Treasure Valley Air Quality Issues

Ammonia, Particulate, and VOC Emissions

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WHITE PAPER
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The Idaho Department of Environmental Quality (DEQ) recently answered questions to the Canyon County Board of Commissioners (CCBC) during a hearing on January 27, 2003. CCBC was considering an appeal to a siting decision concerning a proposed 8,000 head dairy operation to the south of the City of Nampa. A siting panel report prepared by Idaho Department of Agriculture (IDA), Idaho Department of Water Resources (IDWR) and DEQ had been submitted to CCBC prior to the hearing and the report concluded that the facility proposal posed minimal risk to the environment. The report had been developed pursuant to guidelines developed to address potential ground water and odor concerns often associated with large scale livestock facilities utilizing the professional judgement of agency representatives with appropriate expertise for that purpose.

The siting panel did not consider potential air quality impacts from the facility and because of that omission, the report is incorrect in its conclusion that the total of environmental impacts are minimal because the data utilized is insufficient to arrive at that conclusion. DEQ management became aware of that deficiency and offered to provide additional data to the CCBC concerning air quality impacts in term of pollutant load estimates so that the CCBC would have the benefit of this relevant information. That offer was accepted and the DEQ Boise Regional Administrator presented the information at the hearing as requested.

DEQ acknowledges it is unfortunate that the information was presented late in the process and recognizes that the siting panel review process will be amended to allow for appropriate consideration of air quality aspects of facilities as well as other environmental concerns. However, that initial oversight did not obviate the responsibility of DEQ to make the information available to the CCBC once it became aware of the deficiency. DEQ has a fundamental responsibility to ensure that relevant environmental and public health information is available to citizens and governmental entities so that they may fully consider all the available data as they move forward in the decision making process.

Airshed Management
Air pollution monitoring data, meteorological analysis and dispersion modeling clearly demonstrate that air pollution emitted in one area of the Treasure Valley impacts air quality throughout the entire airshed. Airshed Management is an approach that considers all sources within an affected area when developing air quality protection strategies. The intent of Airshed Management is to take proactive measures to improve air quality when possible, rather than waiting until a problem develops and state and federal law mandates action. The primary goals of Airshed Management are to protect public health by avoiding violations of air quality standards, or limits, through proactive management; improve the scientific understanding of airshed-wide air quality; and inform, educate, and involve local communities on air quality issues and management.

Community Choices

The foundation of Airshed Management is community involvement and community directed initiatives to manage air quality. It is important that local leaders and planners understand how their community choices impact air quality now, and in the future. Successful Airshed Management protects public health and keeps air quality decision-making at the local level.

A Brief History of Air Quality in the Treasure Valley

The Treasure Valley has a history of air quality problems. The local terrain and meteorology can trap air pollution for long periods of time during stagnation events. During these events, air quality levels raise to unhealthful levels throughout the region.

Violations of the health based carbon monoxide (CO) standard occurred every winter from 1977, the year CO monitoring began, until 1986. As a result of these high-levels of pollution, Northern Ada County was designated as a CO Nonattainment area. A CO Air Quality Improvement Plan was developed and included transportation control measures to reduce CO levels. The adoption of a Vehicle Inspection and Maintenance Program, improvements in traffic flow, federal vehicle emission standards and improvements in fuel all contributed to a steady decline in CO levels. In December 2002, EPA approved DEQ's Northern Ada County CO Maintenance Plan, demonstrating that the area is now in attainment of the CO standard, and outlining the steps that will be taken to ensure that it will remain so.

Violations of the health based particulate matter (PM_{10}) standard were first documented in the Treasure Valley in the winter of 1985-86, the year PM_{10} monitoring began. PM_{10} is very tiny particulate (10 microns or less in diameter). Northern Ada County was designated a PM_{10} Nonattainment Area by EPA in 1987. In 1991, DEQ submitted an Air Quality Improvement Plan to EPA that outlined strategies to reduce PM_{10} levels and reduce the likelihood of future PM_{10} violations. Wood burning restrictions, road sanding improvements and new industrial permits were implemented to reduce PM_{10} levels. As a result of these control measures, no new violations of the PM_{10} standard have occurred since 1991. In September 2002, DEQ submitted the Northern Ada County PM_{10} Maintenance Plan to EPA. This Plan demonstrates compliance with the PM_{10} through the year 2020. EPA is expected to approve this plan in the summer of 2003. Upon approval of this plan, Northern Ada County will return to attainment status for PM_{10}.

