A REVIEW OF NATIONAL AND INTERNATIONAL ODOR POLICY, ODOR MEASUREMENT TECHNOLOGY AND PUBLIC ADMINISTRATION

Prepared By:

SRF Consulting Group, Inc.
One Carlson Parkway North, Suite 150
Minneapolis, MN 55447-4443
Phone: 763-475-0010
Fax: 763-475-2429

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APPENDICES

1.0 INTRODUCTION

This report was prepared at the direction of the Minnesota Pollution Control Agency (MPCA). Its purpose is to present the current state of the practice in odor regulation in the United States and selected countries around the world, review the regulatory need in Minnesota, the rest of the country and internationally, as well as the state of the science, and present a regulatory framework or policy that could be implemented in Minnesota. Section One provides an overview of odor and its effects as well as an outline to this document. Section Two is a primer on odor measurement and source type. Section Three is a discussion of odor regulation in Minnesota which includes permitting and environmental review activities. Section Four is dedicated to odor issues in Minnesota and features the results of the county odor survey. Section Five provides a review of various odor regulatory methods with Section Six illustrating a model odor regulatory framework. Section Seven is the decision matrix which includes the elements of odor regulation and program management, including the science and technology regarding measurement that can be used to determine a direction on odor policy for the MPCA.

1.1 Odors and their Effects

Odors are defined as sensations that occur when chemical substances (called odorants) stimulate receptors in the nasal cavity (McGinley, 2000). Most odors perceived in the environment are made up of a multifaceted mixture of odorants. The compounds that make up particular odors are often present in small concentrations and can act in the human nose in a complex effect making their regulation by the setting of emissions limits (as is standard for other ambient air pollutants) complicated. The effects of odors are equally complicated and range from the associative and the psychological to the measurable and the physiological.

From an evolutionary perspective, the sense of smell developed to help animals assess their environment. A particular odor may elicit various behaviors, from the attraction to a potential meal, to a warning of present danger or potential sickness. The sense of smell and memory appear to be closely tied together. Odor-evoked memories may seem clearer or more intense than other memories because they appear to be more emotional than memories triggered by visual, audio or other types of cues, (Herz, 1998). While odors don't help people recall more information, the memories they evoke are more emotionally laden.

A common example of this emotionally associative experience occurs when we sense a particular smell triggering vivid memories of experiences that happened long ago. These associative and emotional characteristics of the sense of smell may be important in the field of odor regulation because negative associations to odors, once formed, seem to be difficult to change. For instance, a neighborhood may develop a negative association to a particular odor during a period of intense odorous emissions. This negative association may be maintained even after odors are substantially and measurably reduced.

Potentially negative human health effects may be experienced by people due to exposure to odorous emissions, and a link exists between noxious odors emanating from manures and biosolids and health symptoms (Schiffman et. al, 2000). The most frequently reported health

effects of odors are described as eye, nose, and throat irritation, headache, nausea, diarrhea, hoarseness, sore throat, cough, chest tightness, nasal congestion, palpitations, shortness of breath, stress, drowsiness, and alterations in mood.

1.2 Odor Investigation Activities

In order to comprehend the current range of odor issues in Minnesota, and the current regulatory environment as well as the field of odor measurement technology, the MPCA began this odor investigation process. This project was initiated in early March 2003 and concluded June 30, 2003. Project oversight was provided by three staff persons from the MPCA working with their consultants, SRF Consulting Group, Inc. and St. Croix Sensory, Inc.

Work tasks completed as and documented in this report included the following:

- Reviewing selected literature on odor measurement and regulation (see literature source list in Appendix A);
- Conducting a mail survey to request input on odor problems and regulation from all Minnesota Counties;
- Meeting with key staff from three groups of the MPCA (permitting, compliance and environmental review) staff;
- Meeting with University of Minnesota College of Agriculture professors and engineers;
- Conducting over 30 phone interviews with personnel involved in odor regulation in Minnesota, in other states around the country and other countries.
- A technical evaluation of odor measurement techniques was prepared by St. Croix Sensory, Inc. concurrent with this investigation and is included as Appendix D of this report.

1.3 Report Organization

This report is organized into seven chapters:

1. **Introduction:** This chapter describes the study process, work tasks and introduces the concept of odor and its effects.

2. **A Primer on** Odor: This chapter will orient the reader to basic technical terms used throughout the report. It also presents an overview of current and emerging odor measurement techniques, including those based on sensory measurements (i.e., relying on the human experience of odor), and chemical analysis techniques, in which certain chemicals are identified as "surrogates" for odor and measurement is aimed at identifying the amount of these chemicals present in the ambient air. Typical source types for odor are also described in this chapter, along with the chemicals often associated with the odors they generate.

3. **Current Odor Regulation in Minnesota:** In this chapter, current odor regulation in Minnesota is discussed, for both animal feeding operations, as well as for commercial, industrial, and manufacturing operations.

4. **Odor Issues in Minnesota:** An integral part of this odor investigation was an analysis of the current need for odor regulation or guidance in Minnesota. To this end, the MPCA complaint database was analyzed to determine the amount of complaints typically lodged in a year, as well as the source types referenced in these complaints. In addition, a summary of the results of a survey administered to all 87 Minnesota counties querying them as to their experience in managing nuisance odor issues is also included here.

5. **Odor Regulatory Approaches:** The means by which other states and jurisdictions currently handle nuisance odor emissions is documented in this chapter. The results of telephone interviews held with over 30 state agencies and jurisdictions are summarized, along with an introduction to the various regulatory approaches that are currently available to manage nuisance odor issues.

6. **A Model Odor Regulatory Framework:** A model framework for an odor regulatory process is presented in this chapter, covering the permitting, environmental review and compliance/enforcement process.

7. **An Odor Regulatory Matrix:** In this concluding chapter of the report, various regulatory options available to the MPCA are summarized, in addition to the "pros and cons" of pursuing such a regulatory option.

2.0 A PRIMER ON ODOR

Although almost all persons possess the ability to sense odors, it is a phenomenon not well understood by most. The typical person, when asked to describe an odor, may use a vocabulary as well suited to poetry as to science, using terms like "floral", "woodsy" or "rotten", to name just a few. In the scientific arena, however, odors are characterized not only by descriptive words such as those listed above, but by other terms less immediately comprehensible. The interested layperson can quickly feel overwhelmed, lost in a sea of jargon. For this reader, we attempt to summarize here the most commonly used terms when discussing odorous emissions (Horizontal Guidance for Odour, Part 1 – Regulation and Permitting). Appendix D of this report contains a much more extensive odor terminology glossary for those readers needing greater detail.

Area Source

A surface-emitting odor source, which can be solid (for example the spreading of wastes or material stockpiles) or liquid (manure storage lagoons, effluent treatment plant).

Character

Odor character is a qualitative attribute of an odor and is expressed in words that describe what a substance smells like (eg. fruity or rotten eggs).

Duration

The period of time in which odorants are received by a receptor population and perceived as odors.

Detection Threshold

The point at which an increasing concentration of an odor sample becomes strong enough to produce a first sensation in 50 percent of the people to whom the sample is presented.

Frequency

How often an odorous emission will be experienced by a receptor population.

Hedonic Tone

Hedonic tone describes the degree of pleasantness or unpleasantness and is a subjective assessment of the offensiveness of an odor.

Intensity

Intensity refers to the perceived strength of the odor sensation and generally increases as a function of concentration.

Odor

The perception experienced when one or more chemical substances in the air come in contact with the various human sensory systems (odor is a human response).

Odorant

Any chemical that is part of the perception of odor by a human (odorant is a chemical).

Odor Concentration

Measured as “dilution ratios” and reported as “detection threshold” (DT) or “recognition thresholds” (RT) or as “dilution-to-threshold” (D/T) and sometimes assigned the pseudo-dimension of “odor units/cubic meter.”

Point Source

An intentional point of release, such as a vent or a chimney.

ppb

Parts per billion

ppm

Parts per million

Receptor Population

People who are or may be exposed to odor released from a given source.

2.1 Odor Measurement

Odor Measurement Tools	
Analytical	Sensory
• Chemical Identification • Instruments (Gas Chromatograph-Mass Spectrometer: electronic noses)	• Human response • Field / Laboratory

While odor is a subjective experience that varies from person to person, regulation often requires objective and reproducible measurement techniques.

Measurement of odors is most often done to determine the strength of an odor. Odor strength can be measured as intensity or concentration and sometimes both. Odor may also be evaluated using gas surrogates depending on the chemistry of the odor plume. A technical addendum regarding odor measurement is attached to this report; however, a brief summary of selected odor measurement techniques is presented below.

2.1.1 Odor Intensity

Odor intensity is measured by a panelist or technician who compares an odor to a number of standard solutions of a specific reference chemical at various dilutions. Methods used in this technique have been standardized by the American Society for Testing and Materials (ASTM). Results of this test are expressed as units on a numerical scale, with each numerical unit corresponding to a concentration in ppm of the reference chemical, n-Butanol (see Appendix D, Section 3.4). This method can be conducted by a trained technician in a laboratory or in the field. The test can be applied to a sample of air taken in the field and tested in the laboratory or to ambient air conditions in the field.

Based on conversations with various regulatory agencies (see Section 5.3.3) this method is currently used to measure ambient odor levels in the states of North Carolina and Idaho. The results of intensity measurements are used to determine compliance but cannot be used in dispersion modeling. As described in Section 3.42 of Appendix D, odor dispersion models require units of concentration.

Advantages of this measurement method are portability, and ease of use in addition to its relatively low cost. A measurement can be conducted by a trained inspector in the field using a portable test kit.

2.1.2 Odor Concentration

The measurement of odor concentration, known as olfactometry, is performed through dilution of an ambient odor or an odor sample using the human nose as the sensor to determine thresholds of recognition or perception at various dilutions. Odor concentration results are presented (or reported) as dimensionless dilution factors (dilution ratios) and often also reported as odor units per cubic meter (volume) or dilution-to-threshold (D/T). In general one odor unit equals the

concentration of the odor that is just detectable. For example, if an odor sample is diluted with 5 parts of odorless air to get to the threshold of detection, the sample would be considered to have a concentration of 5 OU or D/T (i.e. one odor unit is the threshold of detection). Further detail on odor concentration units is presented in Appendix D.

Odor concentration measurement can be performed in a laboratory using a dynamic olfactometer or in the field using a handheld olfactometer (commonly referred to as a Scentometer). While these two methods produce results in the same units, they are not currently interchangeable. Based on discussions with University of Minnesota College of Agriculture Staff, Laboratory olfactometry is generally considered to be more sensitive than field olfactometry (see Appendix C for text of the interview). Laboratory olfactometry can be performed on high strength odor samples. The results are expressed in units of concentration that can be used to predict downwind odor concentrations using dispersion modeling.

Sensory Odor Measurement

Concentration	Intensity
• Measures odor strength in terms of how much dilution is required to make a sample undetectable to human nose • Dilution to threshold (D/T) measurements • Concentration sometimes presented in odor units • Evaluated using dynamic olfactometry	• Determines the strength of the odor above the threshold of a reference gas • Butanol commonly used as reference • Intensity expressed in ppm of butanol • Differing static scales in place to state results

As discussed in Section 3.3 of Appendix D, methods for determining odor concentration have evolved over the past 50 years in an attempt to improve accuracy and repeatability. The major sources of error in this type of measurement include the potential for degradation of a sample after it is collected and the variation in performance of odor panelists. The most recent advance is the development of the "European Standard". As described in the appendix, the use of this standard has improved the reliability of odor concentration analysis.

The major advantage to olfactometry is the direct correlation of the odor to the human's sensitive sense of smell. Additionally, olfactometry analyzes the complete gas mixture so that contribution of each compound in the sample is included in the analysis. Sources of error in this method include variations in the sensitivity of odor panelists and degradation of the quality of the sample after it is collected. This measurement method is labor intensive and relatively high cost. A typical single source analysis can cost approximately $700 to $800 assuming that, for regulatory purposes, three or four individual samples must be collected.

2.1.3 Analyzing Specific Chemical Odorants (Chemicals)

Analyzing emissions levels of specific chemical odorants is a means of measuring odor that is not reliant on human sensory perception but instead is aimed at identifying chemicals that may be identified as "surrogates" for perceived odor. These odorants then become chemical markers, the measurement and regulation of which is anticipated to address odor issues. Field analysis of chemical odorants and other chemical substances can be accomplished using a variety of portable analysis methods ranging from low-cost colorimetric detector tubes to higher-cost portable electronic instruments. This approach has particular appeal if the constituent being measured is a major contributor to the odor being represented. Examples of gas surrogates include hydrogen sulfide, total reduced sulfur, ammonia, and volatile organic compounds. Volatile organic acid concentrations have also been used as an alternative to odor intensity assessment and the correlation is good enough to be useful (Zahn, 1997 and Zahn, et.al. 2001). The MPCA currently employs a similar method in the Environmental Review program. See Appendix D, Section 5.0 for a detailed discussion of how individual odorants can be measured and analyzed.

Of the states and localities that were part of the sample interviewed for this Odor Investigation (see Section 5), two are currently regulating the emissions of certain chemical substances as proxies for odor; these areas are the San Francisco Bay Area Air Quality Management District, and the State of Connecticut. It should be noted that both of these areas still have provisions for odorous emissions as a nuisance phenomenon that may be unrelated to measurable emissions of any chemical substances. Odor regulations in Montreal, Canada and in the Province of Ontario also set emissions limits for a wide range of chemical substances; however, they also have established limits for odorous emissions as a nuisance phenomenon unrelated to measurable emissions of regulated chemicals. In discussions with the regulatory agencies overseeing these "two-pronged" odor regulations (one in which odors are regulated based on emissions of chemical compounds as well as by odor strength or concentration) discussed above, it was evident that these regulations were formulated in order to account for the broad spectrum of potential impact to humans from odorous emissions. Although chemical compounds can be used as surrogates for odors, because of the complex way in which odorants interact with the human perception of odors, there can be instances in which odors are perceived by persons although chemical measurement may not result in any substantiated exceedance of regulated compounds. Accounting for both "emissions-based" odor events, in addition to odor events unrelated to measurable emissions allows regulatory agencies to cover the spectrum of any perceived odor issues. In addition, it gives an agency flexibility in determining a response to odor complaints, and in formulating the appropriate enforcement action.

2.1.4 Emerging Odor Measurement Tools

An emerging area of study is the identification of odorants and a correlation between the presence and concentration of individual compounds and the human perception of odors. Gas chromatography and electronic noses are potentially useful in providing an immediate, objective, non-sensory method for odor evaluation. Gas chromatography can identify specific chemical indicators of odor however a larger database of odor compositional information is needed for this technology to be practical in measurement of environmental odors. When tested for fairly

common (dairy and swine) odorants, it was found that the use of an electronic nose to mimic the human response appears to be in its development stage, and the drawbacks of these technologies are likely to be magnified on less common odors (Powers, 2001).

Electronic noses can be calibrated to recognize a specific odor and a relationship between the response of an electronic nose and odor concentration can be derived for odors from the same place at the same time. However the relationship between electronic response and similar odors from different places or from different time periods seem to differ, possibly a result of differences in gas mixtures (Nimmermark, 2001).

While electronic nose technologies appear currently to provide little practical use in odor regulation at this time, this technology may become a more useful regulatory tool in the future. Odor measurement using intensity reference scales, olfactometry, and various chemical surrogate methods appear to be robust, repeatable, and readily available for use to respond to odor issues.

Odor Measurement Summary Table

Methodology	Odor Attribute Measured	Commonly Expressed As	Capital Costs/Maintenance Costs/Training	Environmental Review/ Permitting	Compliance and Enforcement
Lab Olfactometry	Concentration	Odor Units, or Expression of Odor by Volume	Analysis Cost is approx $750/sample, assuming 3-4 samples collected	Useful for determining source strength if a sample is available	Useful for determining source strength and ambient concentration
Field Olfactometry (Scentometer or Nasal Ranger)	Concentration	Dilutions to Threshold or D/T	Moderate Maintenance and Training	Useful only if a facility is operating.	Useful for assessing compliance at off-site receptors.
Odor Intensity Measurement: ASTM E544-99 (n-butanol standard)	Intensity	Butanol concentration to odorous air (ppm)	Low Maintenance Moderate Training	A intensity level could be used as a design goal or standard.	Useful for assessing compliance at off-site receptors
Trained Odor Assessor	Subjective	Various Odor Annoyance Scales	Low Maintenance Moderate Training	Subjective assessment. Not useful for review or permitting.	Subjective assessment is a good first step at determining compliance.
Community Survey	Subjective	Various Odor Annoyance Scales	Low Maintenance and Training	Useful in determining current level of annoyance in a receptor community.	Useful in determining level of annoyance.

2.2 Odor Source Types

Although there are numerous ways in which to organize and categorize odor source types, it was determined that the most effective way to present this information was to categorize source types as animal feeding operations (AFO) or commercial, industrial, or municipal (CIM). This taxonomy was developed for a number of reasons. First, the political and institutional reality of AFO air emission source types is that they are managed differently than other CIM air emission source types in terms of environmental programs. Secondly, although there are as many exceptions to this rule as instances of adherence, AFO odor sources can generally be understood as area or diffuse and uncontrolled sources of odor, the measurement and mitigation of which entails quite different strategies than for those odors arising from point sources (e.g. smoke stacks), as is more commonly the case for CIM odor source types.

It is important to note that for both odor source types, certain chemical compounds can be attributed to odorous emissions. However, chemical compounds are not regulated solely for their odor impacts. Compounds such as hydrogen sulfide and volatile organic compounds (VOCs) are regulated for their impacts on human health and the environment, and while the standards do recognize the concepts of annoyance and nuisance (Minn. R. 7009.0010, subps. 2 and 3) the numbers do not necessarily relate well to odor thresholds. A compound such as hydrogen sulfide has a low odor threshold and can be detected at much smaller amounts than what may be harmful to human health and the environment. In this sense, using currently established federal and state standards for chemical emissions is not a good proxy for odor, as odors can be detected well before the emission levels reach a regulated threshold.

The following examples of source types, particularly for industrial, commercial, and municipal types, describe regulated odorous compounds associated with each type of process. However, these compounds are regulated for their human health impact not for their odor annoyance.

ODOR REGULATORY SUMMARY

AFO	CIM
• Primarily related to livestock • Four major sources within an agricultural operation exist. 1. livestock 2. housing facility 3. waste storage facility 4. land application process • Manure storage and application appear to be the primary cause of odor complaints. • Decomposition of manure emits chemicals and gases such as H_2S and ammonia	• Many potential sources including: 1. sugar beet processing facilities 2. coffee roasting facilities 3. kraft pulp mills 4. auto painting facilities 5. ethanol plants • Primarily point sources • Tend to emit VOCs and HAPs, which are regulated under the Clean Air Act based on their effect on human health • Coffee roasting facilities emit more of nuisance/annoyance odor

2.2.1 Animal Feeding Operation (AFO) Source Types

Although complaints about odors emanating from livestock facilities is no doubt as old as animal domestication itself, its record in legal history dates as far back as 1611 when William Aldred bought suit against Thomas Benton under British common law, claiming that

Benton's hogs were creating an odor infringing on his right to enjoyment of his property. The court decided in Aldred's favor and Benton's hogs were moved (Aldred v. Benton, 77 Eng. Rep. 816).

There are four primary sources of odor from a livestock facility (Jacobson, et al., 1998). They are:

1) The animals themselves;

2) The livestock housing facility;

3) The animal waste storage facility; and,

4) The land application of waste.

A study conducted in the United Kingdom in 1982 reported that roughly 50 percent of all odor complaints were attributed to land application of waste, while 20 percent and 25 percent were attributed to waste storage facilities and livestock housing facilities respectively. This study also reported that hog facilities tend to be the source for slightly more than half of all odor complaints (Hardwick 1985). Presently the use of larger manure pits allows for longer storage of animal wastes, which tends to result in more odor complaints associated with waste storage facilities. The most problematic agricultural odor source is open-air manure storage systems. There are two types of such systems 1) lagoons, which assume a level of treatment within the systems, or 2) basins, which are generally used for storage with no treatment. Odor control measures for open-air manure storage systems are essentially limited to floating covers.

As stored manure begins to decompose, gases and chemicals are released, of which there are over 200 chemicals associated with hog waste. Chemicals responsible for hog manure's distinctive smell include compounds such as hydrogen-sulfide and ammonia (O'Neil and Phillips, 1992). Hydrogen sulfide is of concern as it has significant human health effects including headaches, nausea, and dizziness.

