairy**
Sweet Cream Dairy is a 2,200 freestall facility that scrapes the manure into a collection pit. The manure solids are then separated using a screw press and are windrowed and “composted” for bedding, while the liquid is stored in the lagoon. Wastewater from the parlor and holding pen is separated using a solids settling basin and the liquid drains into the lagoon. Exercise pens for the lactating cows are harrowed...
daily, when weather permits. Lagoon wastewater is applied during the growing season using two center pivots, using overhead sprinklers, and 4 wheel-lines. The dairy also cleans up “unauthorized” manure from around the barns, separators, and irrigation equipment weekly. The dairy works with their nutritionist to monitor excess nitrogen through weekly milk urea nitrogen (MUN) samples. No replacement heifers or calves are kept on the facility.

Example #1
Initial BMP Point Determination:
- Composting: 4 points
  Separated solids from screw press and the settling basin are “composted” or dried without supplemental carbon sources or using rapid composting methods
- Scrape Built Up Manure: 3 points
  Weekly clean-up of “unauthorized” manure from around the barns, separators, and irrigation equipment
- Corral Harrowing: 2 points
  Farm daily harrows of exercise pens, when weather permits, and remove excess manure as necessary
- Manage Dietary Protein: 2 points
  Working with a trained nutritionist to monitor ration for excess nitrogen through the review of milk urea nitrogen (MUN) samples
- Total Points = 11 points

Example #2
Sweet Cream Dairy understands it does not have enough points to meet the 27 points required. Reviewing their options with their Nutrient Management Planner, the dairy farm considers directly composting the collected slurry from the freestall barn with imported mint tailings and straw.

BMP Point Determination for directly composting collected slurry:
- Direct Utilization of Collected Slurry: 10 points
  As an alternative to storing the slurry in the lagoon, the collected slurry is incorporated into compost
- Carbon:Nitrogen Ratio (C:N) Manipulation: 7.5 points
  Mint tailings and straw are used as carbon sources for the collected slurry. In addition to drying the slurry, the high carbon content helps to conserve ammonia (nitrogen) within the compost pile
- Previous points: 11 points
- Total Points = 28.5 points

Example #3
Rather than composting the collected slurry, Sweet Cream Dairy has contracted with several neighboring farms (3rd party receivers) to receive their manure daily during 8 months of the year. Additionally, the dairy farm hires a local hauler to inject the manure on fields specified by his neighbors. During the remaining 4 months of the year, the collected slurry is separated and the liquids are stored in the lagoon.

BMP Point Determination for directly injecting collected slurry:
- Direct Utilization of Collected Slurry: 10 x .75 = 7.5 points
  As an alternative to storing the slurry in the lagoon during 8 months of the year, the scraped slurry is exported off the farm. Points are pro-rated to reflect 8-month implementation
- Soil Injection – Slurry: 15 points x .75 = 11.25
  Manure is injected into the soil at a depth of 2 inches or greater. Points are pro-rated to reflect 8 month implementation
- Previous points: 11 points
- Total Points = 29.75 points
What if I only do a BMP for part of the year? Do I get full credit?
If the BMP can be conducted/implemented year-around, then no, the points would need to be pro-rated to reflect the number of months in which it will be used. This is the case in Example #3 where the amount of points were reduced by 25% to reflect that the collected slurry was exported for only 8 months of the year. If the practice is seasonal in nature, like corral harrowing, the total number of points would be awarded because the season reduction has already been taken into account when the points were assigned.

For more information, please contact

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Appendix A
AMMONIA CONTROL BMPS

LIQUID MANURE STORAGE AND TREATMENT

Synthetic Lagoon Cover.
Definition: Impermeable lagoon cover constructed of flexible polyvinyl chloride (PVC) or high density polyethylene (HDPE). Creates an air and water tight seal over the manure surface. Requires a vent to release carbon dioxide and methane.

Points: Open Lot - 15 points; Freestall Scrape – 20 points; Freestall Flush – 20 points
In general, open lot receives fewer points because of the relative amount of manure that would potentially go into the liquid storage structure.

Compliance: Observation.
Either present or not; recording and reporting not required. Inspector will have discretion if cover has a tear to decide if the size of the tear is affecting practice; dairy will be required to repair to maintain BMP points.

Management Considerations: Cover will result in the accumulation of nitrogen within the lagoon. Manure samples should be taken to ensure that excess nitrogen is applied to crops at appropriate rates. Vent and/or flare is required to release collected carbon dioxide and methane.

Geotextile Cover.
Definition: Permeable cover constructed of non-woven synthetic felt. Constructed to provide complete coverage over liquid surface.

Points: Open Lot - 10 pts; Freestall Scrape – 13 pts; Freestall Flush – 13 pts
In general, open lot receives fewer points because the relative amount of liquid storage is less than with the freestall.

Compliance: Observation.
Either present or not; no recording, no reporting would be required. Inspector will have discretion if cover has a tear to decide if tear was affecting practice; dairy will be required to repair or loose points.

Management Considerations: Cover will result in the accumulation of nitrogen within the lagoon. Manure samples should be taken to ensure that excess nitrogen is applied to crops

Solids Separation.
Definition: Gravity or mechanical separation system to remove manure solids from liquid waste stream. Separation pits should be cleaned on a regular basis with holding times less than one month. Separated solids from mechanical systems should be removed from the separator on a regular basis, not to exceed three days.

Points: Open Lot - 3 points; Freestall Scrape – 3 points; Freestall Flush – 3 points

Compliance: Recordkeeping - deviation log. Maintain a one-time plan or explanation of system used and how cleaning is done. Maintain a deviation log to document noncompliance with plan.
Composting.
Definition: Stacking and drying of separated manure solids or corral manure. Practice may or may not meet the carbon-to-nitrogen ratio criteria specified in Natural Resources Conservation Service Standard #317.

Points: Open Lot - 4 points; Freestall Scrape – 4 points; Freestall Flush – 4 points

Compliance: Observation.

Management Considerations: Composting is a aerobic biological process that results in the degradation of organic materials. For optimum composting conditions the carbon to nitrogen ratio (C:N) should be between 30 – 40:1, and the moisture content should be between 50 – 60% moisture. No special microbes are required for sufficient composting.

Separate Slurry and Liquid Manure Basins.
Definition: Construction and use of separate holding basins/lagoons to keep parlor wastewater and corral runoff away from concentrated slurry (manure and urine). Applicable systems would include freestall scrape and open lot dairies, which scrape their feeding alleys.

Points: Open Lot - 6 points; Freestall Scrape – 10 points; Freestall Flush – 0 points

In general, open lot receives fewer points because the relative amount of liquid storage is less than the freestall scrape.

Compliance: Observation.

In-House Separation.
Definition: Specialized floor design allowing fecal material to remain in place while urine is removed.

Points: Open Lot – 0 points; Freestall Scrape – 12 points; Freestall Flush – 0 points

Compliance: Observation

Management Considerations: This practice utilizes floor designs which will segregate urine and feces from collecting in the same area within the freestall barn. Ammonia emissions are reduced through minimizing contact of time of urine and feces resulting in the conversion of urea to ammonia.

Direct Utilization of Collected Slurry.
Definition: Year-round utilization or direct application of manure slurry instead of placing collected fresh material in storage basis - includes on-farm and export systems. Direct utilization means slurry wastewater is not sent to a wastewater storage basin with the exception of a collection pit. Seasonal systems (daily during the growing season) need to pro-rate points to reflect the number of months in which the process is conducted.

Points: Open Lot - 6 points; Freestall Scrape – 10 points; Freestall Flush – 0 points

Compliance: Observation when it is working; may need deviation log in the winter time when it is not land applied.
Management Considerations: Daily application systems should consult a nutrient management planner or a Certified Crop Advisor. Practice also includes facilities which incorporate collected slurry directly into compost windrows.

**Direct Utilization of Collected (Parlor) Wastewater.**

Definition: Utilization or direct application of parlor wastewater during the active growing season instead of placing collected fresh wastewater in storage basin - includes on-farm and export systems. Direct utilization means that parlor wastewater is not sent to a wastewater storage basin. Wastewater may be stored in a temporary storage (<5 days) until it is utilized and applied daily during the growing season as weather conditions allow.

Points: Open Lot - 10 points; Freestall Scrape – 10 points; Freestall Flush – 10 points

Compliance: Observation.

Management Considerations: Daily application systems should consult a nutrient management planner or a Certified Crop Advisor and consider mixing wastewater with irrigation water during application.

**Direct Utilization of Flush Waste.**

Definition: Utilization or direct application of flush water during the active growing season instead of placing collected flush water in storage basin. Applicable systems would include freestall flush and open lot flush alley systems. Wastewater may be stored in a temporary storage (<5 days) until it is utilized and applied daily during the growing season as weather conditions allow.

Points: Open Lot - 8 points; Freestall Scrape – 0 points; Freestall Flush – 13 points

Compliance: Observation.

Management Considerations: Daily application systems should consult a nutrient management planner or a Certified Crop Advisor and consider mixing wastewater with irrigation water during application.

**Anaerobic Digester.**

Definition: Treatment systems which anaerobically digests organic matter from the manure and converts it into methane using bacteria. The methane is then collected and may be used to generate electricity or as an alternative to natural gas. Steady supply of manure is needed - typically no change to nutrient concentration without additional treatment - also effective in reducing volatile organic compounds, biological oxygen demand, and odor.

Points: Open Lot - 0 points; Freestall Scrape – 0 points; Freestall Flush – 0 points

Compliance: None

Management Considerations: No points assigned because anaerobic digestion converts organic-nitrogen to ammonia-nitrogen. However, digestion allows for additional treatment to be conducted at lower operational costs.

**Anaerobic Lagoon.**
Definition: Biological earthen basis which manure is designed to decompose liquid manure without the presence of oxygen. System has a pH of 7.0 to 8.0, and sludge is designed to be removed every 5 years. Also effective in reducing volatile organic compounds, biological oxygen demand, and odor.

Points: Open Lot - 0 points; Freestall Scrape – 0 points; Freestall Flush – 0 points
No points assigned because this is not an ammonia control.

Compliance: None

Management Considerations: No points assigned because anaerobic digestion converts organic-nitrogen to ammonia-nitrogen. However, digestion allows for additional treatment to be conducted at lower operational costs.

**Aerated Lagoon.**

Definition: Biological treatment basin designed to decompose liquid manure and nitrify ammonia in the presence of oxygen. System has a pH of 7.0 to 8.0, and sludge is designed to be removed every 5 years. Systems should utilize submerged micro-bubble systems to reduce ammonia loss. If engineering guidelines are not specified by the designer, system should be operated to maintain a dissolved oxygen concentration greater than 1.5 mg/l and an oxygen-reduction-potential (ORP) greater than 50. Quarterly monitoring of inflow and outflow nitrogen species is required to track system performance. Also effective in reducing volatile organic compounds, biological oxygen demand, and odor.

Points: Open Lot - 10 points; Freestall Scrape – 12 points; Freestall Flush – 15 points
Point differences are based on the amount of material to be treated.

Compliance: Recordkeeping, Reporting Required - sensor for dissolved oxygen, oxygen-reduction-potential level; quarterly monitoring of the inflow/outflow

Management Considerations: Operational cost for lagoon aeration can be significant.

**Sequencing Batch Reactor.**

Definition: Single tank treatment system that allows for the sequencing of anaerobic, anoxic and aerobic conditions within the tank through the scheduling of wastewater feeding and aeration. Successful systems have been documented to reduce 85% of total nitrogen for animal wastewater. Quarterly monitoring of inflow and outflow nitrogen species is required to track system performance. Also effective in reducing volatile organic compounds, biological oxygen demand, and odor.

Points: Open Lot - 15 points; Freestall Scrape – 20 points; Freestall Flush – 20 points
More points are given than aerated lagoon because of higher efficiency and operational control.

Compliance: Recordkeeping and reporting required. Seasonal monitoring of inflow/outflow will be needed.

Management Considerations: Operational cost for SBR can be high, but achieves an environmentally friendly reduction of nitrogen.

**Lagoon Nitrification and Denitrification System.**
Definition: Engineered lagoon modification or stand-alone system designed and operated to convert wastewater ammonia to nitrate and then to nitrogen gas. Quarterly monitoring of inflow and outflow nitrogen species is required to track system performance. Also effective in reducing volatile organic compounds, biological oxygen demand, and odor.

Points: Open Lot - 15 points; Freestall Scrape – 20 points; Freestall Flush – 20 points

Compliance: Recordkeeping and reporting required. Seasonal monitoring of inflow/outflow will be needed.

Management Considerations: Operational cost for lagoon system can be high, but achieves an environmentally friendly reduction of nitrogen while potentially utilizing the existing earthen storage basin.

Fixed Media Aeration System.

Definition: Stand-alone treatment system designed and operated to convert wastewater ammonia to nitrate. Systems utilize a media or substrate on which to propagate bacterial growth. Several systems have been shown to denitrify wastewater nitrate into nitrogen gas. Quarterly monitoring of inflow and outflow nitrogen species is required to track system performance. Also effective in reducing volatile organic compounds, biological oxygen demand, and odor.

Points: Open Lot - 15 points; Freestall Scrape – 20 points; Freestall Flush – 20 points

Compliance: Recordkeeping and reporting required. Seasonal monitoring of inflow/outflow will be needed.

Management Considerations: Operational cost for fixed media aeration systems are moderate compared to other aeration systems. Several systems have been shown to achieve an environmentally friendly reduction of nitrogen while reducing odor potential of treated wastewater.

GENERAL PRACTICES

Vegetative or Wooded Buffers – Established/Establishing.

Definition: Mixture of hardwood and evergreen trees or shrubs control, capture, and mix higher elevated cleaner air with lower, dust and odor laden air from the ground surface. Also effective on odor, and dust. Should be installed between production facility/lagoon and neighbors. (Established: At mature growth stage; Establishment: Planted but not at manure growth stage.)

Points: (Established) Open Lot – 7 points; Freestall Scrape – 7 points; Freestall Flush – 7 points
(Establishment) Open Lot – 2 points; Freestall Scrape – 2 points; Freestall Flush – 2 points

Compliance: Observation

Management Considerations: NRCS Standard 380 "Windbreak/Shelterbelt Management" should be used as a guide for establishment.

Alternatives to Copper Sulfate.
Definition: Use of approved alternatives to copper sulfate as a hoof treatment and preventative measure. No effect on ammonia; significant reduction in hydrogen sulfide.

Points: Open Lot - 0 points; Freestall Scrape – 0 points; Freestall Flush – 0 points

Compliance: None

Management Considerations: However effective alternatives to copper sulfate will be in reducing odors from dairy storage basins, no direct correlation to reductions in ammonia emission have been established

**FREESTALL BARN**

**Scrape Built Up Manure.**
Definition: Removal of build up manure around the yard and manure handling system. Specific emphasis on ends of barns, around collection pits, mixing tanks and manure loading areas. Also effective in reducing odors and fly production.

Points: Open Lot - 0 points; Freestall Scrape – 3 points; Freestall Flush – 3 points

Compliance: Observation

**Frequent Manure Removal.**
Definition: Practice is under evaluation at the University of Idaho and Texas A&M. No recommendation at this time.

Points: Under Development

Compliance: Under Development

Management Considerations: The effect of manure removal timing on ammonia emissions is currently showing mixed results.

**Tunnel Ventilation.**
Definition: Engineered mechanical ventilation system which draws fresh air into a barn through an open end wall by a slight negative pressure that is created by exhaust fans mounted at the opposite end wall.

Points: Open Lot - 0 points; Freestall Scrape – 0 points; Freestall Flush – 0 points

Compliance: None

**Tunnel Ventilation with Biofilter.**
Definition: Tunnel ventilation system that exhausts air into a biological biofilter for air treatment. Biofilter material should contain 50% shredded wood and 50% finished compost. System is also effective in reducing hydrogen sulfide, odor, and dust from barns.

Points: Open Lot - 0 points; Freestall Scrape – 10 points; Freestall Flush – 10 points

Compliance: Observation
Considerations: Although not currently demonstrated on a dairy facility, this practice has shown significant reductions in ammonia, hydrogen sulfide, and odor emissions from swine facilities.