Ada County vs. Canyon County Air Quality Concerns

As discussed above, in the past Ada County has frequently violated health based air quality standards for both CO and PM_{10}. Canyon County, on the other hand, has never had violations of air quality standards.

Is Canyon County's air quality better than Ada County's? That is not a likely scenario. The likely reason that air quality violations for CO and PM_{10} were not measured in Canyon County was because air quality monitoring did not begin in Canyon County until rapid development started to occur in the mid- to late-nineties. By then, the reductions in emissions that improved air quality in Ada County also improved those in Canyon County. Meteorological analysis and air quality dispersion modeling of air stagnation events both demonstrate that pollution is shared between the two counties. Recently, pollution caused by the fire in Caldwell was evident on air pollution monitors across the valley. That is why it is important to manage air quality on an airshed basis.

Secondary Particulate Matter

$PM_{2.5}$ is a smaller category of particulate matter that is even more damaging to public health. Secondary particulate matter is a type of $PM_{2.5}$ that is not emitted directly into the air, but forms through a chemical reaction between gasses in the air. On high pollution days, secondary particulates account for almost half of the $PM_{2.5}$ in the air, with the remainder coming from smoke, soot, finely ground soil, and other sources[1].

2002 Exceedances (Ozone and $PM_{2.5}$)

The Treasure Valley has been successful at solving their CO and PM_{10} problems of the past. However, rapid growth in the area and recent changes to EPA air quality standards pose new air quality challenges. During the summer of 2002, exceedances of the Ozone standard were measured on monitors in both counties. Additionally, both counties experienced exceedances of the $PM_{2.5}$ standard in December of 2002. These exceedances raise a possibility of Ozone and/or $PM_{2.5}$ nonattainment designation for the Treasure Valley.

In the future, proactive measures should be taken to reduce the emissions that lead to the formation of these pollutants. Because Canyon and Ada Counties currently have no nonattainment designations, communities presently have a great deal of flexibility in how they manage their air quality.

Penalties or Sanctions

Failure to protect air quality standards sets up a costly and punitive chain of events under the Federal Clean Air Act. Once a violation of air quality standards is determined to have occurred, EPA publishes a notice in the Federal Register. The state is given 18 months to prepare an Air Quality Improvement Plan outlining how emissions will be reduced to acceptable levels. Reductions must come from permanent and enforceable control strategies, which can be very costly and difficult for communities and industry to implement.

Once a nonattainment designation is made by EPA, the following things happen:

1) The state must prepare an Air Quality Improvement Plan to fix the problem (past plans in Idaho have cost up to $2-million).

2) Permanent and enforceable controls must be implemented on any sources or air pollution that cause or contribute to the air quality violation. This can result in significant community-wide costs, and can also impact specific sources, such as industry. For example, the Amalgamated Sugar Company in Nampa proposes to spend $12 million in the near future to control its air pollution emissions.

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[1] Kuhns, H., Etymezian, V., Stockwell, W., Kohl, S. Green, M., Watson, J., and Chow, J. 2000, Treasure Valley Secondary Aerosol Study. Prepared for the Idaho Department of Environmental Quality, Boise, ID by the Desert Research Institute, Las Vegas, NV.

3) Stricter permitting requirements apply when a major new facility is built or when a modification is made to an existing facility.

4) All federally funded transportation projects and regionally significant locally funded projects become subject to transportation conformity requirements. Transportation conformity is designed to ensure that efforts to improve air quality are not undermined by transportation impacts, and all transportation plans and programs must “conform” to Air Quality Improvement Plans. If at any time in the future federal transportation projects don't conform to the current Air Quality Improvement Plan, those projects cannot be funded. (In recent years, this rule put $120 million in transportation projects at risk in Ada County).