Hydrogen sulfide inhalation is a leading cause of occupational mortality, and the compound has a known and well-published toxicity (North Carolina Scientific Advisory Board on Toxic Air Pollutants, 2001). Hydrogen sulfide is a colorless gas that smells like rotten eggs. The odor can be perceived at levels as low as 10 ppb, but levels this low are unlikely to cause severe health effects (Mandavia, 2001). Hydrogen sulfide is considered a neurotoxin, and high levels of exposure can cause the human sense of smell to fail, which in turn may lead to overexposure and adverse health effects (North Carolina Scientific Advisory Board on Toxic Air Pollutants, 2001).

Although much of the interest and research in feedlot odor has been directed at hog farms, livestock odor is not restricted to these types of facilities. Dairy farms and poultry farms receive a share of odor complaints as well.

2.2.2 Commercial, Industrial, and Municipal (CIM) Source Types

According to a national study conducted by the United States Environmental Protection Agency, as the level of industrialization increases, the number of odor complaints tends to increase (Young, 2001). CIM or industrial odor sources can include the following:

- sugar beet processing facilities
- coffee roasting facilities
- pulp mills
- auto painting facilities
- ethanol plants
- wastewater treatment facilities

2.2.2.1 Sugar Beet Processing

According to Sugar Knowledge International, 30 percent of sugar produced globally is produced from sugar beets. The average sugar beet is approximately 17 percent sugar, and the rest is byproducts such as pulp and molasses. The pulp is commonly spread on fields to dry, and is then used as animal feed. Odor problems appear to arise when sugar beet pulp begins to rot in the fields; however, processing also creates odor events.

For example, in Yolo County California, dozens of complaints were made to the Yolo-Solano Air Quality Management District and city and county officials regarding the Spreckles Sugar plant. The complainants described the odor as smelling like the inside of a dirty diaper pail, and it was determined that the odor was the result of sugar beet shavings that were rotting in the fields.

According to MPCA staff, odors from wastewater treatment basins at sugar beet processing plants have also been a consistent source of complaints that has led to the MPCA requiring at least one facility to conduct ambient monitoring for hydrogen sulfide around the facility.

2.2.2.2 Coffee Roasters

There are two potential sources for odor from a coffee roasting facility, the actual roasting process, and the cooling process after the beans have been roasted. During the roasting process, green coffee beans are subjected to hot combustion gases which result in the emission of particulate matter and volatile organic compounds (VOCs), such as smoke and odors. After the beans have been roasted they are dumped into large trays where they are exposed to large volumes of cool air, and because the beans are still extremely hot they continue to emit smoke and odors. Gillies Coffee Company in New York City and Craven's Coffee in Spokane, Washington provide two examples of nuisance resulting from odor emissions from coffee roasting facilities.

- In June 2002, after receiving several complaints from a nearby resident, The New York City Department of Environmental Protection (DEP) issued a summons in Winter 2003 against

Gillies Coffee Company for polluting the air around the coffee roasting plant. The DEP cited the coffee odors as a violation under its clean air regulations. The case was heard by the Environmental Control Board of New York City and in April 2003, an Administrative Law Judge ruled in favor of the DEP and ordered Gillies Coffee Company to pay the $400 fine (Grace, 2003).

- Craven's Coffee, is the largest coffee roaster in Spokane, Washington. In the mid-1990s the company was required to install an afterburner to control smoke and odors as required by the Spokane County Air Pollution Control Authority (SCAPCA). However, odor complaints were still being received. After further investigation it was determined that odors were resulting from the cooling process and not just the roasting process. Craven's installed a water quench smoke suppression system, which retards the roasting process, and since then there have been virtually no odor complaints (Compliance Assistance Program Update, 1999).

2.2.2.3 Kraft Pulp Mills

As of September 2000, the United States had 565 pulp and paper plants nationwide. Many of these plants use the kraft process to turn just about any wood species into paper pulp. The kraft process uses chemicals such as sodium hydroxide, sodium sulfide, and sodium carbonate along with heat to produce pulp, which will then be used to make strong fiber paper products such as food board and linerboard. A byproduct of this process is total reduced sulfur (TRS), which is a combination of compounds including, methyl mercaptan, dimethyl sulfide, dimethyl disulfide, and hydrogen sulfide (Young, 2001). It is the combination of these chemicals that results in the detectable odor. The smell has been likened to rotten eggs, bad cabbage, and sauerkraut among other things.

The state of Pennsylvania has three of the nation's kraft pulp mills and all three have had odor complaints filed against them. Two examples follow:

- The P.H. Glatfelter Company, a kraft pulp mill, had 87 complaints filed against it between 1992 and 2000. Complaints were filed with the Pennsylvania Department of Environmental Protection, but the company has never been cited with violating the state's malodor regulation. However, in 1999 the Environmental Protection Agency cited the company for violation of the Clean Air Act based on the plant's total emissions (Smith, 2000).

- Appleton Papers, Inc. was cited by the EPA to be in violation of its sulfur emissions limit, which is regulated under the Clean Air Act. The case was settled in 2000 with the company agreeing to pay upwards of a $400,000 fine and to install pollution control equipment, which would cost nearly $10 million (Smith, 2000).

2.2.2.4 Auto Painting

Chemical odors from VOCs are associated with auto painting shops. To reduce odor emissions from these facilities, auto refinishing spray booths are typically used. In addition to spray

booths, there are also VOC abatement technologies that can be used to break down the chemical compounds into less harmful and less odorous substances.

A number of jurisdictions have had to deal with auto painting facilities as a source of odor.

- The Oregon Department of Environmental Quality (DEQ) has received several complaints regarding odors from auto painting facilities. Currently the DEQ does not issue air permits for auto body repair and painting businesses. However, businesses within the Portland Air Quality Maintenance area are subject to certain requirements. The DEQ is also planning on sponsoring a free training seminar to auto body refinishers to help educate them on how to use paint efficiently so as to decrease air emissions and hazardous waste (Oregon Department of Environmental Quality, 2003).

- Sacramento County in California has established separate complaint line through the Environmental Health Department to report complaints regarding paint fumes (Sacramento County, 2003).

- In St. Louis Park, Minnesota fumes and odor were concerns for residents when a local auto body shop proposed an auto painting facility within 300 feet of a residential neighborhood (City of St. Louis Park, 2002).

- In 1992, odor complaints against Crown Auto Rebuild, Ltd. in Seattle, Washington led to inspections by the Puget Sound Air Pollution Control Agency (PSAPCA). PSAPCA found that the company was operating without proper ventilation systems and cited the facility for the violation. In 1993, a routine inspection found the exhaust system of the facility to be non-compliant and the facility was fined $3,000. Crown Auto appealed to the Pollution Control Hearings Board with the argument that the penalty was unreasonable. Based on the company's previous violations, the Board upheld the PSAPCA decision and ordered Crown Auto to pay the $3,000 fine (Crown Auto Rebuild, LTD v. Puget Sound Air Pollution Control Authority, 1993).

2.2.2.5 Ethanol Plants

The primary source of odor from these facilities results from drying the leftover corn mash after the ethanol has been removed. Although the impacts of ethanol odor have not been definitively quantified or regulated, it has been determined that volatile organic compounds (VOCs), which are often associated with odor, are being emitted in much larger quantities than previously estimated.

Volatile organic compounds are monitored under the Clean Air Act a criteria air pollutants. Exposure to these compounds can result in adverse health effects such as breathing problems, asthmatic complications, decreased lung function, eye irritation, and may lead to more serious health problems such as cancer (Plain English Guide to the Clean Air Act, 2002).

The problems in Minnesota, including problems at the Gopher State Ethanol Plant, have provided the impetus for EPA to begin monitoring ethanol plants across the country. EPA found

that several ethanol plants nationwide were in violation of the Clean Air Act for several regulated pollutants including VOCs and hazardous air pollutants (HAPs).

In April 2003, a landmark settlement was reached between EPA and the Archer Daniels Midland Company (ADMC), which owns 52 plants in 16 states. The settlement requires ADMC to install pollution control technology, shut down some of their older plants, and pay a civil penalty of $4.6 million (EPA Press Release, 2003).

2.2.2.6 Wastewater treatment facilities

Complaints received regarding wastewater treatment facilities are common across the United States. Odorants commonly associated with wastewater treatment facilities are hydrogen sulfide, and reduced sulfur organic compounds.

- In North Carolina an investigation was completed regarding odor problems associated with wastewater treatment facilities. The study used several methods for data collection including: public participation, an advisory board, plant operating records, odor evaluation of plant sources, and wind data (Aitkin and Okun, 1991). This study used odor perception data collected by participants and related the data to individual factors to reveal trends. Trends could then be easily observed through the use of bar graphs.

- In 1993, San Francisco received an EPA First Place Award for its wastewater collection and treatment system. However, periodically there are still complaints received by city personnel. These odor complaints tend to result from temperature fluctuations, build-up of debris in the sewer, and plant process or equipment problems. The city has developed an Odor Control Program and has established a 24-hour hotline where these complaints can be reported (City of San Francisco, 2003).

3.0 CURRENT ODOR REGULATION IN MINNESOTA

ODOR REGULATORY SUMMARY	
Animal Feeding Operation Sources	**Commercial, Industrial, Municipal Sources**
• No direct regulation for odorous emissions • Clean Water Act regulates manure storage and handling procedures as they pertain to water quality for feedlots greater than 1,000 AU	• No direct regulation for odorous emissions • Clean Air Act regulates odorous chemical compounds such as H_2S, VOCs, and HAPs, based on thresholds for human health not thresholds for odor
• Feedlot rules adopted in 1971 and revised most recently in 2000 • State ambient air standard for H_2S enforced by MPCA. Ammonia issues addressed. • Other odor problems can be dealt with using nuisance law	• MPCA Odor Rule in place 1970-1996 • State ambient air emissions standards for H_2S and VOCs enforced by MPCA • Some odor problems can be dealt with using nuisance law

ODOR REGULATORY SUMMARY	
Animal Feeding Operation Sources	**Commercial, Industrial, Municipal Sources**
• Few Minnesota counties have odor regulations • The use of setbacks through planning and zoning is commonly used to address feedlot odor issues • Counties can be the permitting authority for feedlots up to 1,000 AU • Conditional use permits can be used to address feedlot odors • Other odor problems can be dealt with using nuisance law	• Few Minnesota cities have odor regulations • Cities tend to deal with odors using nuisance law • For VOCs and HAPs cities defer to MPCA for regulation

Since 1996, there has been no clear regulatory authority or agency with jurisdictional oversight of odor issues in Minnesota. And yet, as recent events have made clear, it is not an issue that has dissipated simply because regulation has gone lacking.

Many state environmental regulations depend, at least in part, from federal regulation. Although states are free to set more stringent standards, for example, for water or air quality, federal standards, if enacted, must be met at a minimum. For this reason it is instructive to begin a discussion of current state odor regulations with an examination of federal regulations. The federal government does not directly regulate odors under the Clean Air Act or under any other regulatory program; however, odors are sometimes regulated indirectly under traditional ambient air quality standards and emission source regulations insofar as regulating air toxics or other emissions may have beneficial impacts in reducing odors.

3.1 Federal Regulation of Commercial, Industrial, Municipal Odorous Emissions

Currently there are no federal regulations for odor emissions from CIM sources, such as asphalt plants or ethanol plants or any other industrial odor source. Any odor issues arising from sources other than AFOs are typically handled by state agencies, local jurisdictions, or a combination of both, depending on the state (see Section 5). Under the Clean Air Act, the Federal government does regulate criteria air pollutants, as well as air toxics. Some of these pollutants, such as volatile organic compounds (VOCs), are associated with odors; therefore, regulation of these pollutants may indirectly address odor issues, although regulation of odorous emissions is not a direct outcome intended to result from enforcement of these standards.

3.2 State Regulation of CIM Odorous Emissions

As discussed above, there are several state and federal air pollution regulations focused on defined air pollutants; however, even though all current standards for air emissions may be met, odors resulting from animal feeding operations, industrial processes or other regulated processes can still be present in the ambient air. This is due to the fact that not all compounds resulting in

odorous emissions are classified as air toxics under the Clean Air Act (e.g., hydrogen sulfide). In these cases, a Minnesota resident can bring a claim under the nuisance tort of common law claiming that the actions of another person or entity has caused them material injury or annoyance. Since no other odor regulation currently exists in Minnesota, seeking relief under a claim of nuisance may be the only legal recourse that exists in Minnesota.

3.2.1 Minnesota Odor Rule (1970-1996)

Odor was previously regulated by the Minnesota Pollution Control Agency (MPCA) by the Air Quality Division under an odor rule established in 1970 (Minn. Rules Ch. 7011). This rule was intended to directly address odor by regulating emissions from industrial sources. The rule did not regulate odor from feedlots or other agricultural source types.

The former rule was based on numerical standards with odor standards placed on smokestacks and at the property line of the emitting facility. The former rule had two significant deficiencies:

1. Numerical standards are not consistent with how odor is actually perceived. A facility may be out of compliance with these standards, but no complaints may have been generated and vice versa, some sources may be in compliance with the standards, but continue to generate complaints; and,

2. The odor testing method cited in the rule was outdated, and no longer supported by the American Society of Testing and Materials (ASTM).

These deficiencies made the rule ineffective for regulating odor and the MPCA discontinued the enforcement of the odor rule in 1992 (Giles, 1996). Consequently, the rule was repealed effective November 19, 1996 (State Register, 1996). Furthermore, the administrative law judge in the case ruled that MPCA staff had failed to "show need" for a new odor rule. Because no new odor regulation has been written since the repeal of the old rule, many industries are exempted from performing odor emissions testing.

3.3 Regulation of Odorous Emissions from Animal Feeding Operations

The concentration and consolidation of animal production in the United States and in Europe was a phenomenon of the 1990s and continues into the new millennium. Although the number of overall farming operations continues to decrease in Minnesota and the nation, the rise in large, consolidated operations continues. What this means in agricultural communities is that more animals are being raised in confined spaces than ever before. As with any major change, growing pains have been experienced by these operations and by their neighbors. Recent regulations at both the federal and state level address the impacts that these operations may have on the environment and on neighboring communities.

3.3.1 Federal Regulations of Odorous Emissions from Animal Feeding Operations

For AFO air emission sources, there is currently no federal regulation or rule directly addressing odorous emissions resulting from agricultural activities. Under the Clean Water Act, the United States Environmental Protection Agency has promulgated regulatory requirements for concentrated animal feeding operations. These requirements address manure handling and storage as it pertains to water quality.

3.3.2 State Regulations of Odorous Emissions from Animal Feeding Operations

Minnesota rules for regulating feedlots were first adopted by MPCA in 1971 and have been amended in 1974, 1978, and 2000. These rules give the MPCA the authority to control pollution from livestock facilities. The MPCA issues permits to all livestock facilities with the capacity to house more than 1,000 animal units (a.u.). The MPCA and/or its delegated county partners may issue permits for livestock facilities under 1,000 animal units. An animal unit is a number used to approximate the amount of waste and potential environmental impacts resulting from the husbandry of that particular animal. For example, in Minnesota a mature cow over 1,000 pounds equals 1.4 animal units. A laying hen or broiler, if kept in a facility with a liquid manure system, is equal to 0.033 animal unit; however, if the chicken is kept in a facility with a dry manure system it is equal to 0.005 animal units if over five pounds, or 0.003 animal units if under five pounds. More information on the definition of an animal unit in Minnesota can be found at, http://www.revisor.leg.state.mn.us/arule/7020/0300.html.

To help administer these rules, the MPCA implemented the county feedlot program delegating responsibility to Minnesota counties by allowing them to issue permits for all livestock facilities housing less than 1,000 animal units. Odor is addressed as part of the permit application primarily through Air Emissions and Emergency Response Plans, which are required for feedlots with 1,000 animals units or more, and for manure storage facilities capable of holding manure from 1,000 animals units or more. These response plans are required to include the following:

- Identify all sources of emissions
- Methods and practices which will be used to minimize air pollution emissions resulting from the sources
- Methods for mitigating air emissions
- Complaint response protocol, which describes how the owner/operator will respond to odor complaints

The Minnesota Right-to-Farm law (Minn. Stat. Section 561.19) makes it difficult for citizens to bring odor nuisance suits against nearby farmers by providing protection to farmers by "strengthen[ing] the legal position of farmers, when neighbors sue them for private nuisance and protect[ing] farmers from anti-nuisance ordinances and unreasonable controls on farming operations" (Farmland Information Center, 1998). Minn. Stat. Section 561.19 states that "…an agricultural operation shall not be a nuisance if it was not a nuisance when it was established and if it is operating under generally accepted agricultural practices, is located within an agricultural zone, and is in compliance with federal and state statutes." As has been mentioned previously, AFOs can be in compliance with state ambient air emissions standards, but still be perceived as a nuisance to neighboring residents because odors may be detectable, although other air quality standards may be met.

3.3.2.1 Feedlot Hydrogen Sulfide Program

Minnesota Statute 116.0713 directs the MPCA to "monitor and identify potential livestock facility violations of the state ambient air quality standards for hydrogen sulfide and to take appropriate actions necessary to ensure compliance." As manure decomposes hydrogen-sulfide (H_2S) gas, typically associated with a "rotten-egg" type smell, is released. Manure storage and decomposition is one of the primary sources of livestock odor. At high concentrations, above the ambient air standard, H_2S has been linked to severe adverse health effects, such as dizziness, vomiting, diarrhea, nausea, seizures, convulsions, and even fatalities. However, the odor detection threshold for H_2S is much less than the state ambient air quality standard.

The state ambient air quality maximum standard concentration for H_2S is applicable at the property boundary of the farm or parcel where the livestock facility is located (Minn. Rules Chapter 116.0713). Minnesota standards for H_2S emissions are summarized below:

Minnesota State Ambient Air Quality Standard for H_2S
• Not to exceed 30 ppb as a 30-minute average more than twice in five days • Not to exceed more than 50 ppb as a 30-minute average more than twice per year

As a result of significant complaints regarding feedlots in Minnesota, the State Legislature, in 1997, directed the MPCA to enforce the state's hydrogen sulfide standard. The MPCA established a Feedlot Hydrogen Sulfide Program, to comply with the statute requiring the MPCA "to monitor and identify potential livestock facility violations of the state ambient air quality standards for hydrogen sulfide."

Odor is indirectly addressed through the MPCA's feedlot hydrogen sulfide program. The MPCA investigates feedlot operations based on citizen complaints, which are primarily generated based on odors. Citizens may call a 24-hour hotline or the State of Minnesota Duty Officer (also 24-hours a day) to register a complaint. Information gathered at the time the complaint is registered includes: situation description, location description, frequency of incidents, and how the incident is affecting the citizen's life.

Although this program works to address odors in some sense, it is not comprehensive in directly dealing with odor as a pollutant in and of itself. Hydrogen sulfide is not always a good surrogate for odor from livestock operations. This means that a livestock facility could give off an offensive and annoying odor, but not necessarily be exceeding the state standard for hydrogen sulfide. In this case, the MPCA may have limited regulatory options.

In 1998, the Yale Center for Environmental Law and Policy reviewed the MPCA feedlot air quality program along with other state approaches. The MPCA program at the time of the Yale assessment was touted as "the most extensive livestock air pollution program in the United States" (Yale Center for Environmental Law and Policy, 1998).

3.3.2.2 Moratorium on Earthen Storage Systems for Swine Waste

In response to the information presented in the Generic Environmental Impact Statement on Animal Agriculture (October 2002), the Minnesota Legislature amended Minn. Stat. Section 116.0714 (New Open Air Swine Basins). This legislation extended the moratorium for open air swine basins until June 30, 2007, by expressly prohibiting the MPCA or county board from approving any permits for new open air swine basins.

The legislation does allow for some conversion of existing basins or the use of a basin when correcting pollution hazards. The basin must have a capacity less than 1,000,000 gallons, be part of a permitted waste treatment program, or conversion of an existing basin smaller than the stated size. Under all cases, the technical standards must be met.

3.3.4 Local Regulations

Under the MPCA County Feedlot Program, counties are permitted to administer the state feedlot rules and regulations. This program allows counties to permit livestock facilities having less than 1,000 animal units. Currently, 55 counties in the state are active in the program. Counties have commonly been dealing with odor issues from livestock facilities in several different ways: through zoning, separation distances or standards, and nuisance ordinances.