**Tunnel Ventilation with Washing Wall.**

**Definition:** Tunnel ventilation system that exhausts air into engineered washing wall for air treatment. Washing wall is designed to remove ammonia and dust from barn using a cascade of recycled water. Water may be acidified to increase ammonia removal. Systems are also effective in reducing odor and dust from barns.

**Points:** Open Lot - 0 points; Freestall Scrape – 10 points; Freestall Flush – 10 points

**Compliance:** Deviation Log

**Management Considerations:** Although not currently demonstrated on a dairy facility, this practice has shown significant reductions in ammonia, dust, and odor emissions from swine facilities.

### OPEN LOTS AND CORRALS

**Rapid Manure Removal.**

**Definition:** Removal of winter time manure and corral bedding from open lot surface in spring or as quickly as practicable. Manure can then be stockpiled, composted or exported off of the dairy.

**Points:** Open Lot - 4 points; Freestall Scrape – 2 points; Freestall Flush – 2 points

**Compliance:** Observation - if the inspector is present when removal is being done; Recordkeeping - if the inspector is not present when removal is being done

**Corral Harrowing.**

**Definition:** Corral harrowing to distribute deposited manure, reshape corral surface and/or remove manure from corral surface. Harrowing should be conducted no less than three times per week when weather conditions permit.

**Points:** Open Lot - 4 points; Freestall Scrape – 2 points; Freestall Flush – 2 points

**Compliance:** Observation

**Surface Amendments.**

**Definition:** Use of liquid and dry chemical products that will bind or chemically target the conversion of urea to ammonia gas. Produce effectiveness and described use should be specified by manufacture testing. Examples of product may include, but are not limited to: alum, magnesium sulfate, acids.

**Points:** Open Lot - 10 points; Freestall Scrape – 5 points; Freestall Flush – 5 points

**Compliance:** Recordkeeping – documented with receipts for amendment orders
Management Considerations: This practice does not include biological amendments or bacterial stimulants. Producers should consult their nutrient management planner to review the effect of any product on agronomic performance.

**In-Corral Composting/Stockpiling.**

**Definition:** Stockpiling and subsequent drying and potential decomposition of winter manure and bedding in-corral through summer and fall. Practice encourages the timely stacking and cleaning of corral surfaces. Practice cannot receive additional points through carbon-to-nitrogen ratio manipulation.

**Points:** Open Lot - 4 points; Freestall Scrape – 2 points; Freestall Flush – 2 points

**Compliance:** Observation

**Summertime Deep Bedding.**

**Definition:** Six inches of straw on an open corral surface as a one-time application. An approximate 40% reduction in ammonia emission is achieved.

**Points:** Open Lot – 10 points; Freestall Scrape – 5 points; Freestall Flush – 5 points

**Compliance:** Observation

Management Considerations: This practice allows a layer of straw to segregate urine and feces from collecting in the same area within the open lot. Feces deposited on straw will be allowed to dry and thus shed liquids if urinated upon. Ammonia emissions are reduced through minimizing contact of time of urine and feces resulting in the conversion of urea to ammonia.

Special management will need to be taken to manage fly production within lot.

**ANIMAL NUTRITION**

**Manage Dietary Protein.**

**Definition:** With the assistance of a professional nutritionist, develop and follow a strategy to feed closer to National Research Council guidelines and production requirement, incorporate phase feeding or use of appropriate amino acids or enzymes.

**Points:** Open Lot - 2 points; Freestall Scrape – 2 points; Freestall Flush – 2 points

**Compliance:** Recordkeeping – documented with milk urea nitrogen analysis and receipts from protein orders

Management Considerations: Producers should consult their nutritionist to evaluate the level of nitrogen in the rations fed on the farm.
COMPOSTING PRACTICES

Alum Incorporation.
Definition: Regular incorporation of aluminum sulfate with fresh material to reduce ammonia volatilization. Dissolved phosphorus will also be reduced in the applied product.
Points: Open Lot - 12 points; Freestall Scrape – 8 points; Freestall Flush – 6 points
Compliance: Recordkeeping – documented with receipts
Management Considerations: This practice does will increase the nitrogen content of the applied compost. Producers should consult their nutrient management planner to review the effect of any product on agronomic performance.

Carbon-to-Nitrogen Ratio Manipulation.
Definition: Management and material selection to insure that the carbon-to-nitrogen ratio is greater than 35:1 in the finished compost material. Lower carbon-to-nitrogen ratios will encourage greater ammonia volatilization. Practice should not be allocated toward “In-Corral Composting/Stockpiling.”
Points: Open Lot - 10 points; Freestall Scrape – 7.5 points; Freestall Flush – 5 points
Compliance: Recordkeeping
Management Considerations: Composting is a aerobic biological process that results in the degradation of organic materials. For optimum composting conditions the carbon to nitrogen ration (C:N) should be between 30 – 40:1, and the moisture content should be between 50 – 60% moisture. Adding supplemental carbon sources will also increase porosity within the compost pile allowing for better aeration within the pile. No special microbes are required for sufficient composting.

Composting with Windrows.
Definition: Aerobic decomposition of manure or other organic materials placed in long rows. The windrows can be actively turned, passive, actively aerated windrow, or passively aerated windrow. Temperature is between 110 to 150 F, carbon-to-nitrogen ratio is 20:1 to 40:1, moisture is 40% to 60%, and pH is 5.5 to 9.0.
Points: Open Lot - 0 points; Freestall Scrape – 0 points; Freestall Flush – 0 points
Compliance: None
Management Considerations: Compost windrow should be have a pile height between 3 and 10 feet. Windrows less than 3 feet will not have sufficient insulation to maintain temperatures over 100ºF. Windrows with heights greater than 10 feet have been shown to have higher risks of spontaneous combustion.

Composting with Static Piles.
Definition: Engineered composting system through the aerobic decomposition of manure or other organic materials placed in long rows that are not turned/mixed but have aeration pipes installed to facilitate increased air transfer. Bulking agents such as shredded wood should be used to ensure pile porosity.
Points: Open Lot - 6 points; Freestall Scrape – 4.5 points; Freestall Flush – 3 points

Compliance: Observation

Management Considerations: Close management needs to be made when establishing static compost pile to ensure that all materials are thoroughly mixed and meet recommended guidelines. For optimum composting conditions the carbon to nitrogen ration (C:N) should be between 30 – 40:1, and the moisture content should be between 50 – 60% moisture. Adding supplemental carbon sources will also increase porosity within the compost pile allowing for better aeration within the pile. No special microbes are required for sufficient composting. For more information on static pile management, consult the “On-Farm Composting Handbook, NRAES-54”; call 607-255-7654 to order.

**Force Aeration Composting.**

Definition: Engineered composting method using long rows or containers where air is drawn or forced into the piles using mechanical blowers. These piles are not turned. Make sure air is dispersed evenly through the pile. Bulking agents such as shredded wood should be used to ensure pile porosity.

Points: Open Lot - 10 points; Freestall Scrape – 7.5 points; Freestall Flush – 5 points

Compliance: Observation

Management Considerations: Close management needs to be made when establishing compost pile, prior to aeration, to ensure that materials are thoroughly mixed and meet recommended guidelines. Systems can be aerated by either pushing air into the compost pile or pulling air through the pile (see practice: Force Aeration Composting with Biofilter). Additionally, producers should consider temperature control aeration systems to reduce operational cost.

For optimum composting conditions the carbon to nitrogen ration (C:N) should be between 30 – 40:1, and the moisture content should be between 50 – 60% moisture. Adding supplemental carbon sources will also increase porosity within the compost pile allowing for better aeration within the pile. No special microbes are required for sufficient composting. For more information on forced aeration, consult the “On-Farm Composting Handbook, NRAES-54”; call 607-255-7654 to order.

**Force Aeration Composting with Biofilter.**

Definition: Engineered composting method using long rows or containers of carbon material where air is drawn through the compost and discharged into a biofilter. These piles are not turned. Bulking agents such as shredded wood should be used to ensure pile porosity.

Points: Open Lot - 12 points; Freestall Scrape – 8 points; Freestall Flush – 6 points

Compliance: Observation

Management Considerations: This specialized method of force aeration composting, pulls air through a compost pile and discharges air into a biofilter. Biofilter is comprised of half compost and half shredded wood by volume and a sprinkler system to maintain between 40 – 50% moisture within the biofilter. This practices works through filtering volatile compounds and ammonia and then allowing aerobic microorganisms to degrade the compounds.
Close management needs to be made when establishing compost pile, prior to aeration, to ensure that materials are thoroughly mixed and meet recommended guidelines. Producers should consider temperature control aeration systems to reduce operational cost.

For optimum composting conditions the carbon to nitrogen ratio (C:N) should be between 30 – 40:1, and the moisture content should be between 50 – 60% moisture. Adding supplemental carbon sources will also increase porosity within the compost pile allowing for better aeration within the pile. No special microbes are required for sufficient composting. For more information on forced aeration, consult the “On-Farm Composting Handbook, NRAES-54”; call 607-255-7654 to order.

**LAND APPLICATION PRACTICES**

**Soil Injection – Slurry.**

*Definition:* Placement of manure slurry (manure of 8-15% solids) or separated solids beneath the soil surface with a minimum of mixing or stirring of the soil. Rate of slurry is not to exceed the Nutrient Management Plan recommendation for the actively growing crop.

*Points:* Open Lot - 10 points; Freestall Scrape – 15 points; Freestall Flush – 7.5 points

*Compliance:* Recordkeeping

*Management Considerations:* Injection on slurry or separated solids will reduce ammonia emissions, odor, and the potential of flies. The nitrogen value of the slurry will be 15 – 40% than if the manure was not incorporated. Producers should consult their nutrient management planner to review the effect of decreased ammonia loss on agronomic performance.

**Incorporation of Manure within 24 Hours.**

*Definition:* Tilling of field surface following liquid or solid manure application within 24 hours from the time the application of the manure begins. Also effective in reducing hydrogen sulfide emissions and fly propagation.

*Points:* Open Lot - 10 points; Freestall Scrape – 10 points; Freestall Flush – 10 points

*Compliance:* Recordkeeping – documented twice: application and incorporation dates

*Management Considerations:* Incorporation of manure will reduce ammonia emissions, odor, and the potential of flies. The nitrogen value of the slurry will be 15 – 40% than if the manure was not incorporated. Producers should consult their nutrient management planner to review the effect of decreased ammonia loss on agronomic performance.

**Incorporation of Manure within 48 Hours.**

*Definition:* Tilling of field surface following liquid or solid manure application within 48 hours from the time the application of the manure begins. Also effective in reducing hydrogen sulfide emissions and fly propagation.

*Points:* Open Lot - 5 points; Freestall Scrape – 5 points; Freestall Flush – 5 points

*Compliance:* Recordkeeping – documented twice: application and incorporation dates

*Management Considerations:* Incorporation of manure will reduce ammonia emissions, odor, and the potential of flies. The nitrogen value of the slurry will be 15 – 40% than if the manure was not incorporated. Producers should consult their nutrient management planner to review the effect of decreased ammonia loss on agronomic performance.
Considerations: Incorporation of manure will reduce ammonia emissions, odor, and the potential of flies. The nitrogen value of the slurry will be 15 – 40% than if the manure was not incorporated. Producers should consult their nutrient management planner to review the effect of decreased ammonia loss on agronomic performance.

**Nitrification of Lagoon Effluent.**

**Definition:** Use of an engineered aeration system, typically fixed media, to convert stored wastewater ammonia to nitrate prior to irrigation. Also effective in reducing volatile organic compounds, biological oxygen demand, and odor during application.

**Points:** Open Lot - 10 points; Freestall Scrape – 10 points; Freestall Flush – 15 points

**Compliance:** Deviation Log

**Management Considerations:** Similar to fixed media aeration system, however, effluent is nitrified (ammonia converted to nitrate) prior to application. This practice will not prevent losses of ammonia that occur during storage, but will conserve the nitrogen that is typically lost during and immediately following irrigation. Operational cost for fixed media aeration systems are moderate compared to other aeration systems. Several systems have been shown to achieve an environmentally friendly reduction of nitrogen while reducing odor potential of treated wastewater.

**Low Pressure & Energy Application Systems (LEPA).**

**Definition:** Center pivot and liner-move irrigation strategy that applies liquids at low pressures using drop nozzles. Larger droplets result in lower emissions but may cause infiltration problems on some soils. Designed systems and sprinkler packages should not exceed 35 psi. Low pressure overhead sprinklers and wheel lines do not qualify as LEPA technologies. Also effective on hydrogen sulfide and odor.

**Points:** Open Lot - 7 points; Freestall Scrape – 7 points; Freestall Flush – 10 points

**Compliance:** Observation

**Management Considerations:** Producers should consult with Certified Irrigation Designer (CID) and Nutrient Management Planner before converting non-LEPA pivots and linear move systems. Practice is not recommended on highly erodable land (HEL).

**Freshwater Dilution.**

**Definition:** Dilute irrigated wastewater by a minimum of 50% (1:1 ratio waste to fresh water) during all irrigation events. Dilutions can be made in approved mixing pond or chemigation systems.

**Points:** Open Lot - 5 points; Freestall Scrape – 8 points; Freestall Flush – 8 points

**Compliance:** Observation or Recordkeeping: Determined by system design

**Management Considerations:** Regardless of dilution rate, producers still need to take precautions of applying wastewater to crops close to harvest, especially those that will be used for direct human consumption.
**Pivot Drag Hoses.**

**Definition:** Low pressure application method that allows the liquid to be applied on the soil surface directly in the row. This method decreases the amount of liquid lost to wind drift, and to decrease the energy costs associated with pumping enough liquid to maintain the high pressures required for the impact heads. Systems should use pressure regulators or ball valves to regulate flow from drag hoses. Also effective on hydrogen sulfide and odor.

**Points:** Open Lot - 8 points; Freestall Scrape – 8 points; Freestall Flush – 10 points

**Compliance:** Observation

**Management Considerations:** Pressure regulators or valves should be used on each drop to manage flow rates from drag hose. Producers should consult with Certified Irrigation Designer (CID) and Nutrient Management Planner before converting non-drag hose pivots and linear move systems. Practice is not recommended on highly erodable land (HEL) or fields with little or no ground cover.

**Subsurface Irrigation.**

**Definition:** Specialized irrigation method that allows for precise applications of liquid to the root zone of the plant. System requires specialized filtering system to handle wastewater solids and specialized "wastewater approved" drip lines should be used to prevent clogging. Also effective on hydrogen sulfide and odor.

**Points:** Open Lot - 10 points; Freestall Scrape – 10 points; Freestall Flush – 12 points

**Compliance:** Observation

**Management Considerations:** In addition to using wastewater approved drip lines, special attention should be taken in the selection of filter media and selecting backwash frequencies. For more information on wastewater subsurface drip systems visit: www.oznet.ksu.edu/sdi/

The nitrogen value of the slurry will be 15 – 40% than if the manure was not incorporated. Producers should consult their nutrient management planner to review the effect of decreased ammonia loss on agronomic performance.
Appendix B


Reference materials for Yakima Regional Clean Air Agency: Air Quality Management Policy and Best Management Practices for Dairy Operations have been included. This includes:

AIR QUALITY MANAGEMENT POLICY

AND

BEST MANAGEMENT PRACTICES

FOR

DAIRY OPERATIONS

Effective July 1, 2013

“CLEAN AIR IS EVERYONE’S RESPONSIBILITY”

Prepared by:

Gary W. Pruitt, Air Pollution Control Officer
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BACKGROUND

YRCAA began working with local beef cattle feedlots in 1993 to minimize dust emissions. As a result, a policy was adopted and fugitive dust plans were developed and implemented. Since then, the plans, and their effectiveness, have improved each year. In 2001, YRCAA worked with heifer replacement and calving operations to develop a fugitive dust control policy for dairy heifer feeding operations. Because dairy operations generate fugitive emissions, YRCAA has developed this policy using the same approach it has taken for cattle feedlots, heifer replacement, and calving operations. Implementation of this policy will constitute “reasonable precautions” to minimize air emissions from dairy operations.