5) Airports and other large federally funded programs become subject to general conformity requirements. Like transportation conformity, general conformity is designed to ensure that efforts to improve air quality are not undermined by federally funded activities.

If the state does not provide an adequate or timely plan, EPA can invoke sanctions including:

1) Loss of highway dollars.

2) Imposition of a requirement that any new industry obtain emission reductions other companies equal to twice the emissions that the new plant would generate. This effectively limits industrial expansion in these areas.

Ammonia Chemistry

Once it is released into the atmosphere, ammonia undergoes chemical reactions with other pollutants and with the natural components of the atmosphere. The major gas-phase reaction of ammonia involves oxidation by the hydroxyl radical, a normal component of the daytime photochemistry. This leads to formation of organic nitrogen containing compounds, nitrogen oxides and ultimately to nitric acid or organic-nitrate aerosols. This pathway may contribute to both ozone formation and $PM_{2.5}$ secondary aerosol production, depending on the time of year.

In the presence of atmospheric sulfur dioxide and nitrogen oxides and water vapor, the atmospheric acids sulfuric acid (H_2SO_4) and nitric acid (HNO_3) are formed, which react rapidly with any available ammonia to form ammonium sulfate, ammonium bisulfate and ammonium nitrate secondary aerosol particles.

$PM_{2.5}$ Precursors

Oxides of nitrogen, sulfur dioxide, and ammonia are precursors, or ingredients, of secondary particulate matter. Ammonia gas forms ammonium nitrate particulate matter when it reacts with nitric acid in the air. Ammonia gas forms ammonium sulfate particulate matter when it reacts with sulfuric acid in the air. On the most polluted days, approximately 48% of $PM_{2.5}$ is made up of ammonium nitrate and ammonium sulfate [2].

NH_3 (gas)	+	HNO_3 (gas)	←→	NH_4NO_3 (particle)
Ammonia		*Nitric Acid*		*Ammonium Nitrate*

NH_3 (gas)	+	H_2SO_4 (gas)	←→	$(NH_4)_2SO_4$ (particle)
Ammonia		*Sulfuric Acid*		*Ammonium Sulfate*

DEQ research indicates that other "ingredients" (NO_x and SO_2), or precursors, are less abundant than ammonia in the Treasure Valley, and therefore limit the formation of secondary particulates. However, increases in any one of the precursor emissions increases the potential for additional secondary aerosol formation. Increases to ammonia emissions should be considered equally along with those of the other precursors. The role of additional ammonia emissions becomes more significant if either the equilibrium state between it and the other precursors was not properly quantified, is not uniform throughout the valley, or if the relative proportion of ammonia to the precursors changes in the future. Current forecasts anticipate that ammonia could become a more significant factor in the formation of secondary particulate matter as urban and industrial development increases, adding to the availability of other precursors.

Current Airshed Measures

Airshed planning and management is ongoing in the Treasure Valley. Community leaders from both counties have begun the implementation of a number of proactive actions that have reduced, or will reduce, air pollution emissions across the valley. These measures include local burn ordinances, road paving, alternative fuels programs, local dust ordinances and Vehicle Inspection and Maintenance Programs. In addition, DEQ has been working with industry to amend air quality permits to further limit emissions.

Airshed Philosophy

DEQ believes that air quality management and protection must be a community-based project. As such, all air pollution sources in the community have a responsibility to ensure that air quality standards are protected. Local citizens, community leaders, transportation planners, and industry have all been asked to reduce their emissions. Because agriculture is a significant source of air pollution in the valley, this industry sector should also participant in the Airshed Management

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[2] Kuhns, H., Etymezian, V., Stockwell, W., Kohl, S. Green, M., Watson, J., and Chow, J. 2000, Treasure Valley Secondary Aerosol Study. Prepared for the Idaho Department of Environmental Quality, Boise, ID by the Desert Research Institute, Las Vegas, NV.

process. Agricultural emissions are a part of the air pollution pie, and must be included in air pollution management efforts.