3.3.4.1 Zoning

Many of the rural counties have agricultural zoning districts to separate agricultural uses from other land uses in order to prevent annoyances to nearby residents. For instance, in Kandiyohi County the southern half of the county is an agricultural preference area, with residential development allowed at a density of one unit per 40 acres. The northern half of the county is zoned for more intensive residential development, as this area has many lakes and is a desirable vacation and retirement location. By keeping the land uses separated, the county hopes to avoid any complaints regarding nuisance odors. According to Kim Larson, County Feedlot Officer, the system works quite well in meeting the needs of Kandiyohi County.

3.3.4.2 Separation Distances

Separation distances or standards are another commonly used tool to address odor issues arising from livestock facilities. Nearly half of Minnesota counties use some type of setbacks for livestock facilities (*Summary of Animal-Related Ordinances in Minnesota Counties,* Minnesota Department of Agriculture, 2000). The referenced article distinguishes between setbacks and separation distances. Setbacks are used primarily to prevent encroachment of a building on a property line or right-of-way, while separation distances are comprised of land use controls devised to ensure that different, adjacent land uses do not have an adverse impact on each other.

Separation distances used throughout the state can be broken down into two types, simple and sliding scale. Simple separation distances do not account for the size of the facility or the number of animal units present, while sliding scale separation distances will vary the separation

distance required based on type of livestock, size of facility, best available control technologies (BACTs) employed, type of adjacent land use, and other measures (*Summary of Animal-Related Ordinances in Minnesota Counties,* Minnesota Department of Agriculture, 2000).

Nicollet County in southwestern Minnesota uses sliding-scale separation distances. The county employs the OFFSET (Odor from Feedlots Setback Estimation Tool) model, developed by the University of Minnesota Extension Service, to make decisions regarding separation distances of agricultural uses and other land uses. During the permitting process of a new feedlot, the county requires the applicant to supply them with the information necessary to run the OFFSET model and arrive at the recommended separation distances. If those separation distances cannot be met, the county works with the applicant to identify best available control technologies to decrease the potential for odor emissions to a point at which the maximum available separation meets county zoning standards. It should be noted that use of the OFFSET model, or any other zoning and land use tool, is not a replacement for completing an odor impact assessment.

3.3.4.3 Nuisance Ordinances

Although counties may use separation distances and zoning as preventative measures, invoking nuisance law is still a means of seeking legal relief to odorous emissions experienced by residents. Nicollet County, for example, even while using OFFSET modeling as part of their feedlot permitting process (Nicollet County Zoning Ordinance, Sections 302 and 713), has policies in place to investigate and substantiate nuisance odor complaints lodged by citizens.

3.4 Minnesota Environmental Review

The Minnesota Environmental Policy Act (MEPA) of 1973 established the formal process to identify a project's potential for impact on the surrounding natural and social environment in Minnesota. The Environmental Quality Board (EQB) writes the rules for the environmental review process, which is then conducted by the responsible government unit (RGU) such as a county board, city council, or the MPCA.

There are two types of environmental review documents as outlined by MEPA, the Environmental Assessment Worksheet (EAW) and the Environmental Impact Statement (EIS). The EAW is used to provide information about a project that has the potential for having environmental effects and is used to determine whether an EIS is necessary, if it is not a project that requires an EIS by law. According to MPCA staff (interview with Barbara Conti), concerns about odorous emissions have been used in the past as the basis for requesting preparation of an EIS, although these concerns alone have not been enough to require initiation of this additional level of environmental review.

The MPCA Environmental Review Program has developed guidance for completing an EAW on projects for which they are the RGU. Further guidance is available from the MPCA on their website www.pca.state.mn.us/programs/envr_p.html and by request.

3.4.1 CIM Sources

The evaluation of the potential for odorous emissions to result from a proposed project is required under the EAW process; however, the published EQB guidance does not discuss how odor impacts should be evaluated or addressed. It is also important to note that many potential generators of nuisance odors, such as auto body repair shops, coffee roasters, and painting operations may not be subject to any environmental review process.

3.4.2 AFO Sources

The EQB has developed an Alternative EAW form for animal feedlot, which is required for all feedlots proposed to house more than 1,000 animal units. For feedlots with less than 1,000 animal units, an EAW may be required. This alternative EAW differs slightly from a standard EAW and requires that major sources of odor emissions from the proposed livestock facility be identified. Odor emission mitigation measures implemented to avoid or minimize potential adverse impacts need to be discussed as to their anticipated effectiveness. EQB, in conjunction with other state agencies including the MPCA and the University of Minnesota, has developed a list of generally accepted odor management measures including use of biofilters, natural crust, straw cover, plastic cover, and anaerobic digestion.

If no mitigation measures are proposed, the proposed EQB feedlot guidance suggests an air emissions modeling study be conducted, with the results summarized in the EAW. The modeling study will compare predicted emissions at property boundaries with state standards, health risk values, or odor thresholds. Cumulative air quality impacts are addressed in the modeling by using a background concentration for hydrogen sulfide and ammonia developed using the applicable EPA guidance.

4.0 ODOR ISSUES IN MINNESOTA

In order to begin to understand the current scope and range of odor issues in Minnesota, this odor investigation analyzed two primary sources of data; an existing odor complaint database maintained by the MPCA, and a mail-back survey developed and administered to all 87 Minnesota counties. In so doing, it was hoped that patterns would emerge regarding typical source types against which complaints were being lodged, as well as the magnitude of the overall problem as perceived by the MPCA and by Minnesota counties.

4.1 MPCA Odor Complaint Database

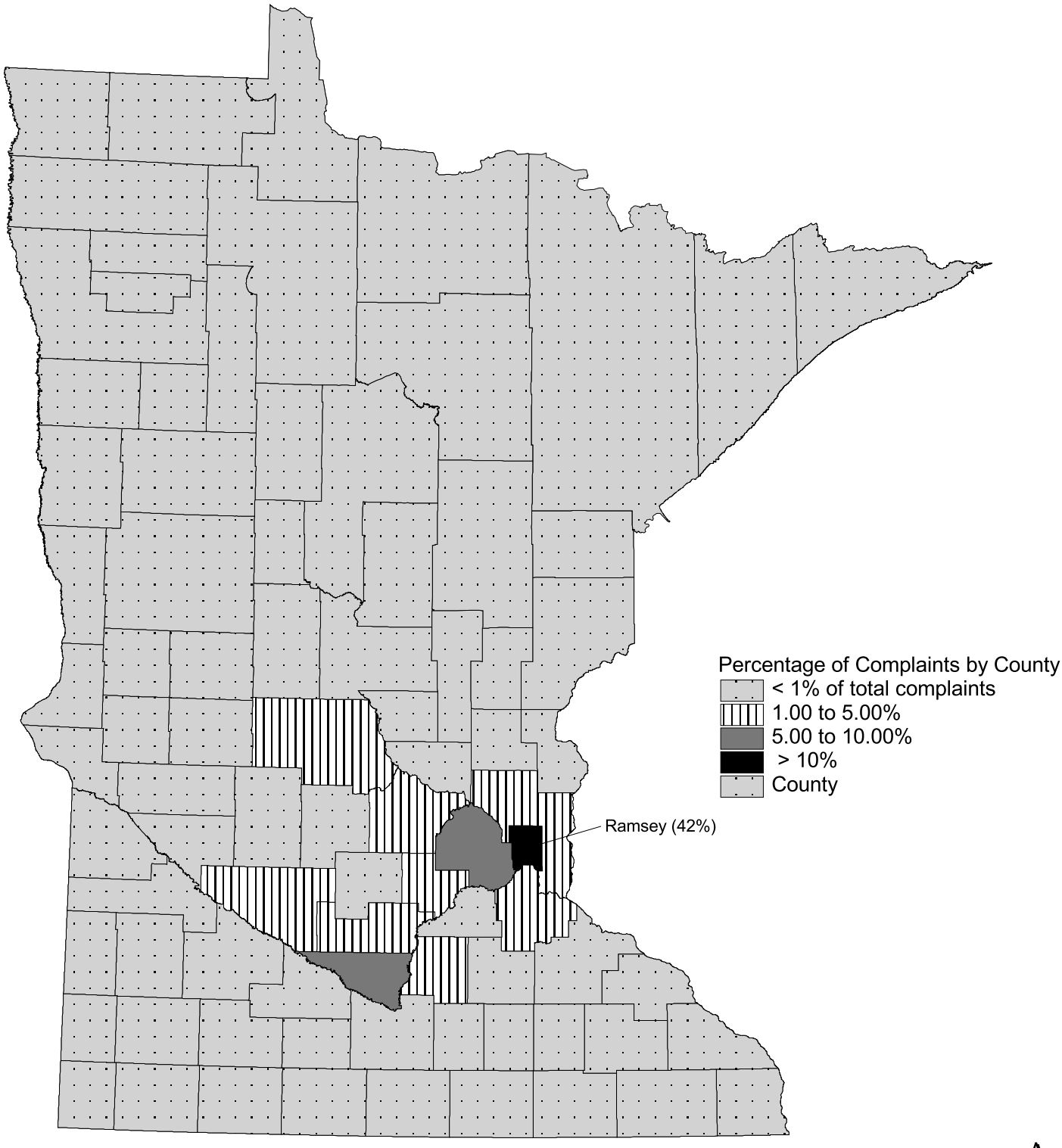
Complaints about odor are the primary mechanisms used to identify odor sources. However, it should be noted that a complaint is ultimately a dissatisfaction with a situation and odor is sometimes used as a surrogate for the real underlying issue, rather than as the issue itself. The MPCA maintains a citizen complaint database, logging all received complaints, not just those relating to nuisance odors. SRF filtered complaints in the database to identify those in which words such as "smells," "fumes," and "odor" were used. Between January 2000 and mid-April 2003, there were 1,642 citizen complaints related to odor. These complaints were then analyzed to determine source types. Aggregation of source types was based on the incident description or the incident address. Source types are compiled in Table 1.

In analyzing trends from January 2000 to April 2003, it becomes apparent that the two primary sources for odor complaints in the state are ethanol plants and feedlots. For the years 2000 and 2001 approximately 35 percent of citizen complaints were attributed to feedlots. This percentage dropped significantly in 2002, possibly as a result of increased efforts to monitor and enforce the state hydrogen sulfide standards.

In 2002 the percentage of odor complaints regarding industrial, commercial, and municipal sources increased significantly. Following the start up of operations at the Gopher State Ethanol Plant (GSE) in St. Paul, ethanol production complaints spiked, accounting for just over half (52 percent) of all complaints received that year.

Other less prominent odor sources throughout the state include production of processed foods (in southeastern Minnesota), plastic processing (in the metro area), masonry and foundry work (in the St. Cloud area), and sugar beet processing (in the southwestern portion of the state). These sources accounted for less than 1 percent of all odor complaints received by the MPCA from January 2000 to April 2003. Table 1 summarizes odor complaints received by the MPCA by source type, while Figure 1 provides a graphic indication of the location in Minnesota from which complaints are received.

Figure 2 illustrates odor complaints as a function of time of year and source type (animal feeding operations, industrial, commercial, or municipal, or unknown). The largest number of odor complaints are received in the summer months, with August and September receiving a significant portion of overall odor complaints. This temporal pattern is consistent with the finding that a significant source for complaints is animal feeding operations. During warmer weather more odors are produced as manure decomposes at a quicker rate due to increased anaerobic bacterial activity. In addition, more people tend to be outside during the summer months, thereby leading to greater exposure to all odorous emissions. The deviation from the established temporal trend in Figure 2 is the spike in the number of complaints received related to industrial, commercial, and municipal sources in March 2003, which can be attributed to occurrences at the Gopher State Ethanol plant.



SRF Consulting Group, Inc.

ODOR COMPLAINTS (JANUARY 2000 to APRIL 2003)

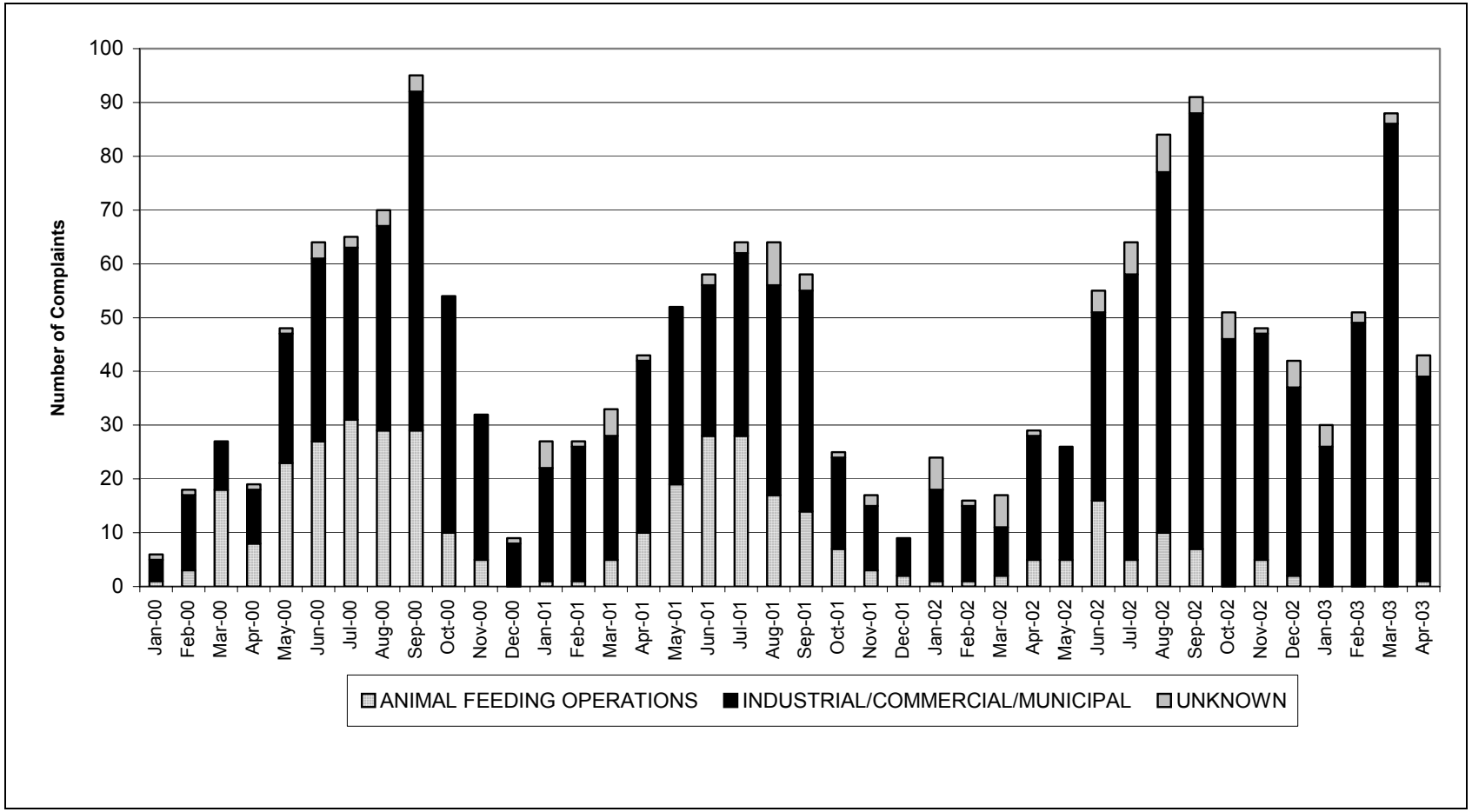
Figure 1

MINNESOTA POLLUTION CONTROL AGENCY
ODOR INVESTIGATION

TABLE 1
SOURCES OF ODOR COMPLAINTS

	2000	2001	2002	2003[(1)]
Industrial/Commercial/Municipal				
AIRPORT	1	3	1	0
ASPHALT	9	2	5	0
AUTO BODY	15	6	2	1
BAKERY	1	0	0	0
BREWERY	8	5	0	0
BURNING	1	0	0	0
COFFEE ROASTING	1	1	5	0
COMPOST	4	9	6	0
DIESEL FUMES	2	3	1	1
ETHANOL – GOPHER STATE	83	91	277	240
ETHANOL – OTHER FACILITIES	0	0	3	1
FOOD PROCESSING/PREP	6	43	25	2
FOUNDRY	2	4	15	4
GAS STATION	2	4	4	0
LANDFILL	6	0	2	0
MARINA	1	0	0	0
OIL REFINERY	11	14	13	1
PAINT	10	3	6	4
PLASTIC PROCESSING	20	14	7	1
PRINTING	3	3	0	0
PRIVATE RESIDENCE	6	10	10	1
PULP MILLS	3	2	0	0
RAILROAD	1	7	0	0
RENDERING	1	7	2	0
RECYCLING	3	0	0	0
SALON	1	1	1	0
SEWAGE	5	2	2	1
SUGAR BEETS	8	2	7	0
WASTEWATER TREATMENT FACILITIES	6	2	3	1
OTHER INDUSTRIAL	64	61	74	10
INDUSTRIAL, COMMERCIAL, MUNICIPAL TOTAL	**309**	**303**	**430**	**198**
ANIMAL FEEDING OPERATIONS				
FEEDLOT	174	134	65	2
NON-SWINE MANURE	10	2	3	0
NON-FEEDLOT AGRICULTURE	7	5	0	0
ANIMAL FEEDING OPERATIONS TOTAL	**191**	**141**	**68**	**2**

(1) Data available for January – April, 2003



ODOR COMPLAINTS BY SOURCE

Figure 2

MINNESOTA POLLUTION CONTROL AGENCY
ODOR INVESTIGATION

SRF CONSULTING GROUP, INC.

MPCA Complaint Database Findings

- The total number of odor complaints lodged in Minnesota in a given month has been relatively steady over the last three years; however, the number of complaints lodged against animal feeding operations has been decreasing while the number of complaints lodged against CIM sources has been fairly stable, except for the large number of complaints received regarding a single source (Gopher State Ethanol) in recent years.

- Metro area counties have the highest number of odor complaints lodged. Other high odor complaint areas are Nicollet, Renville, and Stearns Counties.

- The largest numbers of odor complaints are received in the summer months.

- Counties in Greater Minnesota tend to receive the most odor complaints about feedlots.

- Feedlots and ethanol plants are the two source types that receive the highest number of complaints.

4.2 MPCA Staff-Identified Odor Issues

Early in this Odor Investigation, interviews were held with MPCA staff to discuss instances and issues that staff had encountered in dealing with odorous emissions that may have affected the provision of core MPCA services to clients. Three sets of interviews with conducted, with staff from permitting and rules, environmental review, and enforcement. Key issues raised at these interviews are summarized below.

4.2.1 Permitting and Rules

MPCA staff interviewed were involved in the rulemaking for solid-waste transfer facilities (Yolanda Hernandez) and the MPCA's Feedlot Program (Kim Brynildson).

- According to Yolanda Hernandez, the Advisory Group with which she is working to complete rules for solid-waste transfer facilities, has recommended there be a statewide rule for odor permitting.

- In the past, Yolanda has found that during the permitting process for transfer facilities, hearings have been requested (for which the MPCA must pay) due to concerns regarding the potential for nuisance odors.

- According to Kim Brynildson, there have been notable instances in which odor complaints are lodged although hydrogen sulfide monitoring indicates the feedlot is well within emissions standards.

4.2.2 Environmental Review

Interviews were conducted with Barbara Conti, Kevin Kain, and Jim Sullivan.

- Delay arises in the MPCA's project approvals when an EIS is requested as an outcome of an EAW process.

- Assessment of the potential to generate odors during operation is a requirement of the EAW process.

- Since there is no current threshold or standard for odorous emissions, odors are often used as a supporting part of a petition for an EIS.

4.2.3 Enforcement

Interviews were conducted with Jeff Stollenwerk, Jim Sullivan, and Scott Parr.

- Jeff Stollenwerk discussed his experiences working on various projects in and around the Duluth area. Much of his work has been with the Western Lake Superior Sanitary District and in dealing with odor issues from the Sappi (formerly Potlatch) mill.

  - During periods of bad odors, the MPCA would receive 50 to 100 complaints per year regarding odors from the paper mill. Masking agents and organic plant filters were used to mitigate odors.

- According to Scott Parr, odor emissions are often an indicator that a process is not working properly.

  - Scott's greatest success in addressing odors was in getting all parties together in a mediation process, including businesses against which complaints were lodged in addition to residents (complainants). In mediation, some middle ground can be sought where complainants can recognize the issues a business deals with, and businesses, in turn, can understand residents' concerns.