This policy only applies to dairies where cows are confined for feeding and milking and where the potential for significant emissions of air pollutants exist. This policy specifically acknowledges that air emissions from dairy operations cannot be eliminated and that all management practices must be economically and technically feasible. As part of the development of the final policy, YRCAA worked with dairies during a pilot project, which implemented the policy through developing and implementing flexible, site-specific Air Quality Management Plans.

Pilot Project

The pilot project was conducted as contemplated in RCW 34.05.313, which states in part: “During the development of a rule or after its adoption, an agency may develop methods for measuring or testing the feasibility of complying with or administering the rule and for identifying simple, efficient, and economical alternatives for achieving the goal of the rule. A pilot project shall include public notice, participation by volunteers who are or will be subject to the rule, a high level of involvement from agency management, reasonable completion dates, and a process by which one or more parties may withdraw from the process or the process may be terminated.”

On February 10, 2011 the YRCAA Board of Directors approved the policy as a pilot research project aimed at gathering information, testing the feasibility of implementing the policy, and measuring the effectiveness of the policy. Packets were sent to every Yakima County dairy with information about the pilot project and an invitation to attend an informational workshop held on March 15, 2011. During the workshop, YRCAA staff explained the policy and presented an example of an Air Quality Management Plan (AQMP) to be submitted by dairy operations.

YRCAA recruited and worked with eight producers at fifteen dairy facilities who voluntarily participated in the pilot project, implementing the policy over ten months. The AQMP was further developed and implemented at each participating dairy. YRCAA staff used the AQMPs that were submitted as a starting point for evaluating BMPs utilized to prevent or reduce air emissions. Two site visits were conducted at each dairy. Inspection reports and score sheets, which served as a means to measure the effectiveness of BMPs utilized, were provided to each participating dairy following the site visits. Technical assistance documents were also developed during the project to aid producers in selecting which BMPs to implement.

The pilot study targeted eight air pollutants for each system within a dairy operation. The pollutants were: Ammonia (NH₃); Nitrous Oxide (N₂O); Hydrogen Sulfide (H₂S); Volatile Organic Compounds (VOC); Odor; Particulate Matter (PM); Methane (CH₄) and Oxides of Nitrogen (NOx). The systems were: Nutrition; Feed Management; Housing - Freestall Barns, Housing - Drylot Pens; Grazing;
Manure Management; Land Application (Fertilizer and Manure); and Other (those newly identified during the pilot study).

The project work was completed in December, 2011. A final report of the project was prepared and made available to the Board of Directors and the public in January 2012. YRCAA and the project team conducted an effectiveness assessment of the policy, determined modifications necessary, made minor, non-substantive changes and included compliance assistance documents developed during the project.

**Trial Implementation**
In March of 2012 the Board of Directors approved the policy for a one-year trial implementation period to give opportunity to more dairies to comply with the policy. In 2012 six additional dairy producers submitted Air Quality Management Plans and Agency staff conducted full compliance evaluations at nine facilities operated by the six producers. Findings of the evaluations were similar in all aspects to the findings of the pilot project evaluations. A high level of BMP utilization across all systems was found.

The trial implementation work was completed in December, 2012. A final report of the trial period was prepared and made available to the Board of Directors and the public in March 2013. YRCAA conducted an effectiveness assessment of the policy, determined modifications necessary, and made minor changes to the text for clarification.

**Reasons for the Policy**
There are many dairy operations in Yakima County which YRCAA has recognized as significant air pollution sources. YRCAA's primary air quality concern regarding dairy operations is the generation of fugitive air emissions from feed, urine, manure and other sources.

In recent years, most dairy operators have instituted various practices to control fugitive air emissions. Such practices are also good animal husbandry and good neighbor practices. Air quality management practices can require a significant commitment of time and resources by owners and operators.

Since air emissions from dairy operations are considered to be fugitive emissions (cannot feasibly be collected and passed through a control device), mitigation must be accomplished by prevention rather than control. This policy is intended to use existing regulations and clarify what constitutes "reasonable precautions" to minimize air emissions from dairy operations. The primary means to accomplish this is to identify pollutant-specific and system-specific best management practices (BMPs) for minimizing emissions and to cause these practices to be implemented according to flexible, site-specific Air Quality Management Plans.

This policy applies only to dairy operations where cows are confined for feeding and milking and the potential for significant emissions of air pollutants exists. 100% of the air emissions from dairy operations cannot be eliminated. This policy and all BMPs contained in this policy have been tested, proven to be effective in mitigating air emissions, and found to be economically and technically feasible.

**Jurisdiction**
This policy is not intended for any dairy operation located outside the jurisdiction of YRCAA. YRCAA jurisdiction is all lands inside Yakima County, excluding those lands within the exterior boundaries of the Yakama Indian Reservation.
I. What is the Purpose of the Policy?

The purpose of this policy is to provide guidance and establish requirements for effective prevention and control of air emissions from dairy operations. Objectives to achieve the purpose are:

1. To achieve sufficient prevention of emissions from dairy operations to assure compliance with applicable laws and regulations;

2. To achieve prevention of emissions by describing a menu of system and pollutant-specific best management practices (BMPs) for dairy operations that will be implemented through the use of flexible, site-specific Air Quality Management Plans;

3. To clarify what constitutes "reasonable precautions to prevent" emissions as required by WAC 173-400-040(3); and

4. To inform owners and operators about effective measures for the prevention of air emissions and provide a means by which dairy operations can demonstrate that they are taking reasonable precautions to protect the air quality in Yakima County.

II. Who Must Comply with the Policy?

All dairy operations where animals are confined for feeding and milking and the potential for significant emissions of air pollutants exists, hereinafter referred to as “dairy operation” or “operation.” All dairies will be considered as potentially significant sources of air pollution for purposes of gathering information and determining source classification.

III. How Does the Policy Work?

1. A dairy operation must prepare, or cause to be prepared, an annual Air Quality Management Plan (AQMP), submit it to YRCAA for approval, and pay a registration fee. Fees will be approved annually by the Agency Board of Directors;

2. An AQMP must identify BMPs and operational procedures to be used to reduce air emissions from each system of operation, such as nutrition, feed management, milking, housing, grazing, manure management, and manure and fertilizer application;

3. YRCAA and the dairy operators are expected to work together in good faith toward development of an AQMP which is acceptable to both the operation and YRCAA;

4. A dairy operation must fully implement an approved AQMP according to the criteria and/or implementation schedules outlined in the plan;

5. A dairy operation may make modifications to an approved AQMP as long as the effectiveness of the plan is not diminished, as determined by YRCAA; and
6. YRCAA may initiate good faith discussion with a dairy operation to modify any AQMP which is determined by YRCAA not sufficiently effective in minimizing fugitive emissions.

Should a dispute arise as to compliance with this policy, YRCAA may request the Agency Agricultural Task Force to review the dispute and provide guidance.

IV. Where and When Must an AQMP be Submitted?

1. Dairy operations must submit initial AQMPs to the YRCAA within 90 days of the effective date of this policy;

2. Dairy operations must submit AQMP updates annually and pay a registration fee, no later than February 15th; and

3. New or expanding dairy operations must file notice with YRCAA, which includes an Air Quality Management Plan for the new facility or expansion and pay a registration fee. This plan must be approved by YRCAA prior to operating the new facility or expansion.

V. What Must Be Contained in an AQMP?

1. A description of the operation, including:
   a. A map, aerial photo or drawing of the operation which adequately represents the layout of the operation and provides enough detail to allow YRCAA to adequately review the feasibility and appropriateness of various BMPs for the facility;
   b. A description of the operational capacity of the operation, including the maximum number of cattle which could be confined;
   c. A description of the lands where nutrient byproducts from the operation are applied and the application method(s) used;
   d. Any site-specific features or characteristics which prevent or limit the use of any BMP; and
   e. Any site-specific features or characteristics which require BMP flexibility or adaptation to meet the needs of the operation.

2. Pollutants and pollutant groups to be addressed under the plan.

Of the following eight pollutants and pollutant groups, those targeted for emission reduction must be identified in the AQMP:

a. Particulate Matter;

b. Ammonia (NH₃);

c. Volatile Organic Compounds (VOCs);
d. Oxides of Nitrogen (NO\textsubscript{X});

e. Hydrogen Sulfide (H\textsubscript{2}S);

f. Odor;

g. Methane (CH\textsubscript{4}); and

h. Nitrous Oxide (N\textsubscript{2}O).

3. A description of BMPs to be used under the AQMP to reduce emissions of the targeted pollutants.

a. The description must include which BMPs will be applied for emission reductions from the following physical areas:

i. milking parlors;
ii. sorting alleys;
iii. feed alleys;
iv. dry lots and free stalls;
v. lands where nutrients are applied;
vi. storage lagoons;
vii. compost areas;
viii. feed storage areas;
ix. unpaved roadways; and
x. any other area or process where emissions may occur.

b. The description must include which BMPs will be applied for emission reductions from the following systems:

i. nutrition;
ii. feed management;
iii. housing;
iv. grazing management;
v. manure management; and
vi. land application (both fertilizer and manure application)

c. The descriptions must also include:

i. a description of the equipment and materials to be used for implementing any BMP, including a description of the normal operational capacity or application rate of any equipment;

ii. an operational plan for implementing each BMP;

The operational plan must describe the criteria the operation will use to determine when and for which area of operation to implement each BMP and the criteria for selecting specific BMPs. It is recognized that operations and conditions are variable and that the same BMP may be implemented differently by individual operations. This variability makes the description of how BMPs will be implemented an especially important component of an operation’s AQMP.
iii. a description of which pollutant or pollutant group will be reduced as a result of implementing each BMP;

iv. a method of monitoring and recording the implementation of each BMP; and

v. the person responsible at the facility for the operation’s AQMP and its implementation.

4. A schedule for future BMP implementation, if applicable.

   If an operation intends to implement additional BMPs in the future, target dates for implementation of each BMP should be included in the AQMP.

VI. How are AQMPs Developed and Approved?

1. An operation is responsible for preparing an AQMP and submitting the plan or update to YRCAA for approval on or before February 15th. Technical assistance may be used in developing the plan. Assistance will be provided by YRCAA. However, an operation may choose to employ a technical service provider;

2. Within 30 days, YRCAA staff must review the plan and notify the operation of plan approval in writing or request additional information or propose alternative practices to approve the plan. Failure of YRCAA to notify the operation or request additional information shall not constitute approval;

3. Operations must respond to agency requests for information or modification of the plan within 30 days;

4. The approval process may include good faith discussion, evaluation, collection of information, and other efforts to resolve differences of opinion about the plan, so long as reasonable progress toward the development and approval of the operation’s AQMP is being made; and

5. If agreement on an operation’s AQMP cannot be reached after thorough good faith evaluation of alternatives and consideration of plan effectiveness, costs, and other pertinent matters, YRCAA may initiate compliance action, such as a notice of violation, assurance of discontinuance or corrective action order, only if a violation of regulation (not the policy) exists.

   The purpose of good faith negotiation is to share information and resolve differences of opinion regarding an operation’s AQMP. Both the operation and YRCAA need to be able to exchange information freely and in good faith. Information obtained by YRCAA in the course of negotiation is not obtained for the purpose of any future enforcement activity.
VII. How and What Changes Can be Made to an Approved AQMP?

An operation may make modifications to an approved AQMP as long as the modification(s) do not pose a potential to diminish the effectiveness of the plan. Substantive modifications to a plan must be documented, YRCAA must be notified of the changes, and YRCAA must approve the changes. Substantive modifications include but are not limited to:

1. significant changes in operational procedures;
2. changes in BMP selection, including discontinuance of any BMP; and
3. changes in criteria used to determine BMP implementation (as stated in the BMP operational plan).

Non substantive changes are changes which do not have the potential to diminish the effectiveness of an approved plan. Such changes may be made without notification to YRCAA, but must be included in the next annual AQMP update.

VIII. How Will the YRCAA Determine When an AQMP is Adequate?

In considering whether an AQMP is adequate to achieve the purpose of this policy, YRCAA may consider:

1. whether the plan utilizes BMPs identified in Appendix B of this policy;
2. the ability of the proposed BMPs to maintain conditions which adequately minimize emissions;
3. other measures in the plan which may be effective in minimizing emissions, but which are not recognized BMPs;
4. the adequacy of the operational plan, including the criteria used to begin, end and apply the proposed BMPs;
5. evidence that proposed measures have been effective in similar conditions; and
6. whether the plan addresses all requirements of Section V of this policy.

IX. How Will Compliance and Effectiveness of the AQMP be Determined?

1. Compliance - After an AQMP has been approved, YRCAA will conduct a full compliance evaluation, including a site visit, to determine if the BMPs and operational plans are in effect. Frequency of subsequent site visits will be determined as provided
in Subsection 5.5, Compliance Monitoring Strategy, YRCAA Administrative Code, Part B. Additional site visits may be conducted if requested by an operation. If evaluation determines that the AQMP is not fully implemented or reasonable precautions are not being taken to prevent emissions, YRCAA may initiate compliance action such as a notice of violation, assurance of discontinuance or corrective action order, only if a violation of regulation (not the policy) exists.

2. Effectiveness - After the plan is in place, results of the full compliance evaluation will be used to evaluate the effectiveness of the plan in reducing emissions. If results of the full compliance evaluation indicate that the plan is not effective in reducing emissions, YRCAA will request information from the operation or propose additional or alternative BMPs. As with the development of the initial plan, YRCAA and the operation will work together in good faith to revise the AQMP to increase its effectiveness in reducing emissions.

X. When and How Will This Policy Be Evaluated?

1. This policy will be evaluated as needed and no less frequently than every two years;

2. The evaluation of the policy will be conducted jointly by YRCAA staff and the Agricultural Task Force and will be based on its effectiveness at reducing air emissions and reasonableness of implementation; and

3. The YRCAA Board of Directors will approve any changes to the policy.
APPENDIX A  
STATUTORY AND REGULATORY REFERENCE

This Section is intended to provide the regulatory framework for Dairy operations. Other statutes or regulation may apply, but the references listed below have the most significant bearing on the industry.

A. STATUTORY AUTHORITY

1. The Washington Clean Air Act (the Act), RCW 70.94.011 states that it is public policy to preserve, protect and enhance the air quality for current and future generations and the intent is to protect human health and safety, including the most sensitive members of the population.

2. Dairy operations are sources of air pollution per RCW 70.94.030 and subject to the provisions of the Act except as exempted in Section 640.

3. RCW 70.94.141 empowers Local Authorities to:
   a. Adopt and amend its rules;
   b. Issue orders and take administrative actions to enforce the Act;
   c. Require access to information specific to the emission and control of air pollutants;
   d. Secure necessary scientific and technical services;
   e. Prepare and develop comprehensive plans to prevent and control air pollution;
   f. Encourage voluntary cooperation to achieve the purposes of the Act;
   g. Encourage and conduct studies, investigation and research relating to air pollution causes, effects, prevention, abatement and control; and
   h. Advise, consult and cooperate with agencies, departments, educational institutions, political subdivisions, industries, other states, inter-local agencies, the United States government, and with interested persons or groups.

4. RCW 70.94.151 authorizes local authorities to:
   a. Classify air pollution sources; and
   b. Require registration, reporting and payment of registration fees.

5. RCW 70.94.152 authorizes local authorities to require submittal of application to construct or modify an air pollution source and approve such application prior to construction or modification.

6. RCW 70.94.154 authorizes and describes a Reasonably Available Control Technology (RACT, as defined in 70.94.030(20)) determination.

7. RCW 70.94.380 mandates Local Authorities to have requirements for the control of air emissions that are no less stringent than those of the state.

B. STATE REGULATIONS

Dairy operations are sources of air pollution and are subject to the provisions of WAC 173-400 and WAC 173-460, which require controls to minimize emissions.