Ammonia Sources

The 1999 Treasure Valley Emissions Inventory estimated annual emissions of ammonia. By far, the largest source of ammonia in the Treasure Valley, accounting for 64% of all emissions, was livestock urine and solid waste. The next largest source, fertilizer application, accounted for a much smaller percentage at 14%, with other smaller sources making up the balance of ammonia emissions.

Source	**Tons per Year**	**Percentage of Total**
Livestock Urine and Solid Waste	4,391	64%
Fertilizer Ammonia	978	14%
Cold Storage Ammonia	884	13%
Industrial Point Sources	405	6%
Vehicle Tailpipe Emissions	184	3%
Commercial and Industrial Equipment	4	< 1%
Industrial Natural Gas Combustion and Distillate	3	< 1%
Agricultural Equipment	3	< 1%
Residential Natural Gas Combustion and Distillate	3	< 1%
Construction and Mining Equipment	2	< 1%
Lawn and Garden Equipment	1	< 1%
Commercial/Institutional Natural Gas Combustion	1	< 1%
Total	**6,859**	**100.00%**

Livestock Ammonia Emissions Factors

An emissions factor defines the amount of air pollution emitted from a specific source. There are several issues that have been shown to influence ammonia emissions from livestock. These include:

- Nitrogen content of feed
- Conversion factor between nitrogen in feed and in meat or milk
- Animal type, age, size, and activity
- Animal housing
- Animal waste management system

While these factors may cause emissions to fluctuate somewhat, a reasonable standardization can be drawn so that emissions can be measured. Emissions factors listed in an EPA contracted study[3] of ammonia emissions factors are well accepted and widely used. California[4], Utah[5], and

[3]R. W. Battye, C. Overcash, and S. Fudge, 1994. *Development and Selection of Ammonia Emission Factors*. Prepared for U.S. Environmental Protection Agency, Atmospheric Research and Exposure Assessment Laboratory by EC/R Incorporated, Durham, North Carolina. August. Table 2-9 Recommended Ammonia Emission Factors for Animal Husbandry. Internet address: http://www.epa.gov/ttn/chief/efdocs/ammonia.pdf

other areas that are spearheading ammonia emissions research rely on emissions factors from this report. This study recommends an emissions factor of 87.57 pounds of ammonia per dairy cow per year. This emissions factor was also used in the 1999 Treasure Valley Emissions Inventory.

Calculating Livestock Ammonia Emissions

Based on an emissions factor of 87.57 pounds of ammonia per dairy cow per year, each additional 1,000 dairy cows would contribute an additional 44 tons per year of ammonia to the airshed:

$$1{,}000 \text{ \sout{head}} \times \frac{87.57 \text{ \sout{lbs}}}{\text{\sout{head}} / \text{year}} \times \frac{1 \text{ ton}}{2{,}000 \text{ \sout{lbs}}} = \frac{\textbf{43.8 tons}}{\textbf{year}}$$

The following table shows ammonia emissions from a range of dairy sizes based upon the emission factor discussed here. The 1999 Treasure Valley Emissions Inventory estimates showed that total ammonia emissions in the valley were 6859 tons per year. An 8000 head dairy would increase total ammonia emissions in the valley by about 350 tons per year, or 5%. Application of control technologies could reduce the ammonia emission shown.

# cows	tons ammonia per year	% of current total ammonia emissions (6,859 tons)
100	4.4	< 1%
1,000	43.8	< 1%
5,000	218.9	3%
8,000	350.3	5%

Volatile Organic Compound Emissions from Large Dairies.

Volatile Organic Compound (VOC) emissions are important precursors to ozone and particulate matter. VOCs are formed as intermediate metabolites in the degradation of organic matter in manure. Under aerobic conditions, VOCs are oxidized to CO_2 and water, while under anaerobic conditions VOCs undergo microbial degradation. Microbes degrade VOCs to volatile organic acids and other compounds, which are then degraded to methane and CO_2. This occurs as long as the methanogenic bacteria are not unduly inhibited by such conditions as low temperatures or excessive loading rates of manure in liquid storage ponds and lagoons. VOC compound classes generally associated with livestock wastes[6] and confined animal feeding operations (CAFOs)[7]