  - Typically, odor complaints are referred to the city, as a nuisance action, but the city may not feel they have the expertise in this area to manage the situation and may refer issues back to the MPCA.

  - Currently, mediation processes led by the MPCA are at the will of all parties. If a business is not interested in mediation, there is no mechanism to compel them to take part. In this instance, resolution of odor issues must take place through nuisance actions.

- According to Jim Sullivan, a nuisance threshold category would be helpful during a mediation process addressing odor complaints.

  - The institution of Best Management Practices is not always the solution for odorous emission reductions.

Minnesota Nuisance Law History

Minnesota court cases were compiled using a search engine from West Law, searching for all cases in which the words "nuisance" and "odor" were referenced. These cases were analyzed by SRF Consulting Group, Inc. at the request of the MPCA.

Approximately 90 Minnesota cases originating from 1886 to the present were reviewed for their content pertinent to the common law application of nuisance. Of these cases, approximately 19 cases dealt with a nuisance claim but did not include identification of an odor problem. Thirty-nine cases dealt with nuisance claims in which at least a portion of the claim identified an odor problem. Sources of odor included confined animal feeding operations, livestock yards, horse barns, dog pounds, canneries, compost and dumping sites, fuel storage sites and spills, asphalt roofing materials, funeral homes and undertaking facilities, fertilizing and rendering plants, gas and electric plants, wastewater treatment facilities and raw sewage placement and overland water drainage. Twelve cases dealt with denial of new source permit applications where the source was determined to likely cause a nuisance.

4.3 Odor Complaint Case Studies

Odors have the potential to affect people both physically, with symptoms including headache, irritation of nose, eyes or throat, exacerbation of asthma, (A.P. Van Harreveld, 2001) and emotionally, by interfering with their enjoyment of their property or community. However, as highlighted in the following case studies, odor issues also have an economic impact on businesses, as well as on cities and other jurisdictions and agencies.

4.3.1 Gopher State Ethanol

Minnesota has required gas stations to sell ethanol-blended gasoline since 1997 to fight air pollution; as a result, the ethanol industry has flourished in Minnesota. There are currently 14 ethanol plants in operation in Minnesota, and they produce more than 400 million gallons of ethanol per year (MPCA 2002).

Until the last few years, only ethanol had been considered as a contributing VOC during the environmental review and permitting process for ethanol plants in Minnesota (see discussion in Section 3.4). Later testing of the plants led officials to find that other VOCs including acetaldehyde, acrolein, formaldehyde, 2-furaldehyde, acetic acid, and lactic acid were being emitted in significant quantities. Levels of carbon monoxide emissions, as well as small particulates and dust have also been found at much higher levels than previously believed. The result was that the air emissions permits being issued were inadequate (MPCA, 2002).

Gopher State Ethanol (GSE), located in Saint Paul, has been a major source of odor complaints in recent years. GSE operates onsite with two other industries, the ***MBC*** Holding Company brewery (MBC) and a carbon-dioxide recovery plant (MG-CO2).

GSE and MG-CO2 began operations in May 2000 and August 2000, respectively. Shortly thereafter citizens began calling city officials and the Minnesota Pollution Control Agency with complaints regarding odors from the facilities. Citizens were claiming that they were experiencing adverse health effects including nausea, skin/eye irritation, headaches, asthmatic complications, and sleep deprivation, as a result of the plant's operations. In July 2000, the MPCA conducted two inspections of the facility and noted numerous permit violations. At the

time of permitting and initial stack testing, the emissions of only ethanol and methanol were considered. After later tests, staff found significant amounts of other VOCs being emitted, in total more than 10 times higher than what was first assumed (MPCA 2002).

In October 2000, the St. Paul City Council passed a resolution referring the odor issue to the St. Paul's City Attorney's office to review the operation of GSE and determine whether or not there were grounds for a criminal or civil action against the facility.

The City Attorney consulted with MPCA during the review, but because the MPCA odor rule had been repealed in 1996, there was no legal action that could be taken based solely on odor complaints. However, a health assessment was being undertaken by the Minnesota Department of Health.

The MDH did not find the emissions of VOCs from GSE to be exceeding any MDH Health Risk Values (HRVs). "An HRV is the amount of a chemical, emitted to ambient air, to which the general public, including sensitive sub-populations can be exposed with de minimus health risks" (MDH, 2001).

As a result of investigations, GSE was fined $45,000 for permit violations and was required to install a thermal oxidizer to reduce VOC emissions. More recently, the City of St. Paul brought suit against GSE as a public nuisance based on odor complaints from nearby residents. GSE agreed to strengthen air pollution controls by installing air-filtering devices controlling emissions of particulates and VOCs, as well as changing practices by limiting their production of wet corn mash, a particular concern of residents in terms of odorous emissions.

At the same time, ethanol plants throughout Minnesota were becoming subject to investigation by the MPCA and EPA for VOC and CO emissions. A settlement in October 2002 required 12 of the 14 plants in Minnesota to install thermal oxidizers or an equivalent alternative technology, which cost plants nearly $2 million. In addition the EPA also required the plants to pay fines ranging from $29,000 to $39,000 each. GSE is unique in Minnesota due to its location in a valley in an urban area, and as the ethanol plant is a retrofit to an old building. These factors have contributed to nuisance based actions by the City of St. Paul in addition to the permitting issues that all of the Minnesota plants faced.

The installation of a thermal oxidizer does not specifically address odor problems surrounding the plant although the reduction in VOCs will ultimately lead to lower odor emissions from the controlled. As Minnesota does not have an odor rule, odor itself is not a violation of any standard. Unless the MPCA can tie the odor in with a regulated chemical, odors from this source may still affect nearby residents and other sources of emissions at the facility that are not subject to VOC control requirements might continue to be just as odorous as before.

4.3.2 ValAdCo

Livestock odor continues to be a contentious issue, especially as the trend to consolidate agricultural operations continues in Minnesota and elsewhere, and as the impacts of these large-scale, industrial-type farming operations are felt by the persons and communities living near

them. In Minnesota, there has been increasing concern and complaints generated with respect to feedlot odor, and particularly swine facilities. From 1995 to 2000 approximately two thirds of odor complaints received by the MPCA were attributed to hog farms (Minnesota Issue Watch, 2001). As of November 8, 2002, there were 29,407 feedlots registered in Minnesota. As such, it is instructive to examine the case of ValAdCo.

ValAdCo is a large hog feeding operation, which was started in 1991 in Renville County by a group of 39 corn growers. The feedlot went into operation in 1994 with two liquid manure ponds designed to hold millions of gallons of liquid hog manure. By 1999, ValAdCo was a 10,000 hog operation.

In 1995, a nearby resident, Julie Jansen, alleged that her health was being adversely affected due to odor shortly after two large swine operations began operations near her home. According to Jansen, after a call to the Minnesota Poison Control Center she learned that these health effects were most likely a result of H_2S emissions. Jansen's persistence in attributing the source of her ill health to these swine facilities led to the first ever H_2S citizen monitoring effort in Minnesota in 1996 (Jansen, 1998).

With an Arizona Instruments™ 631X Jerome gold film analyzer used to measure H_2S and other reduced sulfurs, the group of citizens found that 25 percent of the 17 large-scale swine lagoon facilities in the county were possibly exceeding the state air quality standard (Jansen, 1994). In 1997, the State Legislature, though a Governor's initiative, directed the MPCA to enforce the state ambient air standards for hydrogen sulfide and testing and monitoring of the ValAdCo facilities was conducted over the next two years (Minn. Stat. 116.0713 (1997)) and is still ongoing.

Results from the MPCA monitoring effort found that the ValAdCo facility was in violation of the State standard for hydrogen sulfide 53 times in 1998 and 106 times in 1999. Over those two years hydrogen sulfide concentrations were as high as 90 ppb or above on 100 occasions. In January 1999, the MPCA reached a settlement on these violations through a Stipulation Agreement. ValAdCo violated the 1999 Stipulation Agreement and continued to violate the hydrogen sulfide standards. The Minnesota Attorney General joined the MPCA in seeking a settlement of ongoing violations and public nuisance issues caused by odors.

A settlement was reached between ValAdCo and the State in December 2002. ValAdCo was required to drain its 13 million gallon primary basin and replace it with closed holding tanks. Primary basins on six other ValAdCo farms also were to be drained down and used as part of secondary basin systems. ValAdCo was also required to pay $125,000 in civil penalties to the MPCA.

4.4 Survey of Minnesota Counties on Nuisance Odor Impacts

In order to gauge the range and extent of nuisance odor issues in Minnesota counties, the MPCA developed and mailed to all 87 counties in early April 2003 a survey questioning the counties about their experiences (see Appendix B for a copy of the survey). The surveys were to be filled out and mailed back to SRF Consulting Group, Inc. by April 30, 2003. The final deadline for receipt of surveys to be considered as part of the sample population was May 16, 2003. A total of 56 surveys, representing a return rate of approximately 64 percent, were received in time to be part of the sample. A summary of the survey results is presented here.

4.4.1 Odor Complaints and Processes

4.4.1.1 Complaints Received

A majority of counties (70 percent) have received nuisance odor complaints from their residents in the past year. However, the frequency by which they receive these complaints is relatively low. Of the counties receiving odor complaints, fully 76 percent receive less than 1 complaint per month. A total of 23 percent of counties receiving complaints experience approximately 1 to 5 complaints per month. There were no counties responding that complaints were being received with any greater frequency than 1 to 5 per month.

4.4.1.2 Sources of Odor Complaints

In order to identify any trends in sources of odor complaints, a range of potential source types against which complaints were received was identified in the survey. Responses received to this question are summarized in Table 2 below.

TABLE 2

Odor Complaints Received by Source Type

2	Automotive Repair or Other Services	1	Paper Mill
4	Ethanol Production	0	Printing/Laminating/Coating
34	Feedlots	0	Restaurant/Retail Food
9	Other Food Processing Industries	0	Soybean Processing
19	Other	1	Sugar Beet Processing
		10	Wastewater Treatment Facilities

Of those counties receiving complaints in the past year (40 out of 56 counties), the vast majority (85 percent, or 34 of 40) received complaints attributed to feedlots. The only other identified source type that had a clear plurality of responses was wastewater treatment facilities, with 25 percent, or 10 of 40 counties receiving complaints. "Other" source types identified included landfills, composting, rendering plants, manure application, burning, and failed septic systems.

4.4.1.3 Complaint Response Process

When a county receives nuisance odor complaints, they are typically routed to the Planning and Zoning Administrator (27 of 56 counties), the County Feedlot Officer (26 counties), or the Environmental Health Officer (17 counties).

Most counties (71 percent) do not have a standard policy in place for responding to nuisance odor complaints. Of those that do (29 percent), response criteria are based on some combination of factors including duration, severity, frequency and number of complaints. Counties indicating that their response policy was based on a particular source type listed feedlots, manure silos and manure applications as sources.

Open-ended responses to this question were that the zoning inspector investigates complaints; all complaints are investigated as soon as possible, not just odor; complaint response is part of the yearly workplan for feedlots approved by the MPCA; and complaints are handled as part of nuisance response.

4.4.2 Odor Regulations and Processes

Slightly more than one-fourth of Minnesota counties (29 percent) have regulations in place to minimize odors. Fully 75 percent of the counties that regulate nuisance odor emissions do so for feedlots. Only one county responded that all source types were covered in their regulations. In Meeker's zoning ordinance "[a]ll uses causing the emission of odorous matter of such quantity as to be readily detectable at any point beyond the lot line of the site on which such use is located shall be a nuisance (Meeker County Zoning Ordinance, Section 22.17)."

Open ended responses were that "all industrial and commercial were covered, only some agriculture," "solid waste facilities," and, "industry in general."

4.4.2.1 Estimating Nuisance Odor Impacts During Permitting

Some Minnesota counties do currently require applicants to estimate potential impacts of nuisance odor emissions during their permitting processes. A total of 13 of 56 counties responding, or 23 percent, indicated this was a requirement.

4.4.3 Nuisance Odor Regulation

4.4.3.1 Why Statewide Regulation is Needed

A slim majority (30 respondents, or 54 percent) of Minnesota counties indicated that they believed that outdoor nuisance odors should be regulated by the Minnesota Pollution Control Agency. Of those that responded affirmatively, the following reasons were chosen.

TABLE 3

Why Statewide Odor Regulation is Needed			
24	To ensure a good quality of life	27	To protect public health
18	To protect property values	8	Other (please describe)
14	To improve the environment		

Responses were fairly evenly split across the categories; however, the majority of responses did indicate that ensuring a good quality of life and protecting public health were why statewide odor regulation is needed.

Other reasons for statewide odor regulation were given by respondents, such as "state standards would be helpful when updating or writing city ordinances and standards," "to provide a uniform approach and establish legally enforceable standards," because they [odors] are a nuisance," "to protect an individual's right to enjoy their property," and, "especially if they are severe or potentially hazardous."

4.4.3.2 Why Statewide Regulation is Not Needed

Approximately 46 percent of all respondents, or 26 counties, believed that statewide regulation of nuisance odors by the MPCA was not needed. Reasons chosen for this response are summarized in Table 4 below.

TABLE 4

Why Statewide Odor Regulation is Not Needed			
4	Regulation is not needed	5	Regulation would be a burden on private industry
16	Regulation is unenforceable	12	Other (please describe)
11	Regulation would cost taxpayers too much		

The majority of responses given for why regulation of odors is not needed were due to the belief that regulation would be unenforceable (16 responses). The next most frequently chosen reason was that it would cost taxpayers too much.

Other responses given were that "many municipalities already have odor ordinances," "Odor is too subjective to be regulated," it would be a "burden on farmers," the issues would "rate very low on the average taxpayer's list of priorities," "State agencies lack the capacity and flexibility to respond to local situations," nuisance odors are "not a pressing issue," and, nuisance odors "should be kept a local issue – state feedlot rules provide the needed guidelines."

4.4.4 Survey Response by MPCA Region

The MPCA has divided the state of Minnesota into 6 regions. Survey data was queried to see if response patterns varied by region, and the results of these queries are presented here.

4.4.4.1 Complaints Received

The regions with the highest percentage of counties indicating that odor complaints had been received in the past year included the Southwest, the Southeast, and the Metro regions (70 percent of responding counties from each region). The region with the lowest number of counties indicating nuisance odor complaints lodged was the Northeast region, with 50 percent; however, it should be noted that only two of the seven counties in this region responded to the survey.

A total of nine counties were deemed to be "high needs" counties, in that nuisance odor complaints were received on the average of 1 to 5 times per month. These consisted of Anoka, Carver, Fillmore, Freeborn, Hubbard, McLeod, Mower, Murray, and Stearns. It is interesting to note that four of these nine counties are located in the Southeast region.

4.4.4.2 Sources of Odor Complaints

As with the survey population as a whole, the overwhelming majority of complaints received identified feedlots as a source type. Fully 100 percent of all counties in the MPCA's Southeast region that received odor complaints indicated that feedlots were identified. The next highest region for feedlot complaints was the Southwest region, with 86 percent of counties receiving complaints listing feedlots as a source. The Northeast region of the state had no feedlot-related complaints. Almost all regions (with the exception of the Northeast, indicated that they had received complaints lodged against wastewater treatment facilities.

4.4.4.3 Nuisance Odor Regulation

In analyzing responses to the need for statewide regulation of nuisance odors by the MPCA, interesting differences between the regions emerge. Although the Metro region has one of the highest complaint rates (70 percent of responding counties), it has, at 28 percent, the lowest rate of counties indicating support for statewide odor regulation. The Northwest region closely follows it with an approval rate of 31 percent. The remaining regions (the Southwest, Southeast and North Central) all had approval rates quite close to the overall average, ranging from 50 to

55 percent. A total of 100 percent of Northeast region counties supported statewide nuisance odor regulation; however, this was based on a relatively low response rate (two out of seven counties).

4.4.5 County Survey Findings

- A majority of counties (70 percent) have received nuisance odor complaints in the past year; however the frequency by which these are received is relatively low, with the majority of those receiving complaints (76 percent) receiving less than 1 complaint per month.
- Of those counties receiving odor complaints in the past year, fully 85 percent received complaints attributed to feedlots.
- Only 29 percent of Minnesota counties have regulations in place to minimize nuisance odors. Of those counties that do have regulations, most are focused solely on feedlots.
- A slim majority (54 percent) of counties responding indicated that they believed that outdoor nuisance odors should be regulated by the MPCA. Reasons for believing this included protecting public health and ensuring a good quality of life.
- Approximately 46 percent of all respondents believed that statewide regulation of nuisance odors by the MPCA was not needed. Most expressed a belief that such regulation would be unenforceable. Other responses given were that "many municipalities already have odor ordinances," "Odor is too subjective to be regulated," and that "state agencies lack the capacity and flexibility to respond to local situations."

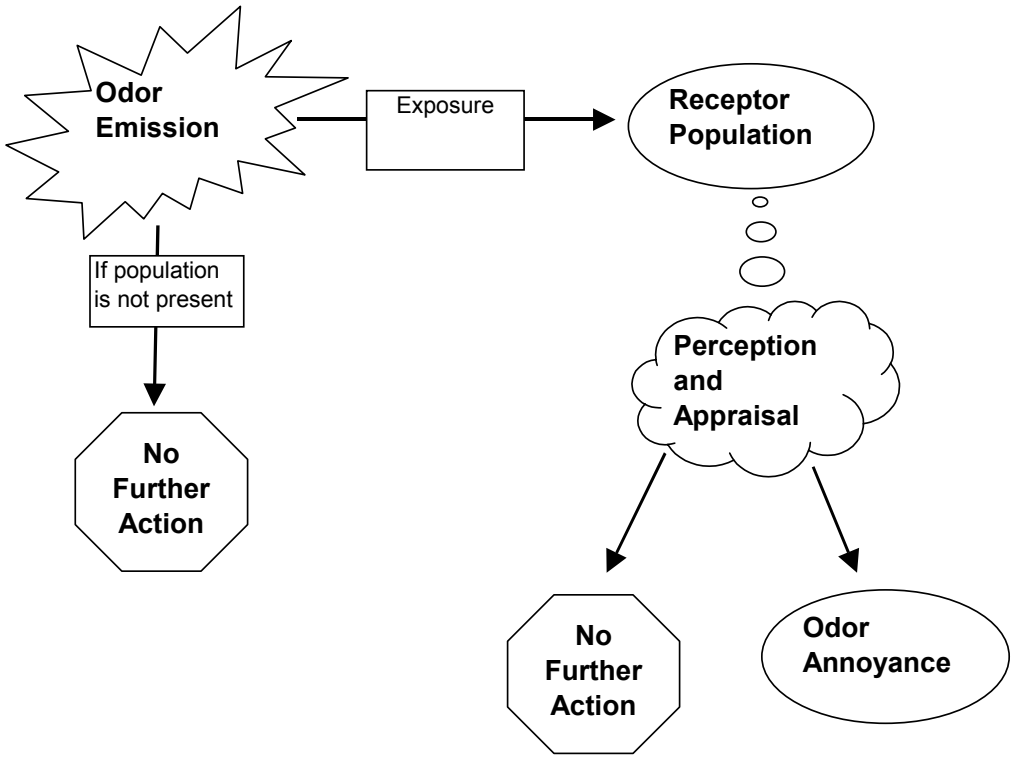
5.0 ODOR REGULATORY APPROACHES

Odor regulation is varied based on the nature of the science and policy available to develop the program. The law of nuisance is generally the legal theory used to develop odor regulations, though some governmental units may rely on a health-based approach. The regulatory spectrum is bracketed on one end by a purely subjective judgment of odor, and, on the other end, by one in which standards are determined for each step in the process. Despite the variety of assessment and measurement methods available, the uniform element consistent to all odor regulation is the experience of odor and its union with the realm of human experience.

5.1 The Odor Regulatory Framework

Unlike many of the air quality pollutants, odor lacks a specific monitoring system designed to measure "odor" as a complex solution. Additionally, odor standards are oftentimes a function of community consensus on quality of life and expectations of living conditions rather than a true health or environmental-based air quality standard as used in the Clean Air Act. Over the past few decades, some communities have attempted to adopt the emerging air quality regulatory trend and apply it to odor regulations. This approach is continuing with the advent of various state odor standards for livestock operations around the country.