C. LOCAL REGULATIONS

YRCAA Regulation 1, Section 1.03 declares agency policy to implement the Washington Clean Air Act by:

1. Protecting human health and safety;
2. Preventing injury to plant and animal life and property;
3. Fostering comfort and convenience;
4. Promoting economic and social development;
5. Facilitating the enjoyment of natural attractions;
6. Preventing or minimizing the transfer of air pollution to other resources;
7. Ensuring equity and consistency with the Federal Clean Air Act (FCAA) and the Washington Clean Air Act (WCAA);
8. Educating and informing the citizens of Yakima County on air quality matters;
9. Maintaining accurate and current policies, regulations, and rules;
10. Performing administrative actions in a timely and effective manner;
11. Cooperating with the local governments, the Yakama Nation, organizations or citizens on air quality matters;
12. Developing strategies to avoid, reduce or prevent air pollution through innovative solutions, early planning and integration of air pollution control in the work of other agencies and businesses;
13. Preparing guidelines which interpret, implement and enforce regulations; and
14. Providing reasonable business and technical assistance to the community.

Section 1.04 declares that all activities, persons and businesses are subject to Regulation I, unless granted a variance or specifically exempted in the regulation.

Section 1.05 provides for the appointment of an advisory council to advise and consult with the Board.

Section 2.03 adopts and incorporates certain state and federal codes and regulations that may be applicable to dairy operations.

Section 3.00 requires operations and maintenance plans to prevent avoidable emissions.

Section 4.01 requires any source with a significant emission, as defined in Table 4.01-2 to register the source annually with the agency and pay the appropriate registration fee.

Section 5.02 provides for civil penalties to be assessed to any person who violates any of the provisions of YRCAA Regulation 1, the WCAA, any permit, order or condition of approval issued by the agency up to $12,000 per day per violation.
APPENDIX B – POLLUTANT-SPECIFIC BEST MANAGEMENT PRACTICES

The purpose of this Appendix is to present a list of best management practices (BMPs) as they apply to reducing emissions from specific air pollutants or pollutant groups. BMPs as they apply to specific dairy operation systems are presented in Appendix C.

General Principles

- The principle mechanism by which most BMPs operate is to maintain conditions which prevent emissions of pollutants addressed by the use of the BMPs; and
- Nothing in this policy should be construed to limit the ability of an Operation to be innovative or to use effective management practices that differ from those offered in this policy.

Following is a list of various BMPs for consideration in reducing emissions from each pollutant or pollutant group. The BMPs have not been prioritized for practicality, economic feasibility, ease of use, or efficacy. These are important factors to consider in the successful selection and implementation of BMPs.

I. Ammonia (NH$_3$)

NH$_3$ is formed when urea in the urine and the urease enzyme found in feces and manure laden soils are combined together. The reaction is very quick and the peak to volatilization is just several hours. Volatilization of NH$_3$ depends primarily on four factors: the protein (N) content in the feed, manure management strategies, the pH of the manure or soil, and the meteorology in general (i.e., temperature and wind speed, etc.). The lifetime of gaseous NH$_3$ is about 24 hours, after which time the NH$_3$ typically deposits near its source. This deposition can lead to eutrophication of surface water, airborne fertilization, and changes in ecosystems.

It is the objective of an NH$_3$ BMP to reduce NH$_3$ emissions and thus, its negative effects. Tradeoffs in NH$_3$ reductions must be carefully considered. Tradeoffs are actions which reduce emissions of one pollutant, but cause an increase in another pollutant emission. Tradeoffs could result due to things such as changes in pH or a shift to aerobic conditions. Therefore, the most effective method of reducing NH$_3$ is to target the source itself. In this case, the source is nitrogen (N) input into the dairy systems. BMPs which reduce NH$_3$ follow.

1. Reduce the amount of dietary protein (N) in the ration to match, rather than exceed, the animal’s needs.

2. Practice phase-feeding.

3. Ensure proper ventilation of freestall barns.

4. Bedding selection and management.

5. Treat recycled lagoon water used for flushing.

6. Remove and spread (harrow) manure frequently.

7. Modify alleyway floors.
8. Provide shade for cattle.
9. Locate feed and water opposite in pens.
11. Use straw bedding in drylot pens.
12. Incorporate wood chips in surface layer.
13. Urease inhibitors.
14. Surface moisture content.
15. Stock appropriate number of animals.
16. Use rotational grazing.
17. Move water and feeding areas frequently.
18. Irrigate pastures immediately after grazing.
19. Manure solids separation.
20. Lagoon or storage covers.
22. Reduce the pH of lagoons and manure piles.
23. Apply N fertilizer below no-till residue.
24. Inject or incorporate fertilizer into soil within 24 hours of application.
25. Apply nutrients according to agronomic recommendations based on soil test results.
26. Do not over-irrigate.
27. Utilize cover crops.
28. Apply during cool weather and on still rather than windy days.

II. Nitrous Oxide (N\textsubscript{2}O)

Emissions of N\textsubscript{2}O result from two different biological processes. There is a very small amount of N\textsubscript{2}O produced during nitrification (the biological aerobic process of converting ammonium to nitrate) though this source is relatively insignificant. The primary pathway of N\textsubscript{2}O formation is the anaerobic process of denitrification (the conversion of nitrate to N\textsubscript{2} or nitrogen gas), in which N\textsubscript{2}O is an obligatory intermediate product. Therefore, many of the emission reduction strategies are associated with minimizing these anaerobic conditions. BMPs which reduce N\textsubscript{2}O follow.
1. Reduce the amount of dietary protein (N) in the ration to match, rather than exceed, an animal’s needs.

2. Urease inhibitors.

3. Surface moisture content.

4. Stock appropriate number of animals.

5. Use rotational grazing.

6. Move water and feeding areas frequently.

7. Apply nutrients according to agronomic recommendations based on soil test results.

8. Do not over-irrigate.

9. Utilize cover crops.

III. Hydrogen Sulfide (H₂S)

H₂S is produced in anaerobic environments from the microbial reduction of sulfate or the decomposition of sulfur-containing organic matter in manure. Most atmospheric H₂S is oxidized to sulfur dioxide (SO₂), which is then either dry deposited or oxidized to aerosol sulfate and removed primarily by wet deposition. The residence time of H₂S and its reaction products is of the order of days. BMPs which reduce H₂S follow.

1. Properly manage and minimize overfeeding sulfur in the diet.

2. Bedding selection and management.

3. Surface moisture content management.


5. Lagoon or storage covers.


7. Surface aeration of lagoons.

8. Encourage purple sulfur bacterial formation in anaerobic lagoons.

9. Properly manage composted solid manure.

10. Properly manage stockpiled manure.
IV. Volatile Organic Compounds (VOC)

VOCs vaporize easily at room temperature and include fatty acids, nitrogen heterocycles, sulfides, amines, alcohols, aliphatic aldehydes, ethers, \( p \)-cresol, mercaptans, hydrocarbons, and halocarbons. The major constituents of dairy VOC emissions that have been identified include organic sulfides, disulfides, \( \text{C}_4 \text{ to } \text{C}_7 \) aldehydes, trimethylamine, \( \text{C}_4 \) amines, quinoline, dimethylpyrazine, and \( \text{C}_3 \) to \( \text{C}_6 \) organic acids, along with lesser amounts of aromatic compounds and \( \text{C}_4 \) to \( \text{C}_7 \) alcohols, ketones, and aliphatic hydrocarbons. Fresh manure and fermentation of feedstuffs have been identified as the primary sources of VOC emissions. BMPs which reduce VOC emissions follow.

1. Properly manage ensiled feedstuffs.
2. Store feed in a weatherproof storage structure.
3. Remove spilled and unused feed from feeding area on a regular basis.
4. Remove manure from barns frequently.
5. Modify alleyway floors.
6. Surface moisture content management.
7. Knock down and remove fence line manure.
8. Manure solids separation.
9. Lagoon or storage covers.
10. Surface aeration of lagoons.

V. Odor

Odor from dairies is not caused by a single species but is rather the result of a large number of contributing compounds including \( \text{NH}_3 \), VOCs, and \( \text{H}_2\text{S} \). Hundreds of compounds contribute to odor from a dairy. A further complication is that odor involves a subjective human response. Although research is under way to relate olfactory response to individual odorous gases, odor measurement using human panels appears to be the method of choice now and for some time to come. Since odor can be caused by hundreds of compounds and is subjective in human response, estimates of odor inventories are not currently possible. BMPs which reduce odor emissions follow.

1. Properly manage and minimize overfeeding sulfur in the diet.
2. Properly manage ensiled feedstuffs.
3. Store feed in a weatherproof storage structure.
4. Remove spilled and unused feed from feeding area on a regular basis.
5. Ensure proper ventilation of freestall barns.
6. Bedding selection and management.

7. Treat recycled lagoon water used for flushing.

8. Remove manure from barns and pens frequently.


10. Use straw bedding in drylot pens.

11. Incorporate wood chips in surface layer.

12. Surface moisture content management.

VI. Particulate Matter (PM)

This policy considers particulate matter as PM$_{10}$, PM$_{10}$, and PM$_{2.5}$. PM$_{10}$ is commonly defined as airborne particles with aerodynamic equivalent diameters (AEDs) more than 10 μm. PM$_{10}$ is commonly defined as airborne particles with AEDs less than 10 μm. Similarly, PM$_{2.5}$ refers to particles with AEDs less than 2.5 μm. Dairies can contribute directly to primary PM through several mechanisms, including: animal activity; animal housing fans; air entrainment from soil and manure; and indirectly to secondary PM by emissions of NH$_3$, NO, and H$_2$S, which are converted to aerosols through reactions in the atmosphere. Particles produced by gas-to-particle conversion generally are small and fall into the PM$_{2.5}$ size range. Key variables affecting the emissions of PM$_{10}$ include the amount of mechanical and animal activity on the soil-manure surface, the moisture content of the surface, and the fraction of the surface material in the 0-10 μm size range.

The diameter of PM is critical to its health and radiative effects. PM$_{2.5}$ can reach and be deposited in the smallest airways (alveoli) in the lungs, whereas larger particles tend to be deposited in the upper airways of the respiratory tract. Smaller particles are also most effective in attenuating visible radiation, causing regional haze. BMPs which reduce PM emissions follow.

1. Store feed in a weatherproof storage structure.

2. Remove spilled and unused feed from feeding area on a regular basis.

3. Do not mix feeds during windy times.

4. Ensure proper ventilation of freestall barns.

5. Provide shade for cattle.


7. Remove and spread (harrow) manure frequently.

8. Use straw bedding in drylot pens.

9. Incorporate wood chips in surface layer.

10. Surface moisture content management.
11. Properly manage composted solid manure.

12. Properly manage stockpiled manure.

13. Apply N fertilizer below no-till residue.

14. Utilize cover crops.

15. Apply during cool weather and on still rather than windy days.

16. Installation of windbreaks or shelterbelts.

VII. Oxides of Nitrogen (NO\textsubscript{X})

Nitrification in aerobic soils appears to be the dominant agricultural pathway to Nitric Oxide (NO). Direct emissions of NO from dairy manure are believed to be relatively minor, but a fraction of manure nitrogen applied to soils as fertilizer can be emitted as NO.

The fraction of fertilizer nitrogen released as NO depends on the amount and form of nitrogen (reduced or oxidized) applied to soils, the vegetative cover, temperature, soil moisture, and agricultural practices such as tillage. A small fraction of other reduced nitrogen compounds in animal manure can also be converted to NO by microbial action in soils.

NO and nitrogen dioxide (NO\textsubscript{2}) are rapidly interconverted in the atmosphere and the sum of all oxidized nitrogen species (except N\textsubscript{2}O) in the atmosphere is often referred to as NO\textsubscript{X}. The residence time of NO\textsubscript{X} is of the order of days in the lower atmosphere, with the principal removal mechanism involving wet and dry deposition. In terms of environmental effects, NO\textsubscript{X} is an important (and often limiting) precursor in tropospheric ozone (O\textsubscript{3}) production. Furthermore, NO\textsubscript{3}\textsuperscript{-} aerosol is a contributor to PM2.5, and nitrogen deposition in the forms of HNO\textsubscript{3}, and aerosol NO\textsubscript{3}\textsuperscript{-} can have ecological consequences.

NO\textsubscript{X} is also emitted as a result of combustion processes (especially at higher temperature combustion), primarily as NO and NO\textsubscript{2}. Since nitrification in soils is important to soil health and crop production, no BMPs are presented to reduce NO\textsubscript{X} emissions caused by nitrification in soils. Following are BMPs which reduce combustion-caused emissions of NO\textsubscript{X}.

1. Replace or retrofit older internal combustion engines.

2. Utilize alternatives to outdoor burning.

VIII. Methane (CH\textsubscript{4})

CH\textsubscript{4} is produced by microbial degradation of organic matter under anaerobic conditions. The primary source of CH\textsubscript{4} from livestock production is enteric fermentation in ruminant animals. Ruminants (sheep, goats, camels, cattle, and buffalo) have unique, four-chambered stomachs. In one chamber, called the rumen, bacteria break down grasses and other feedstuff and generate CH\textsubscript{4} as one of several byproducts. The production rate of CH\textsubscript{4} is affected by energy intake, which is in turn affected by several factors such as quantity and quality of feed, animal body weight, and age.
CH$_4$ is also emitted during anaerobic microbial decomposition of manure. The most important factor affecting the amount produced is how the manure is managed, because some types of storage and treatment systems promote an oxygen-depleted (anaerobic) environment. Metabolic processes of methanogens lead to CH$_4$ production at all stages of manure handling. Liquid systems tend to encourage anaerobic conditions and produce significant quantities of CH$_4$, while more aerobic solid waste management approaches may produce little or none. Higher temperatures and moist conditions also promote CH$_4$ production.

Methane is destroyed in the atmosphere by reaction with the hydroxyl (•OH) radical. Because of its long residence time (~8.4 years), CH$_4$ becomes distributed globally. Methane is a greenhouse gas and, under certain conditions, contributes to global warming with a potential 23 times that of CO$_2$. Following are BMPs which reduce emissions of CH$_4$.

1. Increase the level of starch in the diet.
2. Surface moisture content management.
4. Lagoon or storage covers.
5. Scrub exhaust of enclosed waste containers.
6. Installation of an anaerobic digester.
7. Reduce the pH of lagoons and manure piles.
8. Properly manage composted solid manure.
APPENDIX C – SYSTEM-SPECIFIC BEST MANAGEMENT PRACTICES

The purpose of this Appendix is to present a list of BMPs as they apply to reducing emissions from specific dairy systems.

I. Nutrition

1. Reduce the amount of dietary protein (N) in the ration to match, rather than exceed, the animal’s needs.

2. Increase the level of starch in the diet.

3. Properly manage and minimize overfeeding of sulfur in the diet.

4. Practice phase-feeding.

II. Feed Management

1. Properly manage ensiled feedstuffs.

2. Store feed in a weatherproof storage structure.

3. Remove spilled and unused feed from feeding area on a regular basis.

4. Do not mix feed during windy times.

III. Milk Parlor

1. Ensure proper ventilation.

2. Use recycled parlor (clean) water used for flushing/cleaning holding areas.

3. Treat recycled water used for flushing/cleaning holding areas.

4. Remove manure from holding areas frequently.

IV. Housing – Freestall Barns

1. Ensure proper ventilation of freestall barns.

2. Bedding selection and management.

3. Treat recycled lagoon water used for flushing.

4. Remove manure from barns frequently.

5. Modify alleyway floors to separate urine and feces.
V. Housing – Drylot Pens

1. Provide shade for cattle.

2. Locate feed and water opposite in pens.

3. Remove and spread (harrow) manure frequently.

4. Use straw bedding in drylot pens.

5. Incorporate wood chips in surface layer.

6. Urease inhibitors.

7. Surface moisture content management.

8. Knock down and remove fence line manure.

VI. Grazing Management

1. Stock appropriate number of animals.

2. Use rotational grazing.

3. Move water and feeding areas frequently.

4. Irrigate immediately after grazing.

VII. Manure Management

1. Manage solids separation.

2. Lagoon or storage covers.


4. Installation of an anaerobic digester.

5. Surface aeration of lagoons.

6. Reduce the pH of lagoons and manure piles.

7. Encourage purple sulfur bacterial formation in anaerobic lagoons.

8. Properly manage composted solid manure.

VIII. Land Application – Manure and/or Chemical Fertilizer

1. Apply N fertilizer below no-till residue.

2. Inject or incorporate fertilizer into soil within 24 hours of application.

3. Apply nutrients according to agronomic recommendations based on soil test results.

4. Do not over-irrigate.

5. Utilize cover crops.

6. Apply during cool weather and on still rather than windy days.

7. Installation of windbreaks or shelterbelts.
APPENDIX D - DESCRIPTIONS OF BEST MANAGEMENT PRACTICES (BMPs) FOR AIR EMISSION REDUCTION ON DAIRY OPERATIONS

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The purpose of this document is to present brief descriptions of available best management practices (BMPs) for controlling air emissions from dairy operations. The descriptions are presented in a system-specific manner which includes Nutrition, Feed Management, Housing (Freestall Barns), Housing (Drylot Pens), Grazing, Manure Management, and Land Application (Fertilizer and Manure). Not all components or BMPs presented here may apply to your farm. Pollutants impacted by each BMP are presented in parenthesis. These descriptions are not intended to provide detailed information as to how the BMPs should be implemented. It is expected that exact implementation will vary from farm to farm. When applicable, tradeoffs, limitations, or both are listed for each BMP.