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[4] ARB, 1999. *Estimates of Ammonia Emissions from Beef and Dairy Cattle in California*. California Air Resourrces Board, Planning and Technical Support Division. Internet address: http://www.arb.ca.gov/emisinv/pmnh3/pmnh3files/cattleEmissionsMethod.pdf

[5] Steven Parkin, 2000. *Memorandum: Summary of 1996 Methodology to Estimate PM_{10}, SO_X, and NO_X From Source Categories Inside Utah's 13-County UAM Modeling Domain*, Utah Division of Air Quality, February 16, 2000. Internet address: http://www.deq.sate.ut.us/EQAIR/SIP/PM10SIP/EI/Area_Estimate_Methods.htm

[6] Generic Environmental Impact Statement on Animal Agriculture: Summary of the Literature Related to Air Quality and Odor (H), University of Minnesota, College of Agriculture, Food, and Environmental Sciences, 1999.

include aldehydes, alcohols, carboxylic acids and ketones. Properly designed, sized and maintained lagoons and land application sites can minimize VOC emissions.

Unfortunately, VOC emissions from large dairies are very difficult to accurately quantify. The EPA standard source of emissions factors, AP-42, does not list VOC emissions factors for dairies. However, the South Coast Air Quality Management District, a leader in air quality research, uses a VOC emission factor of 16.0 pounds of VOCs per cow per year for emission credits applied to dairy relocations, under their 1999 Ozone Air Quality Improvement Plan [8].

Calculating Livestock VOC Emissions

Based on an emissions factor of 16.0 pounds of VOC per dairy cow per year, each additional 1,000 dairy cows would contribute an additional 8.0 tons per year of VOCs to the airshed:

$$1{,}000\ \cancel{\text{head}} \quad \text{X} \quad \frac{16.0\ \cancel{\text{lbs}}}{\cancel{\text{head}}\ /\ \text{year}} \quad \text{X} \quad \frac{1\ \text{ton}}{2{,}000\ \cancel{\text{lbs}}} \quad = \quad \frac{\textbf{8 tons}}{\textbf{year}}$$

Livestock Dust Emissions

Industrial sources emitting more than 100 tons per year of PM_{10} are considered “major” sources of air pollution, and must undergo a more rigorous permitting procedure[9].

While agricultural operations have not always been held to the same standards as other industrial sources, this factor does provide some guidance as to acceptable levels of emissions.

Calculating Livestock Dust Emissions

Particulate emissions from livestock made up of dust can be calculated using an emissions factor of 34.4 pounds of PM_{10} per head of cattle per year[10]. Based on this calculation, each additional 5,814 cattle would contribute 100 tons per year of PM_{10} to the airshed.

$$\frac{34.4\ \cancel{\text{lbs}}}{\cancel{\text{head}}\ /\ \text{year}} \quad \text{X} \quad \frac{1\ \text{ton}}{2{,}000\ \cancel{\text{lbs}}} \quad \text{X} \quad 5{,}814\ \cancel{\text{head}} \quad = \quad \frac{\textbf{100 tons}}{\textbf{Year}}$$

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[7] Iowa Concentrated Animal Feeding Operations Air Quality Study, Iowa State University, February 2002.

[8] South Coast Air Quality Management District, Board Meeting Date: December 6, 2002 Agenda No. 22 Internet address: www.aqmd.gov/hb/021222a.html

[9] Idaho Rules for the Control of Air Pollution IDAPA 58.01.01.006.55

[10] ARB, 1999c, *Area Source Methodologies – Section 7.6 (Cattle Feedlot Dust)*. California Air Resources Board, Sacramento, California. December 20. Internet address: http://arbis.arb.ca.gov/emisinv/areasrc/onehtm/one7-6.htm

Considering Impacts

Treasure Valley communities have expressed a willingness to be active participants in Airshed Management and consider the ways in which community planning choices impact air quality. Ammonia, VOCs and dust from livestock operations have the potential to impact air pollution levels and public health. DEQ urges local planners to consider air quality impacts when approving operations within their jurisdictions. The choices we make now will affect the choices we are able to make in the future.