Measurement methods that are used to either analyze odor using human sensory methods or through gas surrogates have proven to be a robust measurement technique and oftentimes cost effective depending on the situation. Air quality modeling to predict odor impacts on a community has also been used over the past few decades with good reports. Electronic nose technology is emerging, however, is not capable of the levels of detection or capable of the reproducible data required for air quality regulation. Currently, the most sophisticated regulatory approaches enacted still rely on the perceptions of people to render their findings of whether odor emissions limits have been exceeded or not. In order to better understand the odor experience, the following diagram is provided.



The relationship between the reception of an odorous emission by a population, and the process involved in perceiving and appraising that odor is, to put it mildly, a complex one. In the regulatory environment, the process of perception and appraisal can be generally understood by Frequency, Intensity, Duration, and Offensiveness (FIDO) model (Mahin, 2001).

Frequency simply refers to how often an odorous emission will be experienced by a receptor population. Obviously, this factor is important in a regulatory framework for, although certain activities, like paving a residential street, can be quite odorous and have a high likelihood for annoyance, the infrequency with which a receptor population is likely to encounter this odor means it should not likely be judged a nuisance in the regulatory arena.

Intensity refers to the perceived strength of the odor sensation, and generally increases as a function of concentration. As described below, some odors can become intense at relatively low concentrations (such as "fishy" or putrescent odors), while for other more "pleasant" odors, such as flowers, concentrations must be quite high before they are deemed intense.

Duration is the period of time in which odorants are received by a receptor population and perceived as odors. Duration is important in a regulatory framework, as longer "odor episodes" (the time in which odors are detectable in the ambient air) can cause people to make changes in activities or make changes in plans that have an impact on their ability to enjoy their property or their community.

Offensiveness is the keystone of the four elements of the odor experience and, not coincidentally, the one in which human perception comes to the fore. Offensiveness is "an expression of the degree of unpleasantness of one odor relative to another." (Horizontal Guidance for Odor, Part 1 – Regulation and Permitting) This perception varies from person to person based on physical as well as social and cultural differences. However, this variability can be predicted in part by knowing the "hedonic tone" of an odorant.

Hedonic Tone: In psychology the terms pleasantness and unpleasantness are expressed using the term hedonic tone. Positive values correspond to pleasantness and the negative values correspond to unpleasantness (Beebe-Center, 6.) http://www2.cedarcrest.edu/academic/writing/pleasure09/boddie.htm In odor regulation, hedonic tone is a judgment of the relative pleasantness or unpleasantness of an odor sample made by a panel of odor assessors. Oftentimes expressed in a 20-point scale, in which +10 is the maximum value for pleasantness with –10 the maximum value for unpleasantness, a hedonic tone value or hedonic score can help to predict the relative offensiveness of various odors.

For illustrative purposes, the table that follows summarizes Hedonic scores for various everyday odors.

TABLE 5
Hedonic Score of Everyday Odors

Description	Hedonic Score
Bakery (Fresh Bread)	3.53
Coffee	2.33
Crushed Grass	1.34
Beer	0.13
Sauerkeraut	-0.60
Gasoline/Solvent	-1.16
Sweaty	-2.53
Cadaverous (dead animal)	-3.75

SOURCE: Horizontal Guidance for Odour: Part 1 – Regulation and Permitting

It is interesting to note that, in a report published by Great Britain's Environment Agency (Horizontal Guidance for Odour: Part 1 – Regulation and Permitting) comparing Hedonic scores from the United States (Dravnieks) to odor rankings done in the UK and in the Netherlands a good general agreement was found for the purposes of determining the relative offensiveness of odors. While variations always exist, it would appear there is some general agreement on the relative offensiveness of various odors.

5.1.1 Regulatory Framework Conclusion

The four elements of the regulatory process as described above, frequency, intensity, duration and offensiveness (sometimes expressed as hedonic tone), all come into play in perceiving an odor experience as an odor annoyance. It is the role of an odor regulatory framework to begin to measure this process and establish threshold criteria for when these various elements, both singly and cumulatively, constitute an odor nuisance.

5.2 Odor Regulatory Tools

At the heart of any regulatory program is the establishment of acceptable limits and tools to implement the program, whether the question is how fast people should drive on streets or highways, or what quantities and compounds of wastewater a business is allowed to produce and discharge. This is certainly the case for any agency or jurisdiction establishing an odor regulation. There are four basic tools by which acceptable odor emissions limits can be set by a regulatory agency or jurisdiction. They are:

1) To set emissions limits for known chemical compounds;

2) To set odor emissions limits based on some characteristic of odor;

3) To establish setback distances from certain source types; and,

4) To require the use of best available control technologies to manage odorous emissions.

5.2.1 Regulation of Individual Compounds

The individual compounds that make up an odor can be regulated (McGinley, 2000). A regulatory approach of this type has the clear advantage of using limits or standards based on concentrations of specific compounds, and monitoring equipment that eliminates human sensory perception. Many individual compounds are already considered regulated pollutants that are regulated under the Clean Air Act. These pollutants are either considered criteria pollutants (which have standards that set the maximum concentrations that are allowed in the ambient air) or hazardous air pollutants (HAPs) (defined by a list of approximately 188 different chemicals that are known or suspected of causing cancer or other serious health effects). The MPCA maintains a permitting program that regulates facilities based on their potential to emit regulated pollutants.

As a means of regulating odorous emissions, regulating individual compounds has yet to prove effective. The reason is that odors commonly consist of a complex mixture of compounds where no specific compound can be isolated and used as a proxy by which to measure and limit overall odorous emissions. This has been demonstrated in Minnesota by the MPCA's feedlot hydrogen sulfide monitoring program. MPCA staff and others interviewed during this odor investigation stated that odors have occurred at feedlots even though, when monitored, hydrogen sulfide emissions have been found well within state standards.

Identifying and characterizing mixtures of compounds that make up odors (referred to as fingerprinting) and development of odor surrogates is the subject of much research for common odors such as feedlots.

5.2.2 Limits on Odorous Emissions

As a regulatory approach, establishing limits for odorous emissions is similar to that for regulation of individual compounds. The difference is that while the regulation of individual compounds relies on measurement tools using electronic instrumentation, the regulation of odorous emissions levels relates to a sensory assessment of odor strength and concentration (McGinley, 2000). It may also be predicted using mass-transfer theory and the chemistry of the material in certain circumstances (e.g. wastewater treatment plants and feedlot operations). The sensory assessment uses the human nose as an instrument along with measurement tools (discussed in Section 2 and in Appendix D) to measure the concentration and intensity of an odor. Sensory assessment of odor provides reliable and accurate quantification of odor strength for all odors. Methods used in sensory assessments provide a direct link between a particular odor and the human response to it. The use of chemistry to predict odorous emission levels has been used to predict odor impacts from livestock operations in Minnesota for approximately seven years. The recently completed Hancock Pro Pork DEIS comparison of the predicted modeling results to the measured results in the field confirms previous findings that this approach can be a useful method to predict and limit emissions of H2S, which is an odorous compound although as stated in Section 5.2.1 this does not necessarily make H2S a reliable surrogate for odor regulation.

The root of this type of regulation is limits or standards of odor strength at off site receptors or in ambient air at property boundaries. As revealed during interviews with staff at other agencies and jurisdictions (see Section 5.0), difficulties with this type of regulation are monitoring and testing of odor levels and determining concentrations of odors that correspond to annoyance thresholds for various odors. None of the regulatory agencies contacted for this research has attempted to impose a sliding scale of source specific odor standards based on a particular odor's annoyance threshold. A common approach in regulating odors is to use one standard for all odors or to target the standard to feedlot odors.

5.2.3 Setback Distances

Setbacks are used by planning agencies to determine separation distances between an odor source and potential receptors of odor (Minnesota Department of Agriculture, 2000). These distances can be simple separation distances required between receptors and a facility, no matter what its size or odor control technology. A more refined, site specific approach can be used.

One example of a site specific separation distance planning tool is the OFFSET (explored in detail below) model developed by the University of Minnesota. This tool was developed as part of a Livestock Odor Task Force recommendation to develop a tool that could be used to help develop setback distances from a livestock operation based on odor impact.

In general, setback distances are effective in siting new facilities in low density, rural settings where potential receptors are widely spread and large distances between sources and receptors are common. Consequently, this approach to odor regulation is primarily used for feedlots. Separation distances can rarely be changed after a facility is sited therefore this tool is used exclusively for planning and permitting.

Potential weaknesses for this approach include its limited application to agricultural or otherwise uninhabited areas. In urban or developing areas, large swaths of uninhabited land needed to meet separation distances are either not available or future development could encroach on the intended separation distances.

A tool for estimating average odor impacts from feedlots and required separation distances has been developed by the University of Minnesota. The tool, "Odor From Feedlots Setback Estimation Tool" (OFFSET) is a simple model that calculates an odor emission number from the size and characteristics of a facility including its odor control measures. This odor emission number is used along with a time variable exposure (91% to 99% of the time annoyance free) to determine appropriate separation distance. The OFFSET model is not designed as an odor assessment tool. It cannot account for site specific spatial temporal and cumulative source issues that are resolved in traditional air quality modeling. The OFFSET tool is an emerging process and was reviewed in the GEIS Air Quality Technical Work Paper. The findings of the review indicate that the OFFSET output values do not match the digital dispersion model outputs of EPA accepted systems and the scaling factors are little more than corrective calibration factors used to make observed values better fit the model input and output values. The review did indicate that the structure of the model is a good first attempt and will likely improve as more data is collected and further refinements made in the model structure (Environmental Quality Board, 2001).

5.2.4 Requirement of Best Available Control Technologies (BACTs)

This type of regulatory approach does not deal with limits or standards of odor levels. Instead, facilities are required to use control measures to prevent or reduce emissions, often with the implied performance standard of no annoyance to surrounding receptors. This approach is used in permitting or as a result of negotiating resolutions during the compliance and enforcement process. Specific control measures are difficult to specify without a detailed analysis of the source process, applicable control technology, economic reasonableness and impact to other natural resources. Methods used to control odors at point sources are incineration, scrubbing, adsorption, biofiltration and masking agents or additives. Control measures at non-point sources such as feedlot manure storage facilities are more difficult to deploy but can consist of biofilters, natural crust, straw cover, plastic cover, and anaerobic digestion, amongst others.

5.3 State of the Regulatory Practice

In order to understand the scope and range of current regulatory practice, telephone interviews with various cities, counties, states and countries were conducted by SRF Consulting Group, Inc. as part of this MPCA Odor Investigation. Although an exhaustive summary of all odor regulations is beyond the scope of work and the resources available for this project, the process of identifying candidate areas for interviewing was intended to result in a representative cross-section of the Upper Midwest, and the United States in general, as well as accounting for areas of the country in which odors are primarily attributed to agricultural operations and areas where odors result from other industrial processes. The results and findings of this process are summarized in Table 6.

TABLE 6
Upper Midwest Odor Regulatory Summary

	Odor Rule or Ordinance	Measurement Methodology	Standard for Complaint Substantiation	Compliance Process
North Dakota	Yes	Scentometer	7 D/T beyond property line in urban areas 7 D/T within 100 feet of receptor in rural areas	Facilitative process
South Dakota	No	NA	NA	NA
Iowa	No	NA	NA	NA
Wisconsin	Yes	None	Inspector evaluating ambient air conditions	Facilitative process
Minnehaha County, SD	No	NA	Inspector evaluating ambient air conditions	Facilitative process
Des Moines, IA	Yes	None	Number of Complaints Received/Time Period	Formal process including compliance plan and inspection
Sioux City, IA	Yes	None	Number of Complaints Received/Time Period	Formal process including compliance plan and inspection

5.3.1 Minnesota

Although the State of Minnesota does not have an encompassing "odor regulation," public protection of nuisance odor emissions is offered through the state's public nuisance statute. Minnesota State Statute Chapter 608.73 defines a public nuisance as:

Whoever by an act or failure to perform a legal duty intentionally does any of the following is guilty of maintaining a public nuisance, which is a misdemeanor:

(1) maintains or permits a condition which unreasonably annoys, injures or endangers the safety, health, morals, comfort, or repose of any considerable number of members of the public; or

(2) interferes with, obstructs, or renders dangerous for passage, any public highway or right-of-way, or waters used by the public; or

(3) is guilty of any other act or omission declared by law to be a public nuisance and for which no sentence is specifically provided.

[HIST: 1963 c 753 art 1 s 609.74; 1971 c 23 s 74; 1986 c 444]

Actual application of the statute requires a claimant to first apply the nuisance statute to an odor problem by establishing facts that lay the foundation for one of the statutes three clauses. Once this foundation of facts is alleged, then the claim is reviewed under two thresholds: 1) does the claim meet the 'reasonable person standard' (i.e., would a reasonable person perceive an odor nuisance under the particular set of facts) and 2) is the claim supported by a 'preponderance of the evidence' (i.e., do the facts more likely than not support that the odor presents a nuisance). Although no state rules define when odorous emissions constitute a public nuisance, at least one Minnesota County, Meeker, (as identified during the MPCA Odor Survey, discussed in Section 4.4) has established nuisance thresholds for odor. Other counties in Minnesota deal with odor issues from specific source types, such as feedlots, primarily through the permitting process. The City of Minneapolis also defines nuisance odors.

5.3.1.1 Minnesota Counties

Under their Zoning Ordinance, **Meeker County** has defined minimum standards for nuisances (Meeker County Zoning Ordinance, Section 22.17). For odors, the threshold for nuisance is defined as "all uses causing the emission of odorous matter in such quantity as to be readily detectable at any point beyond the lot line of the site on which such use is located." Other counties in Minnesota, such as **Blue Earth, Renville, and Nicollet**, focus on managing nuisance odor emissions from feedlots through their county conditional use permitting process. For all of these counties, this is accomplished by establishing setback distances of feedlots from residential dwellings and other land uses. Nicollet County has adopted as part of their Zoning Ordinance use of the University of Minnesota's OFFSET Model (described in detail in Section 5.2 of this report). Different "annoyance free" thresholds are established for different types of land uses. Obviously, establishing setback distances is a means of regulating odor emissions "before the fact", and is not meant to be part of any enforcement or compliance process (or, at least, not easily part of this process given the inherent difficulty in enforcing setback distances once structures have been erected). However, according to Nicollet County, there are ways in which using the OFFSET Model's "annoyance-free" categories of odor impact conditions can be used for enforcement purposes. Specifically, "annoyance-free" conditions equate to time periods (i.e., a 99 percent annoyance free rating corresponds to seven hours/month during which annoying odors would be present from April through October). By keeping odor event logs (a sample

from Nicollet County is attached in Appendix B), a county or other jurisdiction could ascertain whether this category was in fact being met. If annoyance free categories were not being maintained, then enforcement proceedings may be taken against offending livestock facilities, including verifying whether odor control technologies as specified during permitting were in place and functioning and potentially requiring additional BACTs in order to control odors. However, it is important to consider the significant uncertainties present in the OFFSET model as well as the uncertainties related to the "odor free" derivations and the subjective nature of the observer.

5.3.1.2 Minneapolis-St. Paul Metropolitan Area

Of the three Twin Cities metropolitan area cities interviewed as part of the MPCA Odor Investigation, none of the governmental units enforced odor emissions limits. The two cities that did have specific odor regulations as part of their ordinances, Minneapolis and Bloomington, investigate and work to address nuisance odor issues, but do so based on a judgment of ambient air conditions using no odor measurement devices or technology.

The City of Minneapolis manages odor issues under its nuisance regulations. Chapter 47 Section 250 of the Minneapolis City Code states: "Odors shall be deemed unlawful if one or more air contaminants migrate from the premises from which it originated for a period exceeding 30 minutes duration and interferes with the reasonable and comfortable use and enjoyment of property." In practice, this process is a complaint-driven one, meaning that no enforcement actions are taken in the absence of complaints lodged by residents. Minneapolis has a 24-hour complaint hotline, as well as an online complaint form that people may fill out and submit. When a complainant calls in background information is gathered regarding weather conditions, what time the odor is detected, whether it is a one-time instance or recurring, what the odor smells like, and any other details. Complaint substantiation is done by an inspector on site using their judgment of ambient air conditions. No odor measuring equipment, such as a Scentometer, is used.

For substantiated odor complaints, Minneapolis prefers to work in a facilitative process with the industry to resolve any odor issues. After an agreement is reached as to the corrective action and implementation plan, the City will do a compliance check to verify that the terms of the agreement are being met.

St. Paul currently does not have any odor regulation as part of their city ordinances. This may be changing due to the recent, high-profile issues resulting from operations of the Gopher State Ethanol Plant on the city's Lowertown neighborhood, but, as of this writing, no ruling had yet resulted from this case.

The City of Bloomington regulates odor under the city's public health nuisance ordinance (City Code Section 9.07). The overall process is quite similar to Minneapolis's with complaints lodged by telephone and followed up on with on-site visits by city inspectors using their nose and their judgment as to the presence or absence of odors in the ambient air. The city works through a facilitative process with an offending site, whereby they attempt to determine whether the odor event was related to an accidental emission, or whether it may be related to a breakdown

in processes. A nuisance odor violation can be issued if it is determined that the offender knew that odorous emissions would result from their processes. If a facility has a chemical evacuation system, paint booth, or other potentially odorous operation, the Building Inspections Department will inspect annually to ensure that they meet the specific requirements of the air quality permit. The City also has what is known as a "reduction emission plan," which is part of the general air quality permitting.

Metropolitan Council Environmental Services is the agency with authority for all wastewater treatment facilities in the Twin Cities metropolitan area. They are, of course, subject to all applicable state and federal regulations for criteria air pollutants. Even though odorous emissions monitoring is not part of the typical monitoring process required to meet these standards, MCES does routine odor monitoring at 31 sites around the Twin Cities. This sampling is done at the odor source (as opposed to off-property), and the sample of odorous air is then presented to an odor panel, consisting of eight citizens, using ASTM Standard 679-91, which employs dynamic olfactometry along with increasing odor concentrations to establish odor concentrations.

5.3.2 Upper Midwest

Of the states surrounding Minnesota, North Dakota, South Dakota, Iowa and Wisconsin, only North Dakota has an odor statute that sets specific limits for odorous emissions. The remaining states either have no statewide odor regulations (Iowa and South Dakota) or, in Wisconsin, set no measurable standards for odor emissions. A table summarizing odor regulations in the Upper Midwest precedes this discussion (see Table 6). Noteworthy programs are discussed at length immediately following.

5.3.2.1 Wisconsin

Wisconsin's "Malodorous Emissions" statute states that "[n]o person may cause, allow or permit emission into the ambient air of any substance or combination or substances in such quantities that an objectionable odor is determined to result…(Wisconsin, Chapter NR 429)" In this way, their state statute is similar to odor regulations in Minnesota, such as that in Meeker County and in Bloomington and Minneapolis. However, the Wisconsin statute does define "objectionable odor tests", thereby attempting to standardize the process of substantiating complaints. Although the first test mentioned in the statute is essentially identical to typical complaint substantiation processes, basically, the best judgment of an investigator on site, the second test is somewhat unique. In this test, odors are deemed objectionable when "60% of a random sample of persons exposed to the odor in their place of residence or employment…claim it to be objectionable and the nature, intensity, frequency and duration of the odor are considered." In practice, it would appear that this second, survey-driven test is infrequently used; however, it is available for use depending on the situation and administration.

5.3.2.2 North Dakota

The North Dakota Department of Health enforces a statute restricting odorous air contaminants (North Dakota, Chapter 33-15-16). Various emission standards are set, dependent on whether

emissions occur in an urban or a rural area of the state. For urban areas, odors cannot exceed 7 odor concentrations units (7 D/T as measured by a Scentometer) outside the property boundary. For rural areas, the 7 odor concentration units standard is used within 100 feet of any residence, church, school, business, or public building or within a campground or public park, if these sites fall ½ mile beyond the offending source. If these receptor sites are within ½ mile of the offending source, odor measurement can be taken only if the receptor sites were in place before the offending source was in use. It is interesting to note that, prior to June 2001, North Dakota had enforced the odor statute with a limit of 2 odor units (2 D/T as measured by a Scentometer). This standard was changed to a 7 D/T because of the perception that a higher standard (i.e., a lower D/T value) for odor emissions did not give enough protection to businesses. In other words, by establishing a lower D/T, which would mean that lower concentrations of odor in the ambient air could be detectable using Scentometer testing, it was believed that more businesses would be affected by the rule and would be subject to enforcement proceedings.

In addition to limiting odors in the ambient air, North Dakota also restricts emissions of hydrogen sulfide (established as 0.05 ppm sampled at least 15 minutes apart within a 60-minute period).