I. Nutrition

1. Properly Manage Level of Dietary Protein (%CP) in Diet to Match, Rather Than Exceed, an Animal’s Needs (NH₃, N₂O, Odor)

The most effective and practical way of reducing NH₃ emissions is through proper feeding of dietary nitrogen (N). In the diet, the primary source of N is protein. Excess dietary nitrogen is excreted in the urine as urea, which reacts with the fecal enzyme urease and volatilizes as NH₃. In general, available research data has demonstrated that properly managed feeding of dietary protein N will result in an NH₃ reduction. Studies show that the maximum nitrogen retention efficiency in cows is approximately 50% (1), with the typical efficiency at 38%, so small changes can have a big effect. For example, reducing the protein in the diet from 19 to 14% has shown to reduce urinary urea excretion and subsequent NH₃ emission by 33% (2), with no reduction in milk production. The recommended level of CP in the diet is approximately 16%, with considerations made for MUN and herd efficiency factors.

Added advantages of ensuring proper levels of protein in the diet, in addition to reducing NH₃ emissions, include: 1) reduced operating costs considering protein is the most expensive component of the feeds, 2) healthier animals, and 3) improved nitrogen to phosphorus (N:P) ratio for crops when manure is applied to crop land.

2. Increase the Level or Quality of Starch in the Diet (CH₄)

Increasing the level of starch or rapidly fermentable carbohydrates in the diet impacts the rumen pH and microbial population, both of which regulate methane production (3, 4). Since methane emission is the byproduct of incomplete digestion, higher quality diets will allow animals to better digest their feed, be more efficient, and decrease methane production potential. The recommended level of starch in the diet is approximately 23-26%.

3. Properly Manage and Minimize Overfeeding Sulfur in the Diet (H₂S, Odor)

A reduction in sulfur intake to maintenance levels will decrease excretion of sulfur compounds and thus, the emission of odorous gases such as hydrogen sulfide (H₂S). The recommended level of sulfur in the diet is 0.2-0.4% depending on stage of growth or lactation.
4. Practice Group and/or Stage of Lactation Feeding (NH₃)
Group feeding is the separation of cattle into groups (i.e., high milk cows, low milk cows, dry cows, heifers, and calves) based on the dietary needs of each group. The goal is to feed only the necessary nutrient levels, such as protein, for growth and/or milk production to each group. Phase-feeding is very effective in reducing NH₃ emissions because it matches the protein needs of each group more precisely without over or under feeding a nutrient to the whole herd. Phase feeding is synonymous with precision feeding and is both environmentally responsive and economical.

II. Feed Management

1. Properly Manage Ensiled Feedstuffs (VOC, Odor)
Due to the release of low molecular weight organic compounds during fermentation, silage has been found to be a significant source of volatile organic compounds (VOCs), which are responsible for odor in livestock operations. Properly covering, confining, and reducing the release of VOCs from silage storage can result in significant reduction of VOCs and odor emissions. Covered silage piles need to be properly managed during access to minimize VOCs emissions. The primary method of achieving this is to minimize the surface area of the face and the duration of face exposure where and when feed is accessed, respectively. The access face should be covered immediately after the required amount of silage has been obtained.

2. Store Feed in a Sheltered Storage Structure (VOC, Odor, PM)
Since moisture is primary to fermentation and fermentation primary to VOC and odor emission, it is important to minimize the potential for feed becoming wet via rainwater. Weatherproof storage will prevent feed from becoming wet and diminish the potential for spoilage and fermentation. Store feed in a covered bunker with proper drainage, or cover exposed feed piles during the wet season. A feed bunker covered on three sides will also reduce PM emission by limiting wind exposure to and erosion of the pile.

3. Regularly Remove Spilled and Unused Feed from Feeding Area (VOC, Odor, and PM)
Spilled and unused feed is a source of VOC, odor, and PM emissions. Removal of such feed from the storage and loading areas at least every two weeks, or more frequently during wet periods, will significantly diminish the potential for VOCs, odor, and PM emissions.

4. Manage or Minimize the Mixing of Feed During Windy Times (PM)
Mixing, grinding, and chopping of feed during windy times can be a significant source of PM emissions, as well as a waste of feed. Avoiding such activities, or performing them in a sheltered area during wind events, will diminish the potential for PM emission and subsequent transport from the feed processing area.

III. Milk Parlor

1. Ensure Proper Ventilation (NH₃, Odor, and PM)
Temperature is a very important factor in the rate of NH₃ volatilization. As the ambient temperature increases, NH₃ emission increases. Studies show that an increase in ambient housing temperature from 50 to 75°F results in a 46% increase in NH₃ emissions (5). Thus, reducing the temperature inside of enclosed parlor and holding areas with proper ventilation and/or cooling reduces the NH₃ volatilization potential and reduces animal health effects, which can lower milk
production. Odor and PM emissions are likewise reduced by this BMP by circulating air and removing stagnant odor and airborne PM from the enclosed areas.

2. **Use Recycled Parlor (Clean) Water Used for Flushing/Cleaning Parlor (NH₃, Odor)**

Using clean water, recycled parlor water, or most dilute water from a multi-stage lagoon system will decrease the reintroduction of odorant materials and reduce emissions. Recycling concentrated liquid manure through the holding area may increase both NH₃ and odor emissions and should be avoided.

3. **Treat Recycled Water Used for Flushing/Cleaning Holding Area (NH₃, Odor)**

For holding pens and parlors that practice flushing as a means of manure removal, treatment in the form of additives that discourage NH₃ hydrolysis (i.e., pH reducers, urease inhibitors, or biological additives) can help reduce ammonia and odor emissions.

4. **Remove Manure from Holding Area Frequently (NH₃, VOC, Odor)**

Ammonia volatilization is a function of the mixing time of manure on the stall floor right after it is deposited. The production of NH₃ begins immediately and peaks only a few hours after mixing. Odor and VOC production also occurs immediately after manure deposition and continues until removal. Thus, an effective way of reducing emissions from parlors and holding areas is by removing manure at frequent intervals.

Typically, manure removal from parlors and holding areas is performed with a flush system. Studies have shown that a flush system is more effective at reducing NH₃ volatilization over a scrape system, and that more frequent manure removal, every 2-4 hours, reduces odor and NH₃ (6). Whether using a flush or scrape system, the most effective system is one that removes all manure from the alleyway without leaving piles on the edges or reducing it to a film on the surface. These inefficiencies can lead to an increase in NH₃ volatilization via increased mixing and surface exposure. This BMP is also effective in reducing, VOC, and odor emissions.

**IV. Housing – Freestall Barns**

1. **Ensure Proper Ventilation of Freestall Barns (NH₃, Odor, and PM)**

Temperature is a very important factor in the rate of NH₃ volatilization. As the ambient temperature increases, NH₃ emission increases. Studies show that an increase in ambient housing temperature from 50 to 75°F results in a 46% increase in NH₃ emissions (5). Thus, reducing the temperature inside of freestall barns with proper ventilation and/or cooling of the barns reduces the NH₃ volatilization potential and reduces animal heat stress, which can lower milk production. Odor and PM emissions are likewise reduced by this BMP by circulating air and removing stagnant odor and airborne PM from the barn.

2. **Bedding Selection and Management (NH₃, H₂S, Odor)**

The use of non-absorbent bedding materials may help reduce NH₃ and odor emissions when managed well. The most common bedding materials used in dairy barns include: sand, wood shavings, chopped straw, and recycled manure. Among these listed materials, studies have shown, for example, that sand-bedding results in the lowest NH₃ emissions when managed correctly (scraped daily, restocked weekly, and completely cleaned out annually). Sand is non-absorbent and allows urine to infiltrate through it, which reduces urine’s contact time with ambient air. In contrast, composted manure-bedding does not allow urine to percolate through and, therefore, results in higher ammonia emissions than sand-bedding.
In general, however, proper management of any type of bedding including: frequent restocking, daily removal of solid manures, and annual bed change, will significantly reduce the potential of NH$_3$ volatilization from all bedding types. Hydrogen sulfide, which can form under anaerobic bedding conditions, and odor emissions are similarly reduced by this BMP. Most of all, keeping cows from defecating on the bedding material through proper sizing of freestalls has a significant reduction in emission potential by eliminating manure deposition on the beds in the first place.

3. Treat Recycled Lagoon Water Used for Flushing (NH$_3$, Odor)

For barns that practice flushing as a means of manure removal from alleyways, treatment in the form of solids removal or use of additives that discourage NH$_3$ hydrolysis (i.e., pH reducers, urease inhibitors, or biological additives) can help reduce ammonia and odor emissions. Using the cleanest or most dilute water from a multi-stage lagoon system will decrease the reintroduction of odorant materials and reduce emissions as well. Recycling concentrated liquid manure through the barn may increase both NH$_3$ and odor emissions and should be avoided.

Tradeoffs/Limitations: Infrastructure and additive cost.

4. Remove Manure from Barns Frequently (NH$_3$, VOC, Odor)

Ammonia volatilization is a function of the mixing time of manure on the stall floor right after it is deposited. In addition, the thin-spread manure provides more surface area, which exacerbates the respective emissions. The production of NH$_3$ begins immediately and peaks only a few hours after mixing. Odor and VOC production also occurs immediately after manure deposition and continues until removal. Thus, an effective way of reducing emissions from barns is by removing the manure at frequent intervals (every 2 to 4 hours (6)).

5. Manure Removal Technology and Efficiency (NH$_3$, VOC, Odor)

Typically, manure removal is performed with a scrape or vacuum system at milking times when cattle are out of the barn, but can occur more frequently with the use of a flush system or automatic scrapers. Studies have shown that a flush system is more effective at reducing NH$_3$ volatilization over a scrape system, and that more frequent manure removal, every 2 to 4 hours, reduces odor and NH$_3$ (6). However, the most effective system is one that removes all manure from the alleyway without leaving piles on the edges or reducing it to a thin film on the surface. These inefficiencies can actually lead to an increase in NH$_3$ volatilization via increased mixing and surface exposure. This BMP is also effective in reducing, VOC, and odor emissions.

6. Alleyway Floor Texture and Type (NH$_3$, VOC, Odor)

In freestalls, most manure is excreted in alleyways where the mixing rate is highest. Minor changes or modifications to the floor surface that reduce the contact time of urine and feces could make a significant difference in NH$_3$ emission. Modification to a 3% sloped floor, over a level (0%) one, encourages transport of urine away from solid manure and could reduce NH$_3$ emission by 21% (7, 8). A double slope with a gutter in the middle to trap the urine could reduce emission by 50% compared to solid floors (7). Grooved concrete floors that allow urine to collect in channels will help in reduction of NH$_3$, since the main objective is to separate the urine from the feces and reduce contact time. Besides reducing emission potential, surface texture or permeable matting will aid in traction and increased hoof health. This BMP is also effective in reducing, VOC and odor emissions.

Tradeoffs/Limitations: Modification with this BMP may not be possible for existing barns. New construction should consider these guidelines.
V. Housing – Drylot Pens

1. **Provide Shade for Cattle (NH\textsubscript{3}, PM)**

Ammonia volatilization is dependent on the mixing of urea and the urease enzyme from urine and feces, respectively. By spreading out the distribution of urine and feces over the pen surface, the mixing potential is reduced. The installation of a shade structure in the center of the pen will aid in distribution of defecation events as the animals follow the shade during the day, dispersing manure and reducing the opportunity for mixing. This also helps to control course PM by more uniform surface wetting and compaction, and aids in reduction of animal heat stress.

2. **Sitting of Water Trough Within Pen (NH\textsubscript{3}, PM)**

Placing the water-trough and feed bunk at opposite sides of the pen, or rotating the locations (when applicable), helps to spread feces and urine over a larger area of the pen surface, reducing the opportunity for mixing. This also helps to control coarse PM by more uniform surface wetting and compaction. Conversely, locating the water trough near the feed bunk concentrates surface wetting to a collected area (i.e., feed alley) and limits the movement of animals across a potentially dry pen, thus limiting course PM production.

**Tradeoffs/Limitations:** This BMP may not be possible for all pen designs.

3. **Remove and/or Spread (Harrow) Manure Frequently (NH\textsubscript{3}, PM)**

Ammonia emissions from open drylot pens are due to infrequent manure removal. There are two types of in-pen manure management: (i) spreading or harrowing, and (ii) complete manure removal. In general, manure in drylot pens should be completely cleaned out every one to three months. The reduction in the quantity of manure results in less ammonia volatilization and also minimizes PM (dust) production from animal hoof action on the loose manure pack. More frequent (monthly, weekly) removal of manure from areas where manure deposition is highest (i.e., sleeping areas, feed bunks) is desirable. Installation of concrete alleyways adjacent to feed-bunks aids in daily collection of manure and further reduces ammonia volatilization potential. The daily harrowing of pens should be practiced to spread out the manure pack, but should only be done during times of the day when PM production will not be an issue, such as the early morning.

4. **Use Straw Bedding in Drylot Pens (NH\textsubscript{3}, PM, Odor)**

The application of a layer of straw bedding to drylot pens is commonly used as a wintertime management tool to reduce pen wetness and provide animals with a dry layer. However, the addition of straw bedding also aids in the separation of urine and feces to reduce ammonia volatilization, and in reduction of particulate (PM) production from the pen surface. This practice can be utilized year-round for increased ammonia, PM, and odor reductions.

5. **Incorporate Wood Chips into Surface Layer (NH\textsubscript{3}, PM, Odor)**

Incorporating woodchips (1/2 inch diameter average) into the pen surface layer will manage moisture content and encourage aeration of the manure pack. The increase in aeration reduces ammonia, odor, and PM. Woodchips should be placed approximately four inches thick in areas where animals tend to congregate and/or deposit manure (i.e., sleeping areas, under shades, near feed-bunks). These areas should also be harrowed daily to encourage aeration and reduce compaction of the surface layer, and restocked with woodchips as needed.

Additionally, if manure is harvested from pens for composting, the addition of woodchips to the pen increases the carbon content of the compost and eliminates the extra step of adding and mixing the woodchips later in the process.
5. **Urease Inhibitors (NH$_3$, N$_2$O)**

Reduction of NH$_3$ from drylot pens can be achieved through enzymatic treatment with urease inhibitors, which inhibit the urease enzyme in feces from reacting with urea and volatilizing as NH$_3$. Several inhibitors are available such as N-(n0butyl) thiophosphoric triamide (NBPT), which is the most effective in preventing the hydrolysis of urea. Urease inhibitors can either be fed to cattle in feed rations or surface applied to the pen surface. Similar to surface acidifiers, urease inhibitor effectiveness is highly variable and can be very costly to achieve significant reductions. This BMP is also relatively effective in reducing N$_2$O emissions by limiting nitrification.

**Tradeoffs/Limitations:** Can be very expensive to install and maintain effectiveness of surface treatments.

7. **Surface Moisture Content Management (NH$_3$, N$_2$O, VOC, Odor, CH$_4$, H$_2$S, Odor, PM)**

Over-application of water on a dry pen surface activates the hydrolysis and nitrification process, leading to ammonia volatilization and nitrous oxide “bursts”, respectively. Water should only be applied to pen surfaces as a dust (PM) mitigation tool and be applied such that it forms a cohesive moist layer on the surface, but does not penetrate too deeply into the surface. The dust (PM) from a dry pen is inversely proportional to the pen surface moisture content. Increasing the pen-surface moisture content binds surface manure and soil particles to limit the production of dust. Too much moisture, however, encourages the production of odorous compounds. A compromise surface moisture level of approximately 28% has been suggested to balance odor and dust (10). Maintaining this moisture level can be accomplished through regular water application, surface bonding additives, use of straw or wood chips to the surface layer, construction of a shade structure, and pen layout and design. This practice requires routine monitoring of surface moisture content.

On the extreme end, standing water should also be avoided. Standing water promotes anaerobic conditions, which are responsible for odor, CH$_4$, H$_2$S, and VOC emissions. Standing water can be mitigated by grading pens to a minimum 3% slope to channel water away from the pen and into a collection area. Contained runoff can then be treated or land applied. Daily harrowing of pens, filling of holes, and center piling will reduce pen conditions that encourage surface-ponding.

8. **Knockdown and Remove Fence Line Manure (NH$_3$, VOC, Odor)**

Over time, manure builds up along fence lines. This build-up of manure along fence lines provides opportunity for anaerobic decomposition (odor) and fly proliferation. Manure should be knocked down and either spread or removed when build-up is greater than 12 inches deep.

VI. **Grazing Management**

1. **Stock Appropriate Number of Animals (NH$_3$, N$_2$O)**

Overstocking of cattle increases NH$_3$ volatilization from pastures by increasing the concentration of manure on the field and reducing the amount of plant cover and N uptake. Stocking animals at appropriate rates and intervals for each field will reduce over application of manure and maintain pastures.

2. **Use Rotational Grazing (NH$_3$, N$_2$O)**

Practicing rotational grazing will help maintain pasture forage growth and health, which will maximize plant uptake of manure and reduce the potential of NH$_3$ or N$_2$O emission. Pastures
should be evaluated on a regular basis for plant height and quality, and animals should be removed when plants are less than three inches in height or stem density is less than 85%.

3. Move Water and Feeding Areas Frequently (NH$_3$, N$_2$O)

Since the volatilization of NH$_3$ is dependent on the mixing of urine (urea) and feces (urease), dispersing these events evenly over a pasture surface can help reduce NH$_3$ volatilization. Animals on pasture tend to concentrate elimination behaviors around the water trough, feeding, and/or sleeping areas. Studies show that the number of elimination events that occur in a location is highly correlated with the time spent at the location (18). Therefore, distribution of manure deposition can be effected via management and layout of the pasture environment. Moving water-troughs and feed-stations periodically to new locations will disperse cattle activity and thus manure deposition. This will also prevent plant suffocation and trampling in heavily populated areas of the pasture.

4. Irrigate Immediately after Grazing (NH$_3$)

Irrigating pastures following grazing will help incorporate manure into the soil and reduce ammonia volatilization potential. Over irrigation can, however, increase NH$_3$ volatilization and N$_2$O emission.

VII. Manure Management

1. Manure Solids Separation (NH$_3$, VOC, Odor, H$_2$S, CH$_4$)

Solid separation is the removal of the solid portion of the manure waste stream from the liquid portion. The liquid portion is transferred to the storage vessel (i.e., lagoon, tank) and the solid portion is stockpiled, composted, or land applied. Solid separation systems include: screens, rotary drums, centrifugal tanks, earthen pits, weeping walls, settling basins, screw-presses, and others. Approximately 25% of the total manure N is removed with the solids (1); the remaining N stays with the liquid portion of the manure. Solid separation reduces potential of NH$_3$, VOC, Odor, H$_2$S, CH$_4$ emissions from post-separation liquid storages.

2. Lagoon or Storage Covers (NH$_3$, H$_2$S, VOC, Odor, CH$_4$)

The emission rate from the surface of a lagoon is influenced by environmental factors such as ambient temperature, relative humidity, surface wind velocity, and precipitation. To control the effects of these factors, addition of a cover to the lagoon is necessary. Lagoon covers range from floating plastics, synthetic or natural peat, straw, polystyrene, and natural dry matter. When properly installed and managed well, any of these covers can reduce NH$_3$ losses by 80-90% (1), in addition to controlling odor, H$_2$S, and CH$_4$ losses. Any cracks in the cover should be taken care of immediately because they will compromise the efficiency of the cover.

The establishment of a natural crust on the lagoon surface, typically formed by the movement and cohesion of solids to the lagoon surface, can reduce ammonia losses by up to 50% (11). The formation of a natural crust will occur when the lagoon has a high solids-content, the ambient air is dry, and there is little precipitation to break the crust. While natural covers can reduce NH$_3$ and H$_2$S emissions, they need to be monitored for odor, which can emanate from the crust itself.

In general, covers must be checked regularly and maintained to prevent leakage and loss of pollutants from the cover. Secondary treatment methods of captured gas either via biofilters, flaring, scrubbing, or other method should be maintained and operated effectively to minimize emission of untreated pollutants.

Tradeoffs/Limitations: Cost and maintenance time of covers can be high.
3. **Scrub Exhaust of Enclosed Waste Containers (CH₄, Odor, H₂S)**

Using bio-filters to scrub the exit air from enclosed manure storage facilities can significantly reduce NH₃, H₂S, odor, and CH₄ emissions. Bio-filters vary in style, function, and effectiveness. A technical assistant is necessary to design and implement this BMP effectively.

**Tradeoffs/Limitations:** This practice requires technical assistance to install and maintain.

4. **Proper Operation and Maintenance of Anaerobic Digester (CH₄)**

Anaerobic digestion (AD) converts manure into biogas (CH₄ and CO₂), which can subsequently be used for providing energy or heating on the dairy or for sale back into the electric grid. The two common types of digesters found on dairy operations are the plug flow type or the complete mixed digesters. The former is more appropriate for operations with scrape manure systems, while the latter is more suitable for dairies with manure flushing systems. The overarching goal of AD is to reduce methane emission from manure. Other gases produced during AD (H₂S, CO₂) can be scrubbed from the exhaust to provide natural, gas grade CH₄. Although AD reduces CH₄, H₂S, and odor emissions from AD effluent, the digestion process increases the ammonia volatilization potential from the AD effluent. This BMP requires technical assistance and has a high cost associated with installation and operation.

**Tradeoffs/Limitations:** Increases ammonia volatilization potential from effluent; high cost of installation; and requires technical assistance to install and operate properly.

5. **Surface Aeration of Lagoons (NH₃, H₂S, VOCs)**

The biodegradable organic materials in manure can be oxidized to stable end products by aerobic bacteria. These microorganisms require oxygen to affect this process. In general, if enough oxygen is provided, the end products of aeration are odor-free. The main problem is the cost of providing adequate oxygen for this process.

To reduce the cost of aeration, surface aeration is suggested as a method for mitigation of odor and other gases from anaerobic lagoons, which are released from incomplete manure decomposition. Surface aeration can complement anaerobic digestion by acting as a biological-blanket, aerobically degrading odorous compounds from the layer of anaerobic decomposition below. The aerobic bacteria in this blanket consume odorous volatile compounds and releases odor-free gases into the air. For example, this layer oxidizes ammoniacal nitrogen (NH₄⁺, NH₃) into nitrate (NO₃⁻), and oxidizes sulfur containing compounds such as H₂S into elemental sulfur (S) or sulfates (SO₄²⁻). This process thus mitigates emissions of NH₃ and H₂S as well other volatile organic odorous compounds that may try to escape from the anaerobic zone below the aerobic blanket.

**Tradeoffs/Limitations:** High cost associated with running aerators; reduced effectiveness in lagoon with high solids content.

6. **Reduce the pH of Lagoons and Manure Piles (NH₃, CH₄)**

The pH of stored manure, liquid or solid, greatly affects the rate of H₂S and NH₃ volatilization. If the pH of liquid manure stored in a lagoon or tank is maintained above 8 (basic), ammonia volatilization increases and losses may be up to 70% of the total nitrogen entering the lagoon (1). Additionally, in solid manure, the urease enzyme is very active at a pH between 6.8 and 7.6, amplifying the volatilization process from manure piles. At a pH below 6 (acidic), NH₃ is bound in solution or tied-up and little NH₃ volatilization will occur from liquid or solid manure, respectively. Methane emission is also reduced at a pH below 6.5. On the other hand, low pH in the lagoon may result in elevated H₂S emissions and loss of efficiency of the anaerobic process, which may result in increased odor emissions. Reduction of manure pH in lagoons and manure piles is achieved by addition of acidifying compounds such as alum or acids. However, due to the
natural buffering capacity of manure, large amounts of acidifiers are required to reduce pH and frequent monitoring is necessary. 

Tradeoffs/Limitations: Decrease ammonia and methane, but increases hydrogen sulfide and odor production; high cost; and only effective over short-periods.

7. **Purple Sulfur Bacterial Formation in Lagoons (H\textsubscript{2}S, Odor)**

Purple sulfur bacteria (PSB) are photosynthetic, anaerobic bacteria that grow in the presence of carbon dioxide (carbon source), nitrate (nitrogen source), and hydrogen sulfide (13). Purple sulfur bacteria oxidize the hydrogen sulfide in the lagoon for photosynthesis and produce elemental sulfur or sulfate as a photosynthetic by-product (14), both of which are less odorous than hydrogen sulfide. Since PSB are photosynthetic, the use and/or optimization of a solid separator can aid in light penetration and the proliferation of PSB in a lagoon. The conditions conducive to natural PSB formation are an anaerobic lagoon with low solids content and a pH in the 7.0 to 8.5 range (15). Population of PBS in a lagoon is very difficult to induce and typically happens naturally. Therefore, maintenance of an existing population is the most effective H\textsubscript{2}S reduction method for lagoons.

**Tradeoffs/Limitations:** PSB conditions decrease hydrogen sulfide and odor production, but may increase ammonia volatilization; difficulty in inducing PSB formation.

8. **Properly Manage the Composting of Solid Manure (H\textsubscript{2}S, Odor, PM, CH\textsubscript{4})**

The effectiveness of the composting process is highly dependent on good management of pile characteristics including temperature, moisture, carbon to nitrogen ratio (C:N), and aeration. Low temperature, high moisture, and low aeration will lead to anaerobic conditions inside the manure pile and increase odor, H\textsubscript{2}S, and CH\textsubscript{4} emissions. A shift from anaerobic to aerobic process can cause a nitrification/denitrification cycle that can increase N\textsubscript{2}O losses. Low C:N (below 12:1), high temperature, and high aeration of the compost pile will increase NH\textsubscript{3} volatilization, which can be up to 90\% total N loss under these conditions (12). Low moisture will increase PM emissions. A C:N above 12:1, and optimally around 30:1, will have reduced NH\textsubscript{3} emissions, while still supporting an active composting process.

9. **Properly Manage Stockpiled Manure (H\textsubscript{2}S, Odor, PM)**

Stockpiled manure can easily become anaerobic from compaction, too much moisture, or organic matter breakdown if not managed properly. Anaerobic piles will emit odor, H\textsubscript{2}S, and CH\textsubscript{4}. Stockpiles should be stored in a covered area to avoid over saturation with rainwater, or periodically turned to decrease compaction and achieve even moisture levels throughout the pile.

**VIII. Land Application – Manure and/or Chemical Fertilizer**

1. **Apply N Fertilizer Below No-Till Residue (NH\textsubscript{3}, PM)**

The practice of no-till crop harvesting is beneficial in reducing soil erosion from wind (PM) and water transport, and increasing or maintaining soil tilth. The stubble left behind creates a surface cover that helps protect against soil loss. When applying fertilizer the following year to new crops, the fertilizer should be applied under the crop residue, not on top. Applying fertilizer on top of the residue increases exposure to ambient conditions and NH\textsubscript{3} volatilization losses.

2. **Inject or Incorporate Fertilizer/Manure into Soil within 24 Hours of Application (NH\textsubscript{3}, Odor)**

All fertilizer or manure should be injected, incorporated, or applied as close to the ground surface as possible to mitigate NH\textsubscript{3} and odor emissions. Nitrogen applied to crop land is susceptible to
volatilization if left on the soil and leaf surfaces, or sprayed from some height above the soil surface. Incorporation of manure immediately after application (within 24 hours) via chisel or irrigation (or precipitation event under 0.15 inches) is suggested for annual crop fields and can reduce ammonia losses by up to 98% (1). Application of manure with an aerator, sleighfoot or other below leaf canopy surface applicator (i.e., drop hose irrigation) is recommended for forage fields to reduce NH$_3$ and odor. All of these methods work by moving fertilizer and/or manure into the soil profile away from the surface where volatilization and odor emissions occur. In addition to reducing emission losses, this method conserves more nitrogen in the soil, increasing efficiency and reducing fertilizer costs.

Application of manure using a “big gun” or overhead sprinkler has the highest rate of ammonia loss out of all application methods. The sprinkler exposes more manure surface area to the ambient air, allowing a significant portion of the total nitrogen to be volatilized as NH$_3$ before the liquid manure even reaches the soil surface. Furthermore, sprinkler application also enhances transport and dispersion of emissions especially during windy conditions. Broadcast application, which also exposes manure surface area to the ambient air, also has high NH$_3$ losses (20 to 30% of total N) if not immediately followed by manure-incorporation.

For certain crops, controlled-release fertilizers or fertigation is an effective way to deliver chemical fertilizer to the plants at specific rates and times. This is an effective way to match crop needs and fertilization delivery to reduce the amount of N available for volatilization. These are more costly methods and require installation of necessary irrigation infrastructure.

**Tradeoffs/Limitations:** Deep injection of manure decreases NH$_3$ volatilization, but may increase N$_2$O emissions via denitrification.

3. **Apply Nutrients According to Agronomic Recommendations Based on Soil and Manure Test Results (NH$_3$, N$_2$O)**

Application of chemical fertilizer and manure nutrients should always be made at agronomic rates to avoid excess application that exacerbates N losses. Agronomic application is the application of nutrients to meet crop needs. Agronomic application rate is determined by knowing the nutrient content of the soil (soil test), the nutrient content of the manure (manure test), and the crop nutrient needs at the time of application (estimated or historical value). By matching crop needs to available nutrients, over application of nitrogen and subsequent NH$_3$ and N$_2$O emission can be avoided. A nutrient planner can help determine agronomic rate and plan annual applications to match crop needs.

4. **Do Not Over-irrigate (NH$_3$, N$_2$O)**

Irrigation increases soil water content and may increase N$_2$O emissions when over applied by promoting anaerobic conditions and increasing denitrification. When combined with nitrogen from fertilizer or manure application, the rates of emissions are increased. Irrigation to very dry soil can also increase N$_2$O and/or NH$_3$ emission by microbial action. Irrigate at recommended levels and timing throughout the growing season.

6. **Utilize Cover Crops (NH$_3$, N$_2$O, PM)**

Cover crops reduce the amount of surface exposed and provide root structures to hold soil in place. The use of cover crops, instead of leaving fields bare/fallow, decreases wind erosion (PM) and losses of NH$_3$ and N$_2$O by providing surface cover and nutrient uptake, respectively. Cover crops also reduce nitrate leaching during the wet season by taking up soil nitrate.
6. Apply During Cool Weather and on Still Rather than Windy Days (NH₃, Odor, PM)

Temperature, humidity, wind speed, and precipitation all influence the rate of NH₃, PM, and odor losses. Ammonia loss increases exponentially with rising temperatures, and increases with greater wind speeds. PM losses also increase with increasing temperatures which dry out the soil, and increased wind speed that moves soil and manure particles from the surface into the ambient air. Therefore, the application of manure during cool, still weather will decrease the amount of PM and NH₃ volatilized from the manure (16). Applying in the early morning or late evening will not only reduce NH₃ volatilization, but will also reduce the transport of PM and odor to surrounding neighbors. Light precipitation (less than 0.15 inches) following application can also decrease NH₃ volatilization by binding NH₃ in the aqueous phase and moving it into the soil profile.