5.3.2.3 Des Moines

Des Moines enacted an odor ordinance in 1991 as part of a grassroots effort by citizens who were affected by odorous emissions emanating mainly in the southeast quadrant of the city from meat-packing and processing industries (Des Moines, Chapter 42, Article 5, Sec. 42). The City contracted with a consulting firm to assist in the drafting of their odor ordinance, which establishes several citizen participatory and reporting functions, as well as establishes the process of complaint substantiation, penalties, and compliance as part of ordinance enforcement. Significant elements of this ordinance include the following:

- A 24-hour odor hotline for the reporting of odor complaint. This odor hotline is staffed by an answering service trained in asking the complainants certain question used in complaint documentation and reporting.

- A citizen odor board consisting of residents from the affected area.

- A process for designating an odor source as a "Significant Odor Generator" (based on the number of complaints received during a defined time period, see Appendix D for details), which entails submitting a compliance plan documenting the use of BACTs for the mitigation and control of odorous emissions.

5.3.3 Other States and Cities

In total, 15 other states and cities were interviewed as part of this odor investigation and noteworthy programs are discussed in detail in the sections immediately following. A summary table representing the findings from all state interviews is shown below (see Table 7).

TABLE 7
Other States and Cities Odor Regulatory Summary

	Odor Rule or Ordinance	Measurement Methodology	Standard for Complaint Substantiation	Compliance Process
San Francisco/ Bay Area	Yes[1]	Dynamic Olfactometry	If odor sample is detectable by an odor panel at 4 dilution thresholds of clean air to sampled air	Formal process including documentation of violation, corrective action and assessment of fines.
Chicago	Yes	None[2]	Inspector evaluating ambient air conditions	Facilitative process, although fines may be assessed for facilities not operating in accordance with permit requirements
Colorado	Yes	Scentometer	7 D/T in urban areas/ 15 D/T in rural areas For Swine Operations: 7 D/T at property line 2 D/T at receptor location (residence or location of complainant)	Formal process including documentation of how odors will be redressed and assessment of fines
Connecticut	Yes[1]	None[2]	Inspector evaluating ambient air conditions	Facilitative process
Idaho	Yes[3]	Butanol Standard	8-point scale	Facilitative process
Louisiana[4]	Yes	Butanol Standard	8-point scale	NA
Massachusetts	Yes	None	Inspector evaluating ambient air conditions	Facilitative process
Missouri	Yes	Scentometer	7 D/T[5]	
North Carolina	Yes	Butanol Standard	5-point scale	Facilitative process, although penalties may be assessed.
Oregon	No[6]	None	Inspector evaluating ambient air conditions	Facilitative process[7]

	Odor Rule or Ordinance	Measurement Methodology	Standard for Complaint Substantiation	Compliance Process
Rhode Island	Yes	None	Inspector evaluating ambient air conditions	Facilitative process, although penalties may be assessed.
South Carolina	No(8)	None	Inspector evaluating ambient air conditions	Facilitative process(9)
Texas	No(10)	None	Inspector evaluating ambient air conditions	Facilitative process
Vermont	Yes	None	Inspector evaluating ambient air conditions	Facilitative process
Wyoming	Yes	Scentometer	7 D/T	Formal process in which notice of violation is issued for substantiated complaints.

(1) Compounds-based limitations enforced as well as general odorous emissions.
(2) Scentometer testing is stipulated in odor regulation, but in practice is unused.
(3) Idaho has a formal complaint response policy in place.
(4) An interview with Jane LaCour, with Louisiana's Department of Environmental Quality indicated that this rule is not currently enforced.
(5) For CAFOs with over 7,000 animal units, Scenotmeter testing is used as a screening evaluation, not as the sole substantiation of an odor complaint. For these facilities, if the inspector detects an odor using the Scentometer, then air samples are taken. These samples are sent to a laboratory, which then assembles an odor panel that test the air using a butanol standard.
(6) Oregon does have a nuisance control requirement as part of the DEQ's Administrative Rules.
(7) Enforcement of nuisance odor complaints in Oregon is managed through their Small Business Assistance Program.
(8) South Carolina does not have a comprehensive, state rule regulating odorous emissions. However, they do have a regulation for the permitting of animal agricultural operations that covers odor abatement.
(9) In South Carolina, the NRCS (Natural Resources Conservation Service) acts as a consultant to the farmer in preparing the Waste Management/Odor Abatement Plan for all Agricultural Animal Facilities.
(10) Texas does have a formal nuisance protocol in place. See Section 5.3.3.6.

5.3.3.1 Bay Area Air Quality Management District (BAAQMD)

The San Francisco Bay Area is interesting from an odor regulatory standpoint in that it was the only agency or jurisdiction found to use laboratory dynamic olfactometry in the complaint response/enforcement process (BAAQMD, Regulation 7). According to BAAQMD staff, most odor complaints are managed in a facilitative process; however, for those sources that are chronic generators of complaints, a formal process is followed in order to "enact the limitations of th[e] regulation". By rule, the receipt of ten or more complaints within a 90-day process triggers enforcement proceedings. In these instances, an inspector will take a sample of air at the

property line. The sample bag must be evaluated within three hours by an odor panel consisting of three persons. Due to liability concerns, odor panelists consist of BAAQMD staff, pre-tested to ensure that they have an "average nose". Those people who are either too sensitive or too insensitive to odors are eliminated as potential odor panelists. The sample is diluted with 4 parts of odor-free air to one part of sampled air, and this is presented to the panelists. If they can detect an odor, then the source is found to be in violation of the BAAQMD odor regulations.

5.3.3.2 Colorado

Colorado uses Scentometer testing as part of their complaint substantiation process. Their general odor regulations have been in place since 1971; however, in 1999, this regulation was substantially amended to include housed commercial swine feeding operations (other agricultural uses are exempt from the odor regulations) (Colorado Air Quality Control Commission, Regulation No. 2). Although Scentometer testing as a means of substantiating odor complaints is used for both agricultural and non-agricultural odor sources, the standards vary, with higher standards (2 D/T at receptor locations) pertaining for agricultural (swine feeding operations) uses. Any setbacks required for swine operations are all established and enforced at the local level, or by other land use authorities; there is no statewide standard establishing setbacks. It was the opinion of Kirsten King (Supervisor for the Compliance and Support Program, Colorado Department of Public Health and the Environment) that Scentometer testing was not popular with their inspectors, who found the equipment cumbersome to use. The great majority of all odor complaints lodged with the state of Colorado are against swine operations.

5.3.3.3 Massachusetts

Massachusetts was interesting in that it was the only state or city part of the interview sample that used dispersion modeling, with established odor emissions limits, as part of their new source permitting process. Although still a draft policy, John Winkler, permit chief for the Massachusetts Department of Environmental Protection, indicated that it was being used. The standard established is to document that new sources not exceed 5 D/T at their property line. The ISCT model, approved by the U.S. EPA is used in this emissions modeling process.

5.3.3.4 North Carolina

North Carolina administers rules regulating nuisance odor emissions (North Carolina Administrative Code, Sect. 1800). Two separate rules are enforced, one dealing with agricultural sources, the other dealing with other source types. When complaints are lodged, the complainant is asked to keep a logbook. Field tests are then done under similar circumstances (i.e., time of day, weather conditions, etc.) to those noted in the logbook.

Summary of State and City Regulations

- Although many states have odor regulations, regulatory approaches are variable. Most states do not make the connection between regulation and environmental review and permitting processes.
- About half of the agencies use some type of odor measurement technology while the other half rely on the judgment of the inspector.
- Some states have odor thresholds in place, but in practice are not using these standards.

North Carolina uses ASTM Standard E544-99, in which butanol is used as a baseline odor calibration (smelled using a mask) and then ambient air is smelled to establish the odor intensity on the ASTM Odor Intensity Referencing Scale. This is done by a comparison of the odor intensity of the sample to the odor intensities of a series of concentrations of the reference odorant, which is 1-butanol (n-butanol). North Carolina uses a 5-point butanol scale. Staff members are trained in this technique, and it is used in the field to substantiate odor complaints. In the opinion of Gary Saunders, Special Project Engineer for the North Carolina Department of Environment and Natural Resource, the ASTM Standard is working quite well in North Carolina. He did not believe that other measurement techniques would allow for the ease in use and training that the ASTM standard allows.

If an objectionable odor finding is made in the field, then state staff work with the facility operator to institute a Best Management Plan. It is incumbent on the facility to propose a plan to alleviate nuisance odors. Only if odor problems persist does the State step in to initiate Maximum Feasible Controls (as referenced in their Odor Rules). This last step is seen as rather dire by the industries and as of yet, a situation has not deteriorated to the point where this was instituted.

5.3.3.5 Oregon

Oregon enforces nuisance control requirements, although they do not have any odor regulations, per se. A nuisance situation is determined based on 1) frequency, 2) duration, 3) strength or intensity, 4) number of people impacted, 5) suitability of each party's use to the character of the locality, 6) extent and character of the harm to complainants, and 7) source's ability to prevent or avoid harm (Oregon Department of Environmental Quality, Division 208).

No measurement technology is used in substantiating a complaint, beyond the inspector's judgment of ambient air quality. According to Scott Manzano, an Environmental Analyst with Oregon's Department of Environmental Quality, odor measurement technology was found to be unreliable and was not a valuable part of the process.

If a nuisance is substantiated, then a Best Practices Agreement to remediate the nuisance situation is entered into. If the use is a permitted use, the permit is amended to reflect the Best Practices Agreement. If the facility is not permitted, then the Best Practices Agreement is a stand-alone document kept on file for future reference.

5.3.3.6 Texas

The State of Texas' Commission on Environmental Quality (TCEQ) has a formal 'Nuisance Protocol', which is used to regulate odorous emissions (Part 30 TAC 101.4). This protocol is based on the state's nuisance law but expands the process for determining an odor nuisance and any necessary enforcement.

The state has an odor complaint hotline with trained staff receiving calls and directing them to the relevant departments of the TCEQ. Where adverse health effects are alleged by a citizen or detected by an investigator, an investigation must be conducted as soon as possible. If adverse

health effects are not alleged or suspected, an investigation should be conducted to determine the odor according to prioritization procedures. The prioritization procedures are based on the health effects occurring to neighbors.

The following categories are used by inspectors in classifying odors detected in the ambient air:

Category 1	Category 2	Category 3	Category 4	Category 5
No odor detected.	Odors barely detected. Odors very faint. Odors very intermittent and faint. Odors not strong enough or of sufficient duration to identify or characterize the odors.	Odors light, not objectionable. Odors noticeable but not unpleasant.	Odors light to moderate, but not unpleasant. Odors somewhat objectionable but not sufficient to interfere with the normal use and enjoyment of property. Odors strong and objectionable, but very intermittent, and because of lack of duration would not tend to interfere with normal use and enjoyment of property. Odors strong but not at all unpleasant and would not create adverse reactions or interfere with the normal use and enjoyment of property.	<u>General</u> Odors capable of causing nausea. Odors capable of causing headaches. Odors overpowering and highly objectionable. Odors would create a need to leave the area. <u>Residential Areas</u> Odors offensive enough to prevent working or playing in the yard. Odors tend to stay in the residence and make it difficult to sleep, eat, etc. Odors tend to interfere with entertaining guests. <u>Commercial Areas</u> Odors tend to interfere with normal activities of office workers. Odors tend to stay in building and make it difficult to read, type, concentrate, etc. Odors tend to interfere with normal warehouse work activities. Odors tend to interfere with normal outdoor work activities.

TECQ staff attributed the success of the nuisance protocol program to the objectivity by which they could make a nuisance determination (for example, the categorization of odors). Texas counties can choose to be the delegated agencies managing this protocol, otherwise, the regional TCEQ offices retain responsibility. This odor investigation did not uncover any other U.S. state with a similar program to expand the nuisance law and the TCEQ is unaware of any other state researching their method.

5.3.4 International Odor Regulations

Some of the more sophisticated, and stringent, odor regulations are found in other countries around the world, including the nations of the European Union, and Canada and Australia. Due to the difficulty involved in interviewing agency staff from foreign countries, the sample for this interview was relatively small and focused on Canada and Australia. Although this

consideration was partly practical in nature given language barriers in Europe, it was also appropriate given the greater similarity between density of land uses and dispersion of population between Canada and Australia to conditions in the United States.

5.3.4.1 City of Montreal, Canada

The City of Montreal does regulate nuisance odors, and has done so since the 1970s. Montreal does regulate the emissions of certain compounds, such as toxics and classes of VOCs, however, they also limit odors in general (Montreal, Regulation 90). During the permitting process, review staff tries to ensure that BACTs will be in place to regulate odorous emissions. In doing so (review of BACTs), the staff rely on their knowledge of the industries and any known potential to emit odors. For source types with which staff has no experience, they turn to other experts for assistance.

Although for certain sources routine odor checks are done, in other instances enforcement is complaint based. Complaints against facilities are lodged by phone. Every complaint is followed up on. Questions complainants are asked are the odor's intensity, duration, severity, and characterization.

When an inspector goes out to follow up on complaints, no testing methodology is used other than their judgment of odors present in the ambient air. The inspector will attempt to identify the offending source, and even what process may be ongoing that is creating the odor. If the complaint is deemed credible, the source will be notified of the complaint.

If the offending source is a permitted one, then the permit may be checked as part of the enforcement process; if the source is a new one that is not permitted (because they may not have known of the need to get a permit) then the inspector will inform them of the need to get a permit. This process begins in a facilitative manner.

If problems are not being addressed and odor complaints persist, then a more formal complaint substantiation process is enacted. This consists of odor sampling (if a point source, at the chimney; if an area source, at the property line). The offending facility can be required to do its own sampling by paying a consultant pre-approved by the City. Air samples are administered using dynamic olfactometry to an odor panel of 5 persons. City staff must be present when the test is administered. Montreal's standard is a 1:1 dilution threshold.

5.3.4.2 Province of Ontario, Canada

Ontario does regulate odorous emissions under the province's air quality act (Ontario, Environmental Protection Act, R.R.O. 1990, Regulation 346). Compliance with odor standards is required during the permitting process, including Ontario's version of an Environmental Assessment. The firm seeking the permit is required to provide documentation of compliance.

Dispersion models used by the Ministry of Environment are, for a single source, the USEPA Screen III model and Aeromod. For multiple sources it is the ISC 3. All of these models are US EPA approved; however, Ontario uses a 10-minute average, rather than a one-hour average.

The permittee (facility) does the inventory based on a list of 87 regulated contaminants, using a dispersion model.

Any permitted facility, after beginning operations, is required to do testing about 2-3 months after opening (after operations are established and operating routinely) in order to ensure that they are within their permitted emissions limits. If the facility is not within their limits, then they must draft a plan for coming into compliance.

Routine testing of certain types of permitted facilities is done in order to ensure they are within their permitted limits of emissions. Ontario's odor standard is a 1:1 D/T.

Every odor complaint lodged is followed up on. Critical information to receive from the complainant includes place, time, and characteristics of the odor event. No equipment, other than the judgment of the inspector using his or her nose, is used to substantiate the odor complaint.

Even if the inspector cannot detect an odor, the facility will be contacted and a facilitative process of identifying the cause of the odor emissions and redressing any ongoing problems will begin. The facility is responsible for documentation of issue and any follow-up steps, if necessary.

Typically, a facilitative process is used to address issues. However, in extreme instances, sampling of odorous air at the source is done (four samples are taken), and an odor panel is convened (consisting of people not from the area and unaccustomed to the odor) to test the air sample using dynamic olfactometry. Samples are tested within 24 hours of having been taken.

5.3.4.3 State of Victoria, Australia

The State Environmental Protection Policy for Air Quality Management No. S 240 identifies odor as an unclassified air quality indicator of local amenity and aesthetic enjoyment of the air environment. Design criteria and standards are set for pollutants including odor. The dilution threshold for odor is 1 odor unit, which is measured in mg/m^3 on a 3-minute averaging time at the property line. This threshold is for new and expanded sources.

For industries involving intensive animal husbandry (CAFOs), odor emissions must be modeled to demonstrate that the maximum odor level does not exceed 5 times the odor detection threshold at and beyond the property boundary.

Complaints are investigated and substantiated by trained EPA officers based on their judgment of conditions in the ambient air. Inspectors use a checklist to characterize the odor that includes: hedonic tone, intensity, frequency, etc.

5.3.4.4 Western Australia

Western Australia (WA) has guidance on assessment of odor impacts from new facilities. It is not a regulation, but provides the basis of evaluation by the WA Department of the Environment

for new and expanded facilities. Section 49 of the WA Environmental Protection Act makes "unreasonable" odor emissions an offense; however, prosecutions under this Section are rare. The WA DOE guidance is purely nuisance based.

Odor may be addressed in an operating license, but quantitative limits are generally not specified. For some sources where odor is an ongoing problem, odor concentration limits based on dynamic olfactometry have been applied.

There are three stages to a typical response to an odor complaint: assessment of whether the department or local government should investigate, obtaining background information such as a description of the odor, identification of nearby industries, wind direction, time of day and others. After doing so, a site investigation is made to determine offensiveness.

If the odor is deemed offensive then the facility could be prosecuted under Section 49, but as mentioned before this rarely happens. More commonly, an Environmental Field Notice is sent to the polluter who must respond to the notice. Field officers also assess potential health impacts of the odor.

5.3.5 Regulatory Practice Findings

5.3.5.1 Minnesota Findings

- Minnesota has no statewide rule regulating odorous emissions.

- Local jurisdictions can establish odor ordinances. Based on responses to the Minnesota County survey administered as part of this odor investigation (see Section 4.4), only 29 percent of Minnesota counties have regulations covering nuisance odor emissions. Of those counties that do have ordinances, most of them cover feedlots odors, and do so by establishing setback distances. Nicollet County is the only county that references use of the University of Minnesota's OFFSET model in establishing setback distances as part of their zoning ordinance.

- There is no jurisdiction in Minnesota that currently regulates odorous emissions based on odor emissions standards.

5.3.5.2 Upper Midwest Findings

- Two other states in the Upper Midwest region, Wisconsin and North Dakota, do have statewide odor regulations. North Dakota has set odorous emissions standards of 7 dilutions to threshold as measured by a Scentometer.

5.3.5.3 Other States and Cities Findings

- Of other states and cities around the United States, there was a fairly even split between those with established odorous emission standards and those without. In instances where no standards were established, inspectors used their judgment of odors in the ambient air to substantiate complaints.

- Odor measurement methodology in other states and localities included dynamic olfactometry, Scentometer testing, and the n-butanol method.

- The San Francisco Bay Area was the only area using dynamic olfactometry as part of the complaint substantiation process.

- Although Connecticut and Chicago have odor regulations that reference odor emissions standards of D/T as measured by a Scentometer, this methodology of odor measurement is not used in practice. In both instances, using this equipment had come to be viewed as not valuable in the complaint substantiation/compliance process.

- The state of Louisiana has odor regulations establishing odorous emissions thresholds using the n-butanol standard on an 8-point scale; however, in practice, this regulation is unenforced.

5.3.4.3 International Findings

- The most sophisticated odor regulations are found outside the United States.

- Regulations in Canada and in Australia include requirements for dispersion modeling of the potential for nuisance odor impacts during the environmental review and permitting process. These countries also have stricter odor emissions limits (1:1 D/T) than were discovered in any other area of the United States.

- Although Montreal and Ontario use dynamic olfactometry and dispersion modeling during their environmental review and permitting processes, this tool is not typically used as part of their complaint response process. Their inspectors typically use their judgment of odors in the ambient air and no other odor measurement tool when responding to complaints.

6.0 A MODEL ODOR REGULATORY FRAMEWORK

A model is presented here for the MPCA's consideration. This model is based on the current state of odor science and regulation as found during literature review and surveys of other regulatory agencies. Although other factors such as cost and staff resources would enter into the decision to adopt such measures, these approaches are potentially applicable to the types of odor issues encountered in Minnesota. The regulatory framework covers:

1. The permitting and environment review process; and,

2. The compliance and enforcement process.

It is important to separately address these two processes because of the various means by which odors are addressed during these steps. The goal of the permitting and environmental review process is to eliminate the potential for problems before a facility begins operating; the goal of the compliance and enforcement process is to provide a mechanism to address problems that arise after a facility is operating.

6.1 Permitting / Environmental Review

This sequence of steps is used to outline a process where potential odor impacts from a new or expanding facility can be evaluated in an environmental review or permitting process. (See Figure 3 for a flow chart illustrating this process.)

6.1.1 Determining Whether the Facility is a Potential Problem

The first step in determining whether a new or expanding facility has the potential to generate odors is based primarily on a familiarity with the types of facilities that have been known to produce odors in the past.