IX. Other

1. Installation of Windbreaks or Shelterbelts (NH₃, Odor, PM)

Windbreaks or shelterbelts could be either natural (e.g., a line of trees) or artificial (e.g., a solid brick or hay bale wall). Windbreaks mitigate emissions through multiple pathways. One, windbreaks break or slow the wind and thus reduces the transport of emitted gases, particulates, and odor from the dairy. A windbreak, composed of trees or a physical barrier, will partially reduce wind speeds for a distance of roughly 30 times its height (17). Two, windbreaks promote mixing and dispersion of emitted gases and odor, which dilute the respective emissions, with respect to the receiver. Three, windbreaks intercept particulates and odor, which subsequently break down as in the case of odorous compounds, or is deposited on site as in the case of particulates. The effectiveness of a windbreak, therefore, depends on its placement, height, spacing or porosity, and prevailing direction of wind and its fluctuations. Windbreak structures ranging even in modest heights ranging from 20 to 30 feet can provide significant mitigation of odor and particulate problems (19). These structures can be installed on individual systems (barns, lagoons, compost or manure piles, etc) in the dairy or on the entire dairy.

Other indirect benefits that accrue from installation of windbreaks, especially of the natural kind include: (i) alleviation of complaints which are sometimes influenced by visual images of the dairy, and (ii) enhanced landscape aesthetics of the dairy.

2. Vehicle Road Condition Management (PM)

Vehicle traffic on on-farm dirt roads can be a significant source of course particulate matter. Feed trucks, manure tankers, maintenance vehicles, etc. are constantly moving around the facility. Watering roads or applying a surface binder can significantly reduce the incidence of PM production from on-farm vehicle traffic. This should be conducted during dry times of the year and during high traffic times.

3. Engine Selection and Efficiency (NOₓ)

Engines used on-site for power generation should be energy efficient and properly maintained to minimize the production of NOₓ from combustion processes.
References


### APPENDIX E: DAIRY BMPs QUICK REFERENCE TABLE

<table>
<thead>
<tr>
<th>BMP # (NOTE)</th>
<th>Best Management Practice</th>
<th>Ammonia (NH$_3$)</th>
<th>Nitrous Oxide (N$_2$O)</th>
<th>Hydrogen Sulfide (H$_2$S)</th>
<th>Volatile Organic Compounds (VOCs)</th>
<th>Odor</th>
<th>Particulate Matter (PM)</th>
<th>Methane (CH$_4$)</th>
<th>Oxides of Nitrogen (NO$_x$)</th>
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<tbody>
<tr>
<td>I. 1</td>
<td>Properly manage level of dietary protein (%CP) in diet to match, rather than exceed animal's needs.</td>
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<td>I. 2</td>
<td>Increase the level or quality of starch in the diet.</td>
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<td>I. 3</td>
<td>Properly manage and minimize overfeeding of sulfur in the diet.</td>
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<td>I. 4</td>
<td>Practice group and/or stage of lactation feeding.</td>
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<td>II. 1</td>
<td>Properly manage ensiled feedstuffs.</td>
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<td>II. 2</td>
<td>Store feed in a sheltered area or storage structure.</td>
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<td>II. 3</td>
<td>Regularly re-pile or remove spilled and unused feed from feeding area.</td>
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<td>II. 4</td>
<td>Manage or minimize feed mixing during windy times.</td>
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<td>III. 1</td>
<td>Ensure proper ventilation.</td>
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<td>III. 2/3</td>
<td>Use recycled (clean) or treated water for flushing parlor.</td>
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<tr>
<td>III. 2/3</td>
<td>Use recycled (clean) or treated water for cleaning holding pen.</td>
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<td>III. 4</td>
<td>Remove manure from barns frequently.</td>
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<td>IV. 1</td>
<td>Ensure proper ventilation.</td>
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<td>IV. 2</td>
<td>Bedding selection and management.</td>
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<td>IV. 3</td>
<td>Treat recycled lagoon water used for flushing.</td>
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<td>IV. 4</td>
<td>Remove manure from barns frequently.</td>
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<td>IV. 5</td>
<td>Manure removal technology and efficiency.</td>
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<td>IV. 6</td>
<td>Alleyway floor texture and type.</td>
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## APPENDIX E: DAIRY BMPs QUICK REFERENCE TABLE

<table>
<thead>
<tr>
<th>BMP # (NOTE)</th>
<th>Best Management Practice</th>
<th>Ammonia (NH₃)</th>
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<th>Oxides of Nitrogen (NOₓ)</th>
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<tbody>
<tr>
<td>V. 1</td>
<td>Provide shade for cattle.</td>
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<td>V. 2</td>
<td>Sitting of water trough within pen.</td>
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<td>V. 3(a)</td>
<td>Remove manure frequently.</td>
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<td>V. 3(b)</td>
<td>Spread (harrow) manure frequently.</td>
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<td>V. 4</td>
<td>Use straw bedding in pen (seasonal).</td>
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<td>V. 5</td>
<td>Incorporate wood chips in surface layer.</td>
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<td>V. 6</td>
<td>Use urease inhibitors.</td>
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<td>V. 7</td>
<td>Surface moisture content management.</td>
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<td>V. 8</td>
<td>Knock down and remove fence line manure.</td>
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<tr>
<td>VI.1</td>
<td>Stock appropriate number of animals.</td>
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<td>VI.2</td>
<td>Use rotational grazing.</td>
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<td>VI.3</td>
<td>Move water and feeding areas frequently.</td>
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<td>VI.4</td>
<td>Irrigate immediately after grazing.</td>
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<td>VII.1</td>
<td>Manure solids - mechanical separation.</td>
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<td>VII.2</td>
<td>Manure solids - settling basin.</td>
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<tr>
<td>VII.3</td>
<td>Lagoon or storage covers (natural or composite).</td>
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<td>VII.4</td>
<td>Scrub exhaust of enclosed waste containers.</td>
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<td>VII.5</td>
<td>Proper maintenance of installed methane digester.</td>
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<tr>
<td>VII.6</td>
<td>Surface aeration of lagoons.</td>
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<td>VII.7</td>
<td>Reduce the pH of lagoons and manure piles below 6.</td>
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<td>VII.8</td>
<td>Properly manage the composting of manure.</td>
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# APPENDIX E: DAIRY BMPs QUICK REFERENCE TABLE

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<tr>
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<th>Oxides of Nitrogen (NOₓ)</th>
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<tr>
<td>VII. 9</td>
<td>Properly manage stockpiled manure.</td>
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<td>VIII. 1</td>
<td>Apply N fertilizer below no-till residue.</td>
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<td>VIII. 2(a)</td>
<td>Corn - Inject fertilizer/manure into soil at application.</td>
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<tr>
<td>VIII. 2(b)</td>
<td>Forage - Manure/fertilizer application method and/or incorporation practice.</td>
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<tr>
<td>VIII. 3</td>
<td>Apply nutrients according to agronomic recommendations based on soil and manure test results.</td>
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<td>VIII. 4</td>
<td>Do not over-irrigate.</td>
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<td>VIII. 5</td>
<td>Utilize cover crops in winter crop rotation.</td>
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<td>VIII. 6</td>
<td>Apply during cool weather on still rather than windy days.</td>
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<td>IX. 1</td>
<td>Installation of windbreaks or shelterbelts.</td>
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<td>IX. 2</td>
<td>Vehicle road condition management.</td>
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<td>IX. 3</td>
<td>Engine selection and efficiency.</td>
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**Note:** The BMP numbers correspond to the BMP numbers in Appendix C

This table provides a graphical depiction of which pollutants can be mitigated by implementing each BMP, within each system. Used in conjunction with Appendix C, it provides a quick reference for selecting BMPs which target specific pollutants, specific systems, or both.
APPENDIX F - AIR QUALITY BMP SELECTION MATRIX

The matrix presented here provides a tool for selecting best management practices (BMPs) for air quality emission reduction. For detailed descriptions of respective BMPs, refer to the sister-document entitled “Descriptions of Best Management Practices (BMP)”. This current document is neither intended to provide detailed information as to how the BMPs should be selected (or implemented), nor is it the only feasible approach on selection (or implementation) of BMPs. It is expected that exact selection or implementation will vary from farm to farm. When applicable, be mindful of tradeoffs, limitations, or both for each BMP.

Definitions: $NH_3 = \text{ammonia}; \ N_2O = \text{nitrous oxide}; \ H_2S = \text{hydrogen sulfide}; \ CH_4 = \text{methane}; \ VOC = \text{volatile organic compounds}; \ PM = \text{particulate matter}.$

The following matrix outlines the process for identifying sources of emissions on your facility and how to choose and implement BMPs to mitigate those emissions. Use this chart and the detailed example that follows it as guides when developing your Air Quality Management Plan.

I. List the sources of emissions on the dairy.

II. For each source, list the expected pollutants in order of importance
(Example: VOCs for silage storage area; PM for dry open feedlots; etc.).

III. List the sources in order of importance with respect to expected or projected emission level
(Example: Open anaerobic lagoons because of their size and open nature, are likely be to more important with respect to air emissions than sand-settling basins; broadcast (big gun) land application is likely to have greater impact on air quality than injection; etc.).

IV. Define the emissions mitigation goal for each of the sources.
The goal for individual sources, for example, could be:
1. To address existing regulations – either local, State, or federal
2. To minimize nuisance lawsuits
3. To champion environmental stewardship
4. To address the most important pollutant in terms of volume or health impact
5. To address other goals

V. Depending on the goal for each source, list three BMPs to address the goal based on a three-tier-system with respect to effectiveness, cost, ease of implementation, compatibility with other BMPs, and in compatibility with your nutrient management plans.
1. Tier 1 being the least expensive and easy to implement
2. Tier 3 being the most advanced and most expensive to implement
List the sources of emission on the dairy. The following sources are the most common areas of air pollutant emission on a dairy operation. Not all areas may apply to your farm. Select the sources that do apply and list the specific factors (i.e., production areas) within that source that can contribute to air pollutant emission (e.g., Manure Storage may have manure holding pit, lagoon, and compost pile as areas within the source that can contribute emissions).

1. Nutrition
2. Feed Management
3. Milk Parlor
4. Housing - Freestall Barns
5. Housing - Drylot Pens
6. Grazing Management
7. Manure Management
8. Land Application
9. Other

For each source, list the expected pollutants in order of importance. For each source, the pollutants of concern have been listed below in general order of importance. Your farm may have a different order. When in doubt, use the order listed below.

1. Nutrition: NH₃, CH₄, H₂S, N₂O.
2. Feed Management: VOC, PM, Odor.
3. Milk Parlor: NH₃, VOC, Odor, H₂S.
4. Housing - Freestall Barns: NH₃, VOC, Odor, CH₄, H₂S.
5. Housing - Drylot Pens: NH₃, PM, Odor, H₂S, CH₄, VOC, N₂O.
6. Grazing Management: NH₃, N₂O.
8. Land Application: NH₃, PM, Odor, N₂O.
9. Other
List the sources in order of importance with respect to expected or projected emission level. For each pollutant of concern, the primary sources that emit that pollutant have been listed below in order of importance. Your farm may have a different order; when in doubt, use the order listed below. For each source, identify and list the specific factors that are contributing to that pollutant (these should have been listed in I. above).

1. **Ammonia (NH₃)**
   a. Nutrition
   b. Housing - Freestall Barns
   c. Housing - Drylot Pens
   d. Milk Parlor
   e. Land Application
   f. Manure Management
   g. Grazing Management
   h. Feed Management

2. **Methane (CH₄)**
   a. Manure Management
   b. Nutrition

3. **Hydrogen Sulfide (H₂S)**
   a. Manure Management
   b. Housing - Drylot Pens
   c. Nutrition

4. **Volatile Organic Compounds (VOC)**
   a. Feed Management
   b. Housing - Freestall Barns
   c. Housing - Drylot Pens
   d. Milk Parlor
   e. Manure Management

5. **Particulate Matter (PM)**
   a. Housing - Drylot Pens
   b. Land Application
   c. Feed Processing
   d. Manure Management

6. **Nitrous Oxide (N₂O)**
   a. Nutrition
   b. Housing - Drylot Pens
   c. Land Application
   d. Grazing Management

7. **Odor**
   a. Land Application
b. Manure Management

c. Housing - Drylot Pens

d. Housing - Freestall Barns

e. Milk Parlor

f. Feed Management

g. Nutrition

**Define the emissions mitigation goal for each of the sources.** Emission mitigation goals are going to be specific to your farm, objectives, and source emissions. List goals for each source.

The goal for individual sources, for example, could be:

- To address existing regulations – either local or federal
- To minimize nuisance lawsuits
- To champion environmental stewardship
- To address the most important pollutant in terms of volume or health impact
- To address other goals

Depending on the goal for each source, list three BMPs to address the goal based on a three-tier-system with respect to effectiveness, cost, ease of implementation, compatibility with other BMPs, and in compatibility with your nutrient management plans. **Tier 1 being the least expensive and easy to implement. Tier 3 being the most advanced and most expensive to implement.** Tier 1, 2, and 3 level BMPs have been listed for each source on a dairy farm. This list correlates to the BMPs listed in the “Descriptions of Best Management Practices (BMP)” document. This list is not exhaustive and tier level BMPs may vary for your individual farm. Refer to Table 1 (at the end of this document) for a selection matrix guide for choosing tier level BMPs for each source.

1. **Nutrition**
   a. *Tier 1* - Properly Manage Level of Dietary Protein (%CP) in Diet to Match, Rather Than Exceed, an Animal’s Needs (NH₃, N₂O, Odor); Properly Manage and Minimize Overfeeding Sulfur in the Diet (H₂S, Odor).
   b. *Tier 2* - Practice Group and/or Stage of Lactation Feeding (NH₃).
   c. *Tier 3* - Increase the Level or Quality of Starch in the Diet (CH₄); Utilize feed additives to maximize efficiency (NH₃, H₂S, CH₄).

2. **Feed Management**
   a. *Tier 1* - Regularly Remove Spilled and Unused Feed from Feeding Area (VOC, Odor, and PM); Manage or Minimize the Mixing of Feed During Windy Times (PM).
   b. *Tier 2* - Properly Cover and Manage Ensiled Feedstuffs (VOC, Odor).
   c. *Tier 3* - Store Feed in a Sheltered Storage Structure (VOC, Odor, PM).

3. **Milk Parlor**
   a. *Tier 1* - Use Recycled Parlor (Clean) Water Used for Flushing/Cleaning Parlor and Holding Area (NH₃, Odor); Ensure Proper Ventilation (NH₃, Odor, and PM).
   b. *Tier 2* - Remove Manure from Parlor and Holding Area Frequently (NH₃, VOC, Odor).
   c. *Tier 3* - Treat Recycled Water Used for Flushing/Cleaning Holding Area (NH₃, Odor);
4. Housing - Freestall Barns
   a. *Tier 1* - Remove Manure from Barns Frequently (NH$_3$, VOC, Odor); Ensure Proper Ventilation of Freestall Barns (NH$_3$, Odor, and PM).
   b. *Tier 2* - Bedding Selection and Management (NH$_3$, H$_2$S, Odor); Manure Removal Technology and Efficiency (NH$_3$, VOC, Odor).
   c. *Tier 3* - Treat Recycled Lagoon Water Used for Flushing (NH$_3$, Odor); Alleyway Floor Texture and Type (NH$_3$, VOC, Odor); Manure Removal Technology and Efficiency (NH$_3$, VOC, Odor).