Sources that are commonly associated with odor problems in Minnesota are presented in Section 4. In addition to past experience with a particular type of facility, information regarding the process should be evaluated.

- A list of chemicals to be used at the facility
- Amounts of chemicals used and types of processes
- Substances to be emitted and emission rates
- Proposed containment and control technology

6.1.2 Identify Odorants and BACTs

Various regulatory agencies have developed lists of common odorants. One such list is published by the New South Wales Environment Protection Authority in a Draft Policy: *Assessment and Management of Odour from Stationary Sources, January 2001* (pages 3 and 4), http://www.epa.nsw.gov.au/air/odour.htm. This list includes the odorant along with a concentration (in parts per million) that corresponds to its

Steps in the Permitting/Environmental Review Process

- Determine potential to generate odors
- Identify odorants
- Establish level of detail of odor assessment
  - Density of receptors
  - Cumulative impacts
  - Odor strength and character
  - Frequency and duration
- Complete odor assessment
  - Qualitative or quantitative means depending on need
  - Predict odor emissions
  - Dispersion modeling
- Characterize potential impact
  - Odor strength
  - Frequency and duration
  - Odor character
  - Density of receptors
- Develop permit conditions
  - Stipulate Best Available Control Technologies (BACTs)
  - Set odor emissions limits

threshold of detection. This concentration is known in this policy as ground-level concentration (GLC) criteria and is determined by dynamic olfactometry.

If a facility is thought to have the potential to emit odors, the applicant should provide the following mitigation measures:

- Measures to be taken to prevent the generation of odor where possible.

- Measures and treatment technology that will contain and or treat emissions where prevention of odors is not possible

Technologies to control odors are specialized for each source type. Assessment of reasonable control technologies requires knowledge of the effectiveness, cost and feasibility of these measures. If it can be shown that control technologies will eliminate odor emissions, no further assessment is needed. However, if prevention and mitigation cannot fully eliminate the need for odor emissions, an assessment of odor impact is needed.

6.1.3 Determining the Level of Detail Required in an Odor Impact Assessment

If odor emissions can be measured or predicted, an odor impact assessment can be performed that predicts odor concentrations at specific receptor sites. The predicted odor concentrations are used to determine whether there will be a reasonable cause for annoyance. The level of detail of the odor assessment will depend on the potential magnitude and degree of risk of a potential impact. A simple scoping study may be appropriate to determine the level of detail required in an odor assessment. Factors to consider in determining the level of detail required for an odor assessment include:

- **Density of potential receptors** – While the number of people affected by a particular odor may be irrelevant to a regulatory program, the number of people that could be affected is still an important consideration because the likelihood of impact to very sensitive individuals is increased along with the number of people affected. With higher population density around a potential odor source, the proportion of sensitive individuals is also likely to be higher and more stringent odor criteria may be necessary. The possibility of future development should also be considered when assessing the density of potential receptors.

- **Potential for Cumulative Impacts** – If a new source is located in an area where odor impacts already occur or if the new source is the result of an expansion of an existing source, the cumulative impacts of the existing sources may have to be included in the assessment.

- **Character and Strength of odor** – The character of the potential odor will play a role in the annoyance potential. The concentration of an odor that will cause an annoyance will vary depending on the hedonic tone of an odor. Everyday and industrial odors have been studied and ranked using hedonic tone. A summary of hedonic tone ranking results for the United States, Netherlands and the United Kingdom is presented in the *Integrated Pollution Prevention and Control (IPPC) Draft Horizontal Guidance for Odour, Part 1, Page 30, published by the UK Environment Agency, October 2002.* While the hedonic tone of a

potential odor should be considered during a planning process, the only accurate way of estimating the actual level of annoyance in a particular community is by carrying out a dose-effect study on the affected population.

- **Frequency and Duration of Emission** – Odor emissions may be continuous or may only occur during a particular process or clean-up activity. A short duration or uncommon odor release will likely be less annoying than a constant odor.

6.1.3.1 Qualitative and Quantitative Odor Impact Assessment Methods

Using the information described above, a qualitative odor assessment may determine that the proposed emissions will not cause annoyance. If there is uncertainty or if odors have the potential to cause annoyance, a quantitative odor assessment may be required.

A quantitative odor assessment is generally accomplished by predicting an exposure level at nearby receptors and generally center on dispersion modeling. The predicted odor exposure is commonly compared with a performance criterion or a standard. A generalized process for an odor assessment method is presented below. Another, more detailed evaluation of odor impact assessment methods and is presented in Appendix 3 of the IPPC Guidance mentioned above.

6.1.4 Predicting Odor Emissions

Odor emission rates are used as input into a dispersion model along with meteorological and topographic information. Emission rates and predicted concentrations are normally presented in odor units or mass concentrations and can be estimated or measured. However, physical and chemical data may also be used with mass-transfer algorithms to generate reasonable odor input values that reflect the emission characteristics of some air emission sources (Thomann, 1987). For a new or expanding source, emission rates must be estimated unless a pilot test can be run with emission measurement. Industrial processes generally discharge in a point source such as a smoke stack, while sources such as landfills, composting sites or agricultural operations discharge over diffuse areas. If the air emission source is an areas source, similar to a manure storage system or a wastewater treatment pond, the chemical sampling method may be used. The project proposer should present the basis for determining emission rate estimates that can be confirmed by measurement once a facility is active.

Agricultural sources may be point sources such as a ventilation output from a barn or non-point sources such as a manure lagoon. Techniques exist to measure odor emission rates from manure storage systems, including direct measurement and mass-transfer methods.

6.1.4.1 Dispersion Modeling

Dispersion modeling attempts to assess distribution of emissions as they are diluted and transported on the wind. Output from dispersion modeling is presented as a spatial representation of odor concentration or constituent concentration for a given set of meteorological conditions. Chemical surrogates are often used in the modeling process rather

than odor. For a complete discussion of this approach, see the Hancock Pro Pork Draft EIS posted by the MPCA on May 27, 2003.

Dispersion modeling is generally used when an emission rate is known or can be estimated. Emission rates in odor units can be modeled to estimate odor concentration in odor units at specific receptors or property lines. The accuracy of the emission data is crucial because source emissions are used by the models as a starting point. The computer models that perform these calculations also take into account factors such as distance from the source to the receptor, meteorology, intervening land use and terrain, pollutant release characteristics and background pollutant concentrations. The US Environmental Protection Agency maintains a Support Center for Regulatory Air Models at the website: http://www.epa.gov/ttn/scram. Various dispersion models are available and have been extensively reviewed and evaluated.

The benefit of digital air dispersion modeling is that it provides predicted durational data that better reflects the potential odor impacts to a community based on local meteorological data and site specific inputs. Additionally, digital modeling can account for the various offsite sources which may contribute to air quality impairments in a community. Air quality modeling is generally cost effective (typically between $2,500 and $10,000 depending on the nature of the project) using either the direct measurement methods for odor input values or the chemical methods using mass-transfer algorithms. Guidance is readily available for developing a modeling protocol from the EPA and many states have adapted these practices for their own programs.

Various regulatory agencies have set odor limits, or criteria, generally ranging from 1 to 10 odor units, as predicted during dispersion modeling. An analysis performed by the New South Wales Environmental Protection Agency compared various odor performance criteria used Worldwide and concluded that a range of 2 OU to 7 OU is generally consistent with odor performance criteria used world wide. However, this document goes on to say that nuisance levels from various odors can be as low as 2 OU and as high as 10 OU. However, odor units are but one dimension of the odor event that humans are able to sense through olfactometry. Intensity, hedonic tone and duration are also critical factors in the evaluation of odor. The assessment of odor impacts where chemistry is not readily available may involve a ratio of the intensity to the odor concentration as the quantified value with hedonic tone and odor characteristics as the qualitative descriptor. Where a chemical odorant is the known cause of the malodorous condition, concentrations developed by the industrial hygenists may be used (Amore, 1985 and Amore et al, 1983).

While odor or chemical surrogate performance criteria appears suitable as a generalized goal for proposed facilities and community specific impact analysis, it is important to recognize the uncertainty of the modeling process that results in the predicted impact. The most important input in a dispersion model is the emission rate of the proposed facility. This number is based on a measurement or an estimate of proposed emissions. In evaluating calculations of predicted impacts it is crucial that staff be knowledgeable in the assumptions, and the limitations and uncertainty of dispersion modeling. For a further discussion of modeling and uncertainty, see the work of Isukapalli, (1999).

6.1.5 Characterize Potential Impact

The goal of an odor assessment is to determine whether a facility that will emit an odor will be judged to be offensive and thus cause an adverse impact to nearby receptors. In practice, offensiveness is ultimately judged by public reaction and therefore can only truly be evaluated by determining actual public response. However, in planning and permitting a new source, the potential for annoyance must be characterized through the use of the following:

- Odor strength is the odor concentration predicted by a dispersion model.
- Frequency/duration should be addressed in the odor impact assessment. Dispersion models commonly present a "worst case" odor strength as well as the frequency and duration of odor episodes should also be included in an odor assessment.
- Odor character can be addressed by assessing the unpleasantness of a particular odor. This assessment can be done by evaluating past experience of odors from a similar source type or if little data is available, a sample of the odor can be analyzed as to its offensiveness.
- Density of potential receptors and setting of potential impact.

Using the tools described above, a reviewer can make a reasonable determination of the affect of odors from a particular source. The results of these types of studies can help a facility determine what control measures will be needed to head off future problems associated with odor impacts.

6.1.6 Permit Conditions or Setting an Odor Limit or Design Criterion

The crux of any traditional odor regulatory program is setting a standard or limit that should not be exceeded. Odor performance criteria or a design goal for a facility is typically set as a number of odor units at a specific receptor or property line. Many regulatory programs such as those regulating water and air quality or noise have relatively simple standards setting limits on specific compounds or noise levels. Many of these types of standards use an averaging time, for instance, the Minnesota state standard for carbon monoxide in ambient air is an average of 30 parts per million for a one hour time period and an average of 9 parts per million for an 8 hour average. A simple standard, such as these, applying to all odors does not recognize the varying characters of odors and the corresponding variation in effect of different odors on people nor does a simple standard recognize the variation in effect of odors from one setting or community to another.

Ideally, a specific odor and the setting in which it is perceived would be sufficiently characterized so that the relationship between its concentration and community annoyance level could be understood. This type of information can be obtained through community surveys and odor characterization studies; however, one cannot expect to have the time and resources to gather this data for every odor problem. A suitable compromise appears to be a flexible policy

that can be adapted to set site-specific odor limits or design goals administered by adequately trained and experienced regulatory personnel. Adaptive management practices will allow an odor regulatory and evaluation program to develop a working body of knowledge and experience that can be used to address odor problems more efficiently as the process evolves.

6.1.7 Permit Conditions

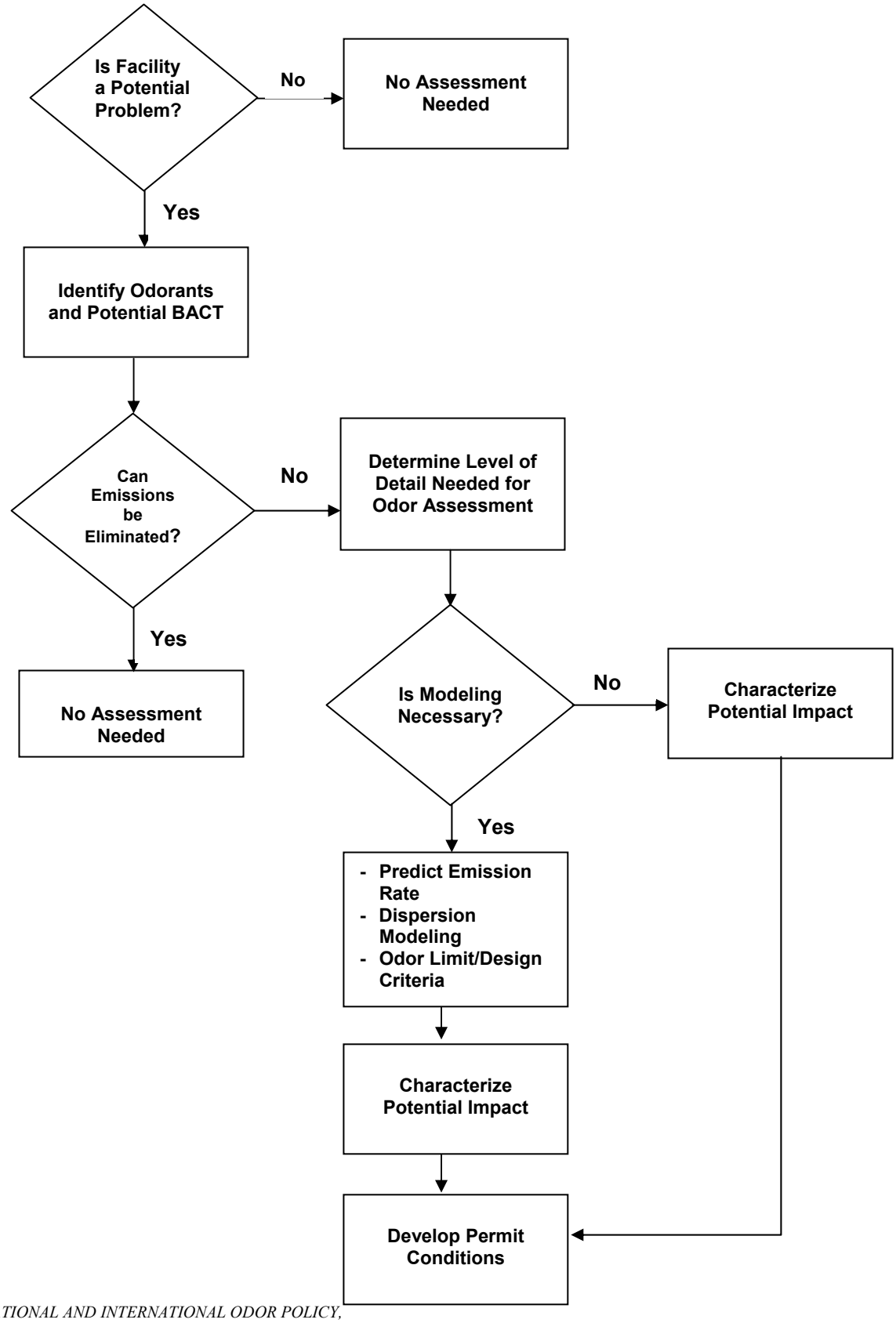
In many cases, control technology will be shown to adequately mitigate odors so that no impact is anticipated, in such cases, a standard permit condition requiring control technology, either specific or general can be included in a permit.

Where there is a higher risk of odor impacts, specific conditions for determining emission rates of odor or odorants could be required. Emission rate conditions should include a measuring location and method. Emission rates assumed in the odor assessment should be used as a guide. However, because of the generally conservative nature of the dispersion models, the actual levels will likely be lower than the modeled levels at the receptor locations.

6.2 Compliance and Enforcement

A successful regulatory program will have methods for determining compliance with permit conditions and standards. While it is possible for staff to perform inspections and take measurements to determine compliance, staffing levels may not permit regular compliance inspections and odor complaints must serve as indicators of an odor problem. Many jurisdictions have dedicated odor complaint phone numbers and respond to each complaint with a field visit to determine the validity of the complaint and identify the source. Other jurisdictions have established thresholds for when action is taken, such as the City of Des Moines, Iowa, which stipulates that "ten or more calls must be received within a six-hour period relating to a single odor description" in order to call an odor alert, at which time enforcement action is taken. Still other locations prioritize complaints, such as Texas, which prioritizes complaints based on allegations of health impacts, or Rhode Island, which bases it on health impacts as well as the inspectors knowledge of whether the offending source is one against which complaints have been lodged in the past.

Figure 3
Permitting and New/Expanding Source Review



For a complaint system to be effective, it must be publicized. An odor regulatory program should have a promotional element outlining public involvement and the complaint process. Complaint recording should include the following information:

- Location and time odor was noticed
- Character of odor
- Frequency and duration of odor
- Activities and/or weather conditions associated with the odor

Complaints are an indicator that there may be a problem but should not used as a measure of compliance. A community may get desensitized or over sensitized to an odor. Therefore, the total numbers of complaints lodged may not necessarily correspond to the severity of an odor problem and a verification process is needed.

Steps in the Compliance and Enforcement Process
• Maintain complaint log • Substantiate complaints – Odor source – Initial assessment – Gather public input – Odor measurement • Initiate compliance process – Negotiated resolution – Compliance plan • Enforcement

6.2.1 Complaint Substantiation

The first step in verifying an odor complaint often involves a site visit by trained regulatory staff. The focus of this site assessment is to identify the source and characterize the odor. Measurements of odor intensity may be conducted, if odors are detectable. The process of characterizing an odor impact, identifying and resolving the problem generally follows a path of increasing effort based on the speed with which odor issues may be redressed by an offending source. According to many of the persons interviewed from other states and jurisdictions, odorous emissions are often a signal of some industrial or other process gone awry, and the process of redressing it may be as simple as drawing the problem to the attention of the offending source (such as a malfunctioning fan in an air exhaust system). The first step in the enforcement process is confirming that there is a problem, identifying the sources of the problem, and working with the source to find a solution.

6.2.1.1 Identify Source of Odor Complaint

Oftentimes a complainant may identify the source of the odor complaint lodged. In instances where a source is not alleged, or in instances where there is some uncertainty as to which source of several may be contributing to the odor complaint, that source or sources must first be identified in order for the compliance and enforcement process to move forward. Identifying an odor source can involve ambient air odor sampling, sampling at the source, and testing the air to

make the determination of the offending source. Other tools include using community surveys, requesting that complainants keep logbooks documenting odor events, and having inspectors work with complainants as well as potential offending sources to identify the odor source.

6.2.1.2 Conduct an On-Site Odor Impact Assessment

After an initial investigation of an odor complaint, it is common to contact the source to determine whether the odor was the result of a malfunction or rare incident. If the odor release is found to be the result of a rare incident, no other assessment may be necessary. If the odor is judged to be an ongoing problem and cannot be immediately redressed, additional assessment may be warranted.

The primary goals of an on-site odor assessment are to assess a particular odor emission and to determine whether the emission causes an unacceptable impact. The characterization of an impact may relate to a permit condition or exceedance of an odor standard.

Odor episodes at specific receptor sites may be brief and dependent on specific meteorological conditions. As such, a single site visit may not adequately characterize an odor. Additional site visits performed during high odor conditions may be required by a single technician or by a panel of odor observers. The timing of such field assessments is crucial and should be determined by additional information gathered from odor receptors correlated with meteorological and/or source activities.

Questions to ask during an odor impact assessment include the following:

- How many people are potentially being affected by the odorous emissions?
- Of what frequency, intensity and duration are the emissions?
- Do any of the emissions contributing to the odor have the potential to be regulated as air toxics?
- Are there any physical maladies suffered by the receptor population that merit a unique response?
- How many total complaints have been received against the offending source? How many people have lodged complaints against the offending source?
- Is there a prevailing sentiment in the community of whether the odors fall within a community standard for acceptability?
- Have complaints been lodged against the offending source in the past? If so, what negotiated resolutions took place and what commitments to redress odor issues were made?

6.2.1.3 Gather Public Input

Information regarding specific conditions, frequency, duration and magnitude of an odor problem can be obtained from complainants or community surveys. An individual complainant or complainants may be requested to keep a diary, or a logbook of odor exposure. Alternatively, if the number of complaints or the potential for community-wide exposure warrants a more intensive effort, odor impacts can be assessed over an expanded community population through the use of surveys. These tools may be used in the early phases of an odor investigation to assess the impact or can be used in conjunction with measurements to determine a dose-effect relationship. Wisconsin was the only state in the interview sample that stipulated the use of public surveys in their regulations as a formal part of the complaint substantiation process. In this instance, if 60 percent of a random sample of persons exposed to the odor in their place of residence or employment find an odor objectionable based on the frequency, intensity, duration and character, than it is considered an "objectionable odor" and subject to regulation. However, this tool is rarely used by the state, and no record exists to allow its analysis in terms of usefulness.

6.2.1.4 Measurement of Odor Levels at Receptors

Collection of meaningful measurements at downwind receptor locations using standard odor analysis methods is difficult due to variations in odor strength over time and distance and the nature of the odor sampling method. Sampling and measurement typically assesses a sample that is discrete in time and space and may not adequately characterize a constantly varying exposure.