5. Housing - Drylot Pens
   a. *Tier 1* - Spread (Harrow) Manure Frequently (NH$_3$, PM); Surface Moisture Content Management (NH$_3$, N$_2$O, VOC, Odor, CH$_4$, H$_2$S, Odor, PM).
   b. *Tier 2* - Remove Manure Frequently (NH$_3$, PM); Incorporate Wood Chips in Surface Layer (NH$_3$, PM, Odor); Use Straw Bedding in Drylot Pens (NH$_3$, PM, Odor); Knockdown and Remove Fence Line Manure (VOC, Odor).
   c. *Tier 3* - Urease Inhibitors (NH$_3$, N$_2$O); Provide Shade for Cattle (NH$_3$, PM); Siting of Water Trough within Pen (NH$_3$, PM).

6. Grazing Management
   a. *Tier 1* - Stock Appropriate Number of Animals (NH$_3$, N$_2$O); Use Rotational Grazing (NH$_3$, N$_2$O).
   b. *Tier 2* - Move Water and Feeding Areas Frequently (NH$_3$, N$_2$O).
   c. *Tier 3* - Irrigate Immediately after Grazing (NH$_3$).

7. Manure Management
   a. *Tier 1* - Manure Solids Separation (NH$_3$, VOC, Odor, H$_2$S, CH$_4$); Properly Manage the Composting of Solid Manure (H$_2$S, Odor, PM, CH$_4$); Properly Manage Stockpiled Manure (H$_2$S, Odor, PM).
   b. *Tier 2* - Lagoon or Storage Covers (NH$_3$, H$_2$S, VOC, Odor, CH$_4$); Scrub Exhaust of Enclosed Waste Containers (CH$_4$, Odor, H$_2$S).
   c. *Tier 3* - Installation and Proper Operation of an Anaerobic Digester (CH$_4$); Surface Aeration of Lagoons (NH$_3$, H$_2$S, VOCs); Reduce the pH of Lagoons and Manure Piles (NH$_3$, CH$_4$); Encourage Purple Sulfur Bacterial Formation in Anaerobic Lagoons (H$_2$S, Odor).

8. Land Application – Manure and/or Chemical Fertilizer
   a. *Tier 1* - Apply Nutrients According to Agronomic Recommendations Based on Soil and Manure Test Results (NH$_3$, N$_2$O); Inject or Incorporate Fertilizer into Soil within 24 Hours of Application (NH$_3$, Odor); Do Not Over-irrigate (NH$_3$, N$_2$O); Apply During Cool Weather and on Still Rather than Windy Days (NH$_3$, Odor, PM).
   b. *Tier 2* - Utilize Cover Crops (NH$_3$, N$_2$O, PM); Apply N Fertilizer below No-Till Residue (NH$_3$, PM).
   c. *Tier 3* - Installation of Windbreaks or Shelterbelts (Odor, PM).
9. **Other**
   a. *Tier 1* - Installation of Windbreaks or Shelterbelts (NH$_3$, Odor, PM).
   b. *Tier 2* - Vehicle Road Condition and Management (PM).
   c. *Tier 3* - Engine Selection and Efficiency (NOx).
Table 1. BMP selection matrix based on source and tier level mitigation

<table>
<thead>
<tr>
<th>Sources of emission on a dairy</th>
<th>Expected pollutants for each source in order of importance</th>
<th>Suggested BMPs for emissions reduction Tier 1</th>
<th>Suggested BMPs for emissions reduction Tier 2</th>
<th>Suggested BMPs for emissions reduction Tier 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrition</td>
<td>NH₃, CH₄, H₂S, N₂O</td>
<td>Properly Manage Level of Dietary Proxins (NCP) in Diet to Match, Rather Than Exceed, an Animal’s Needs (NH₃, N₂O, Odor)</td>
<td>Practice Group and/or Stage of Lactation Feeding (NH₃)</td>
<td>Increase the Level or Quality of Starch in the Diet (CH₄)</td>
</tr>
<tr>
<td>Feed Management</td>
<td>VOC, PM, Odor</td>
<td>Regularly remove Spilled and Unused Feed from Feeding Area (VOC, Odor, PM)</td>
<td>Properly Cover and Manage Feasted Feedstuffs (VOC, Odor)</td>
<td>Utilize feed additives to maximize efficiency (NH₃, H₂S, CH₄)</td>
</tr>
<tr>
<td>Milk Parlor</td>
<td>NH₃, VOC, Odor, H₂S</td>
<td>Use Recycled Parlor (Clean) Water Used for Flushing/Cleaning Parlor and Holding Area (NH₃, Odor)</td>
<td>Remove Manure from Parlor and Holding Area Frequently (NH₃, VOC, Odor)</td>
<td>Store Feed in a Shattered Storage Structure (VOC, Odor, PM)</td>
</tr>
<tr>
<td>Housing – Freestall Barns</td>
<td>NH₃, VOC, Odor, CH₄, H₂S</td>
<td>Remove Manure from Barns Frequently (NH₃, VOC, Odor)</td>
<td>Bedding Selection and Management (NH₃, H₂S, Odor)</td>
<td>Treat Recycled Water Used for Flushing/Cleaning Holding Area (NH₃, Odor)</td>
</tr>
<tr>
<td>Housing – Drylot Pens</td>
<td>NH₃, PM, Odor, H₂S, CH₄, VOC, N₂O</td>
<td>Spread (Harrow) Manure Frequent (NH₃, PM)</td>
<td>Manure Removal Technology and Efficiency (NH₃, VOC, Odor)</td>
<td>Treat Recycled Lagoon Water Used for Flushing (NH₃, Odor)</td>
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<tr>
<td></td>
<td></td>
<td>Surface Moisture Management (NH₃, N₂O, VOC, Odor, CH₄, H₂S, Odor, PM)</td>
<td>Remove Manure Frequently (NH₃, PM)</td>
<td>Alleyway Floor Texture and Type (NH₃, VOC, Odor)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use Straw Bedding in Drylot Pans (NH₃, PM, Odor)</td>
<td>Incorporate Wood Chips in Surface Layer (NH₃, PM, Odor)</td>
<td>Manure Removal Technology and Efficiency (NH₃, VOC, Odor)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knockdown and Remove Fence Line Manure (VOC, Odor)</td>
<td>Provide Shade for Cattle (NH₃, PM)</td>
<td>Urease Inhibitors (NH₃, N₂O)</td>
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<td>Sitting of Water Trough within Pen (NH₃, PM)</td>
<td></td>
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<tr>
<td>Sources of emission on a dairy</td>
<td>Expected pollutants for each source in order of importance</td>
<td>Suggested BMPs for emissions reduction</td>
<td></td>
<td></td>
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<td>-------------------------------</td>
<td>----------------------------------------------------------</td>
<td>--------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grazing Management</td>
<td>NH₃, N₂O</td>
<td>Stock Appropriate Number of Animals (NH₃, N₂O)</td>
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<tr>
<td></td>
<td></td>
<td>Use Rotational Grazing (NH₃, N₂O)</td>
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<tr>
<td>Manure Storage</td>
<td>Liquid: NH₃, H₂S, CH₄, Odor, VOC</td>
<td>Manure Solids Separation (NH₃, VOC, Odor, H₂S, CH₄)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Solid: NH₃, H₂S, PM, CH₄</td>
<td>Properly Manage the Composting of Solid Manure (H₂S, Odor, PM, CH₄)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Application</td>
<td>NH₃, PM, Odor, N₂O</td>
<td>Properly Manage Stockpiled Manure (H₂S, Odor, PM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Apply Nutrients According to Agroeconomic Recommendations Based on Soil and Manure Test Results (NH₃, N₂O)</td>
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<tr>
<td></td>
<td></td>
<td>Inject or Incorporate Manure into Soil within 24 hours of Application (NH₃, Odor)</td>
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<td></td>
<td></td>
<td>Do Not Over-Irrigate (NH₃, N₂O)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Apply during cool weather and on still rather than windy days (NH₃, Odor, PM)</td>
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<table>
<thead>
<tr>
<th>Suggested BMPs for emissions reduction Tier 1</th>
<th>Suggested BMPs for emissions reduction Tier 2</th>
<th>Suggested BMPs for emissions reduction Tier 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Move Water and Feeding Areas Frequently (NH₃, N₂O)</td>
<td>Irrigate Immediately after Grazing (NH₃)</td>
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<td></td>
<td>Lagoon or Storage Covers (NH₃, H₂S, VOC, Odor, CH₄)</td>
<td>Installation of an Anaerobic Digester (CH₄)</td>
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<td></td>
<td>Scrub Exhaust of Enclosed Waste Containers (CH₄, Odor, H₂S)</td>
<td>Surface Aeration of Lagoons (NH₃, H₂S, VOC)</td>
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<tr>
<td></td>
<td></td>
<td>Reduce the pH of Manure (NH₃, CH₄)</td>
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<td></td>
<td></td>
<td>Encourage Purple Sulfur Bacterial Formation in Lagoons (H₂S, Odor)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Installation of Windbreaks or Shelterbelts (Odor, PM)</td>
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Air Quality Management Policy for Dairy Operations
APPENDIX G: BMP SCORE SHEET

## Description of Score Sheet
Scores entered in the gray boxes range from 0 to 5 for each pollutant (5 being optimum implementation). Scores for each BMP are based on the visual evaluation and/or documentation of practices assessed during inspections. For descriptions of BMPs listed, refer to the document "Descriptions of Best Management Practices (BMPs)" (YRCAA, 2011).

### How to use this table
1. Review your overall score. A score above 80% is good, between 70-80% is adequate, and below 70% is poor and should be evaluated for improvements.
2. Review the score (%) for each category (i.e., Nutrition, Housing, etc.) and each pollutant (i.e., Ammonia, Nitrous Oxide, etc.). The values listed in the "Category Level of BMP Implementation (%)" row gives the relative effectiveness of the BMPs for that specific category as implemented at your facility at the time of inspection. A value below 70% should be evaluated and you should consider making improvements in that category.
3. Look at the individual score given to each BMP. Use these to identify the areas where improvements can be made.

### How to use this table
- 1) Review your overall score. A score above 80% is good, between 70-80% is adequate, and below 70% is poor and should be evaluated for improvements. 2) Review the score (%) for each category (i.e., Nutrition, Housing, etc.) and each pollutant (i.e., Ammonia, Nitrous Oxide, etc.). The values listed in the "Category Level of BMP Implementation (%)" row gives the relative effectiveness of the BMPs for that specific category as implemented at your facility at the time of inspection. A value below 70% should be evaluated and you should consider making improvements in that category. 3) Look at the individual score given to each BMP. Use these to identify the areas where improvements can be made.

<table>
<thead>
<tr>
<th>BMP #</th>
<th>Best Management Practice</th>
<th>Ammonia (NH₃)</th>
<th>Nitrous Oxide (N₂O)</th>
<th>Hydrogen Sulfide (H₂S)</th>
<th>Volatile Organic Compounds (VOCs)</th>
<th>Odor</th>
<th>Particulate Matter (PM)</th>
<th>Methane (CH₄)</th>
<th>Oxides of Nitrogen (NOₓ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall Score (%) &amp; Grade: #DIV/0! #DIV/0! #DIV/0! #DIV/0! 100-90% 90-80% 80-70% 70-60% &lt;60%</td>
<td>Good</td>
<td>Adequate</td>
<td>Poor - Needs Improvement</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
<td>NA</td>
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<tr>
<td>I. 1</td>
<td>Properly manage level of dietary protein (~16%CP)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
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</tr>
<tr>
<td>I. 2</td>
<td>Increased level or quality of starch in diet (23-26%)</td>
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<td></td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
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</tr>
<tr>
<td>I. 3</td>
<td>Manage and minimize overfeeding of sulfur-containing feed</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
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<tr>
<td>I. 4</td>
<td>Practice group and/or stage of lactation feeding</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
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<tr>
<td></td>
<td>Category Level of BMP Implementation (%)</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
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<td>II. 1</td>
<td>Properly manage ensiled feedstuffs</td>
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<td>0</td>
<td>0</td>
<td></td>
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<td>II. 2</td>
<td>Store feed in a sheltered storage structure</td>
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<td>0</td>
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<td>II. 3</td>
<td>Regularly remove spilled and unused feed from feeding area</td>
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<td>II. 4</td>
<td>Manage or minimize feed mixing during windy times</td>
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<tr>
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<td>Category Level of BMP Implementation (%)</td>
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<td>#DIV/0!</td>
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<td>III. 1</td>
<td>Ensure proper ventilation</td>
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<td>Use recycled (clean) or treated water for flushing parlor</td>
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<td>Use recycled (clean) or treated water for cleaning holding pen</td>
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<tr>
<td>III. 4</td>
<td>Remove manure from holding area frequently</td>
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<td></td>
<td>0</td>
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<td></td>
<td>0</td>
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<tr>
<td></td>
<td>Category Level of BMP Implementation (%)</td>
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<td>#DIV/0!</td>
<td>#DIV/0!</td>
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<td>IV. 1</td>
<td>Ensure proper ventilation</td>
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<td>Bedding selection and management</td>
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<td>Level of BMP Implementation (%)</td>
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<td>#DIV/0!</td>
<td>#DIV/0!</td>
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<td>Treat recycled lagoon water used for flushing</td>
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<td>Remove manure from barns frequently</td>
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<td>Provide shade for cattle</td>
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<td>Sitting of water trough within pen</td>
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<td>Remove manure frequently</td>
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<td>Spread (harrow) manure frequently</td>
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<td>Use straw bedding in pen (seasonal)</td>
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<td>Incorporate wood chips into surface layer</td>
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<td>Utilize urease inhibitors</td>
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<td>Surface moisture content management</td>
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<td>Knock down and remove fence line manure</td>
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<td>Stock appropriate number of animals</td>
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<td>Use rotational grazing</td>
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<tr>
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<td>Move water and feeding areas frequently</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>VI. 4</td>
<td>Irrigate immediately after grazing</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>VII. 1</td>
<td>Manure solids - mechanical separation</td>
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<td>Manure solids - settling basin</td>
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<td>VII. 2</td>
<td>Lagoon or storage covers (natural or composite)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>VII. 3</td>
<td>Scrub exhaust of enclosed waste containers</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>VII. 4</td>
<td>Proper maintenance of installed methane digester</td>
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<td>0</td>
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<td>VII. 5</td>
<td>Surface aeration of lagoons</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>VII. 6</td>
<td>Reduce the pH of lagoons and manure piles below 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
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<td>Purple sulfur bacterial formation in lagoons</td>
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<tr>
<td>VII. 8</td>
<td>Properly manage the composting of manure</td>
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<td>0</td>
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<td>0</td>
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<td>VII. 9</td>
<td>Properly manage stockpiled manure</td>
<td>0</td>
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<td>0</td>
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Air Quality Management Policy for Dairy Operations
### VIII. Land Application - Manure or Chemical Fertilizer

<table>
<thead>
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<th>Category</th>
<th>Level of BMP Implementation (%)</th>
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<tr>
<td>VIII. 1 Apply N fertilizer below no-till residue</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>VIII. 2(a) Corn - Inject fertilizer/manure into soil at application</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>VIII. 2(b) Forage - Manure/fertilizer application method and/or incorporation practice</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>VIII. 3 Apply nutrients according to agronomic recommendations based on soil and manure test results</td>
<td>0 0 0</td>
</tr>
<tr>
<td>VIII. 4 Do not over-irigate</td>
<td>0 0 0</td>
</tr>
<tr>
<td>VIII. 5 Utilize cover crops in winter crop rotation</td>
<td>0 0 0</td>
</tr>
<tr>
<td>VIII. 6 Apply during cool weather and on still rather than windy days</td>
<td>0 0 0 0 0</td>
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**IX. Other**

<table>
<thead>
<tr>
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</tr>
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<tbody>
<tr>
<td>IX. 1 Installation of windbreaks or shelterbelts</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>IX. 2 Vehicle road condition management</td>
<td>0 0 0</td>
</tr>
<tr>
<td>IX. 3 Engine selection and efficiency</td>
<td>0</td>
</tr>
</tbody>
</table>

| Overall Level of BMP Effectivity by Pollutant (%)                         | - - - - - - - -                |