Measurement of odor levels at nearby receptors may be necessary to determine compliance with a standard. If a not-to-be-exceeded standard were used, odor levels could be measured during peak odor periods to attempt to determine whether a violation has occurred. This process may be a purely subjective one, based on an inspector's judgment of ambient air conditions, or it may be based on use of odor measurement technology to determine whether odors were in excess of an acceptable standard.

In order to add an element of quantification to the process, gas surrogates could be used rather than odor samples. The relationship between known gas concentration thresholds and nuisance or annoying odor is well documented in the technical literature (Zahn, DoSpirito, et. al., 2001; Amoore, 1985 and 1983; Hellman and Small, 1974).

6.2.2 The Compliance Process

When odor complaints have been substantiated, then the next step in the process is to identify the measures taken to redress the problem. To whatever extent this process can be a facilitated solution, bringing together all the parties in the process, including the offending source, the affected parties, and the responsible agencies, a greater potential for a successful resolution will be realized.

6.2.2.1Negotiated Resolution

Negotiated resolution is a process to resolve complaints quickly and to the satisfaction of all parties without reaching formal findings. In instances where resolutions are sought to odor issues, the complainant would be brought together with the offending facility to attempt to work towards a resolution. This benefits both parties, in that an offending source may not know specifically what process or chemical that they are using is causing the offensive odor. In speaking to the complainant, this may become clear and it may be that there are simple means of redressing the issue. It also benefits the complainants to know, from the offending source's standpoint, what the source is willing and economically able to do to redress odor issues. The MPCA has used this process in the past and has acted as a "third-party facilitator" in resolving disputes in the Twin Cities area, even after the statewide odor rule was revoked (interview with Scott Parr, Section 4.2.3).

6.2.2.2 Compliance Plan

A compliance plan may be required of an offending source. This plan will include documentation of the odor event that led to the compliance and enforcement action, and action steps, including changes to process or installation of odor control technologies, to address the problem.

If the offending facility has an operating permit, documentation of the actions to redress can become part of the permitting documentation, as is currently done in Oregon. If the facility does not have an operating permit, then this documentation should be part of its record and can be referred to if future odor complaints are lodged.

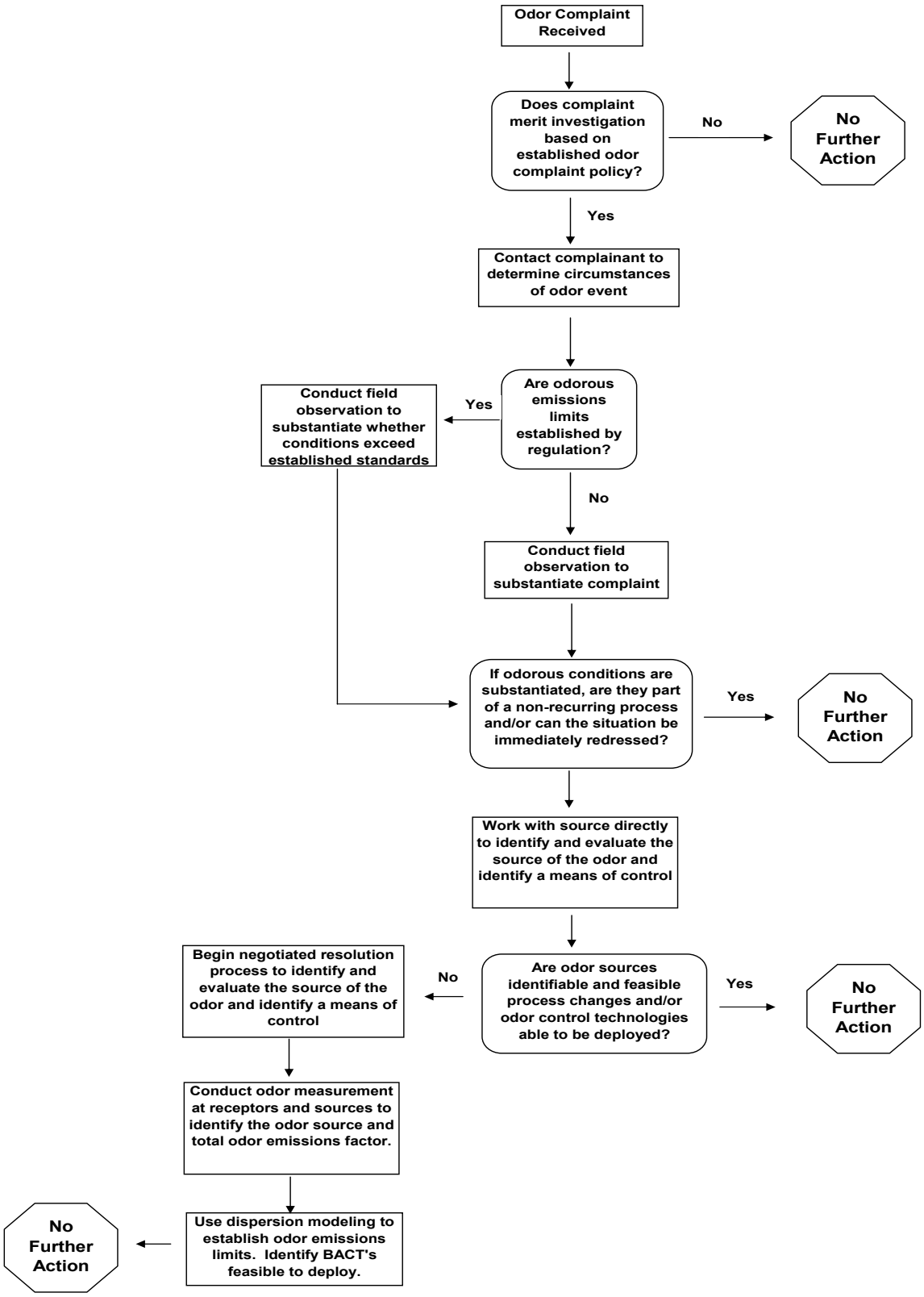
6.2.3 Enforcement

Enforcement actions will hinge partly on whether the offending source has an operating permit, and whether its operating permit specifically addresses odors or not. If the source is permitted, then an investigator can check to see what permit conditions apply, such as requirements for installation of BACTs and emissions limits, and check to see whether such conditions are being met. If the source is not in compliance with the permitted conditions, then penalties may be assessed and compliance schedules established. If the permit contains site-specific odor requirements and the odors persist, follow-up enforcement action can be taken.

If the source does not have an operating permit containing odor related requirements, some actions may still be taken to require changes to processes and practices causing odorous emissions. Such actions will likely be based on general statutory authority or application of a state or federal rule or a permit condition that does not specifically address odors. Since these types of action address a noncompliance issue other than the odor problem itself, they will generally be less effective in addressing odor issues than site-specific odor requirements that have been established in operating permits. It is possible that, even when the source is in compliance with these non-odor related requirements, the odor problem will still exist to some degree.

The MPCA is limited in its ability to address odor issues through enforcement of nuisance statutes. Such actions must be initiated by the Office of the Attorney General.

Figure 4
Complaint Response and Enforcement Process



The compliance and enforcement process should be an adaptive tool, one that enables an agency to choose the best path from a variety of options, depending on circumstances. The table that follows summarizes this adaptive approach, describing various tools for use depending upon what the agency is trying to achieve and suggesting tools of varying complexities that may be used.

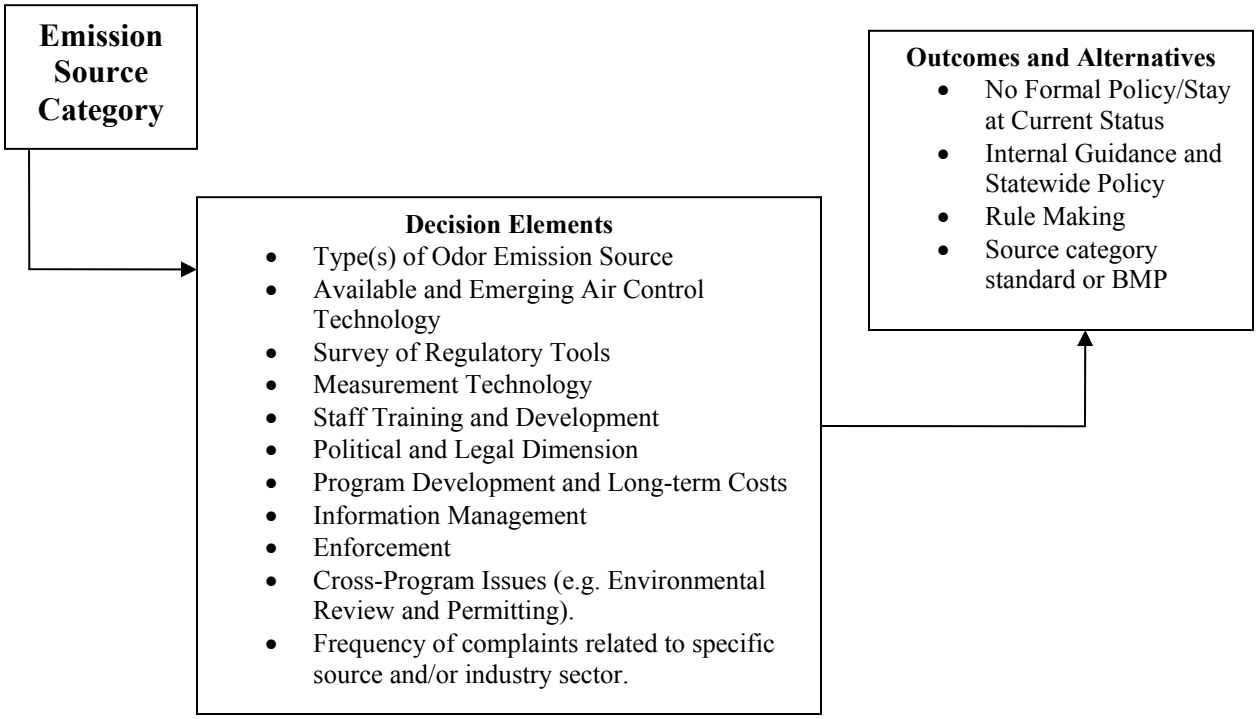
TABLE 8
Compliance and Enforcement Tools

What are you trying to achieve?	Simple/Scoping	Complex (more expensive)
Identify Source	Complaint records – use of odor descriptors ("smells like") timing of complaints relative to operations Site investigation – can be done by agency staff or can be done by agency staff working with complainant Refer to any permitting information that may indicate offending source	Conduct olfactometry testing. Ambient air may be sampled from downwind and upwind locations in order to identify one source among many that may be the offender. Olfactometry may also be used to compare an ambient air sample to a source sample of air, thereby determining the offending source.
Identify Specific Nuisance Conditions	Request that complainants keep logbooks noting time of day, weather conditions, and other relevant information regarding odor events. Plot complaint locations using GIS or other tool already available. Refer to any permitting information that may indicate whether complaints are coinciding with a particular process or maintenance activity.	Field observers – sent out to assess extent or other characteristics during specified time periods and/or weather conditions taking measurements at several locations.
Ascertain Attitudes of Receptor Population	This information may become available through responding to complaints, or by forming a local liaison committee, or through some other form of public involvement activity.	Community Attitude Survey – Conduct a random sample survey of the receptor population to quantify attitudes, tolerance and other attributes of the population.
Identify Receptor Population	Plot complaint locations using GIS or other tool already available, and calculate receptor population.	Use dispersion modeling to estimate the extent of the odor spread and calculate the receptor population from this information Use a social impact analysis tool to identify whether a receptor population may qualify for additional protection as a
Identify Enforcement Action	Check any operating permits to determine whether permitted conditions are being met. Begin simple facilitative process involving complainant(s), offending source, and 1 MPCA staff person.	Conduct odor measurement at receptors and sources to identify the odor source and total odor emissions factor. Use dispersion modeling to establish acceptable threshold of emissions. Assess fines against the facility.

7.0 STATEWIDE ODOR POLICY DECISION MAKING MATRIX

This portion of the document is considered the "operating manual" for the entire body of work. Given a particular source type and regulatory scenario, a variety of decision elements are considered. Consideration of these decision elements will help guide a policy maker to an approach to odor regulation. An outline of the decision making matrix is illustrated below.

Odor Decision Making Matrix



The first step in using the matrix is categorizing odor sources. The broad categories of emission sources studied in this document are animal feeding operations (AFOs) and Commercial Industrial and Municipal (CIM) facilities. Both of these broad categories are further divided into point and area sources. A summary of Minnesota's odor source types and discussion of the regulatory considerations for various source types are presented below in Section 7.1. See Section 4 for a detailed analysis of Minnesota's source types.

In considering regulatory options for the various categories of odor sources, ten decision elements are presented in the center box of the decision making matrix. These decision elements are discussed below in Section 7.2. The final box of the matrix is discussed in Section 7.3 and describes general categories of potential regulatory alternatives. The outputs of the matrix can be used to determine the need for a policy based on the state of the science and public administration using results of the research presented in Sections 1 through 6 and the technical report presented in Appendix D.

7.1 Emission Source Category

These four broad categories options are meant to represent categories in which all of the Minnesota odor source types can be found. The categories were developed based on the study of existing and potential source types presented in Sections 2 and 4 of this report. As explained in Section 2.2, source types were categorized into two groups: AFO and CIM facilities. Due to significant differences in potential odor control technologies these groups are further categorized as to whether they are point and area sources.

Common examples of Minnesota's source types are presented in Table 9 below.

TABLE 9
Common Minnesota Odor Source Types

	AFO	CIM
Point	Manure Storage in an Enclosed Barn Enclosed wastewater treatment structure	Ethanol plant Coffee roaster Pulp mill
Area	Open Manure Storage Lagoon Land application of manure	Wastewater treatment pond Landfill

Within these four broad categories presented in the Table, specific characteristics of a source type should also be considered. These specific characteristics are analyzed in Section 5 and include the hedonic tone of a source type's typical odor and the presence of other regulatory programs that may address (directly or indirectly) odor problems associated with a particular source type.

7.2 Decision Elements

7.2.1 Type(s) of Odor Emission Sources

As discussed above, different source types may require different regulatory approaches. An examination of the source type is a useful first step in addressing odor issues. An illustration of the difference in source type characteristics is presented below

Area vs. Point Source: In this example, a point source factory facility with painting operations is contrasted with an area source municipal waste water treatment facility. While both facilities produce odors and have nearby receptors, the painting facility's odors can be controlled relatively easily with common effluent treatment technology while controlling odors from an area source is often not practical. During the permitting process the painting facility may be required to treat its emissions to remove or destroy odorants assuring there will be no odor impacts. An area source, on the other hand, may not have the means to control its odors so an analysis of odor impact using dispersion modeling may be required to analyze potential impacts. Similarly, an enforcement action for a point source may require control of odors while solutions to an area source odor problem may be difficult to find.

AFO vs. CIM Source: In this case, a point source AFO (a series of swine barns with enclosed under-barn manure storage) is contrasted with a point source pulp mill.

The setting of the AFO is generally rural with low densities (though this is not always the case) of potential receptors while the pulp mills in Minnesota are located in relatively densely populated urban areas. Because receptors are generally more scattered and farther away from the AFO odor source, AFO emissions may not cause as much of an impact in comparison to odorous emissions from a pulp mill in a densely populated area.

Indirect regulation of odors from the AFO is already accomplished through enforcement of the hydrogen sulfide standard. The odorants released by pulp mills tend to be indirectly related by state and federal emissions limits on VOCs and total reduced sulfur. However, not all of the point sources at these complex, multi-source plants are subject to limits and not all of the odorants are emitted from point sources. Some plants, for example Boise Cascade, located in International Falls, have implemented odor response plans so that they can quickly identify the source of an odor when a complaint is received either directly or via MPCA staff.

Objectionable and constant odor point source vs. intermittent point source with pleasant odor: This example compares a bakery to a plastics manufacturing facility. The first contrast is the comparison of hedonic tone. Most people will find a bakery smell to be pleasant while the same concentration or intensity of a plastics smell may be objectionable. This illustration shows that a universal odor strength standard is not appropriate for all circumstances.

In addition, the bakery's odors are present only at night and in the early morning hours. No odors are present during most of the daytime hours. The plastics plant may run 24 hours a day causing constant odor emissions. This element of time illustrates that frequency and duration of odors must be considered in regulating odors.

7.2.2 Available and Emerging Air Control Technology

Control technologies for reduction and elimination of odor emissions are available for most odor sources. Odor control technologies are much better suited for point sources than for area sources. Requirement of odor control technologies is a potential option for addressing existing or proposed facilities. Effectiveness and practicality of specific odor control technologies is very case dependent. A specific evaluation of odor control technologies was not conducted for this report however; a general summary of available control technologies and their effectiveness was summarized from the IPPC Guidance for Odor Assessment and Control (IPPC Part 2) and is presented in this section.

Control Technologies for Point Sources

Point sources are natural candidates for add-on controls. None of these controls removes 100% of the odorants but may reduce ambient odor to a tolerable level, perhaps in combination with a stack height increase to improve dispersion.

- Incineration: This technology can only be used on a point source and destroys odorants prior to release. Incineration of odorous gasses can be accomplished using afterburners or catalysts placed in the process line or stack. These technologies are widely available, very effective and are commonly used to reduce emissions of hazardous air pollutants.

- Wet Scrubbing: Scrubbing of gas emissions is a process where odorants are adsorbed into a liquid solvent typically in a stack. Similar to incineration, this technology is commonly used to reduce emissions of hazardous air pollutants and is very effective and widely available.

- Adsorption or Dry Scrubbing: Adsorption is a process where gas molecules of an odorant are retained on a solid surface. Materials, such as carbon are used in a bed or filter through which a gaseous stream passes to remove odorous gasses. Similar to incineration and wet scrubbing, adsorption technology is very effective and widely available.

- Biofilters and Chemical Filtration: Biofiltration is typically accomplished by running a gas through a large bed of soil, compost or peat. Microorganisms living in the medium metabolize and degrade odorants as they pass through. The University of Minnesota Extension Service brochure "Biofilters for Odor Control" describes biofilters as effective and relatively inexpensive. There are a number of function biofiltration systems operating at various livestock operations around the state of Minnesota. Chemical filters operate in much the same way as a biofilter with the exception of a biological process to facilitate the process. Cost varies depending on the pollutant and the nature of the facility.

Control Technologies for area sources:

- Floating covers: A floating permeable cover is available to control odors from manure storage lagoons. This product provides a floating medium for microbe growth providing a large surface area biofilter. In addition, the cover would reduce volatilization of odorants from the lagoon surface. Covers are generally composed of high density polyethelene or related material with a variety of costs and odor reduction effectiveness reported. Reduction values vary from 50 to 90%.

Control Technologies for both area and point sources:

- Dispersion: This control technology typically consists of releasing odorants through a high stack causing dilution of the odorants before receptors are exposed. The use of minimum separation distances between an odor source and receptors can also be thought of as dispersion. This is an effective control method if adequate separation distances exist or if a facility has a large stack. Gas buoyancy and industrial process is also a major factor.

- Odor modification: Odor modification refers to the introduction of additional odorants or substances into the atmosphere to change the perceived intensity or character of an odor. An odor modifier may be considered a masking agent, a counteractant or a neutralizer. The effectiveness of this control method is questionable and its application would be limited to specialized situations.

7.2.3 Survey of Regulatory Tools

Various states and countries all have either slightly or wholly different legal tools and policies to address odor. This element should be able to provide a short survey of these approaches.

A survey of regulatory tools is presented in Section 5 of this report. A summary of these findings is presented below.

Regulation of Individual Compounds as Odor Surrogates: In the United States, the State of Connecticut and the San Francisco Bay Area Air Quality Management District were the two agencies interviewed as part of the odor investigation interview process that regulate individual compounds as surrogates for odor. It should be noted that both of these areas still have provisions for odorous emissions as a nuisance phenomenon that may be unrelated to measurable emissions of any chemical substances. Odor regulations in Montreal, Canada and in the Province of Ontario also set emissions limits for a wide range of chemical substances; however, they also have established limits for odorous emissions as a nuisance phenomenon unrelated to measurable emissions of regulated chemicals.

Limits or Standards of Odor Strength: Of the many interviews conducted as part of the odor investigation of jurisdictions within the United States, a total of seven jurisdictions regulate odorous emissions based on standards of odor strength and concentration. These jurisdictions include North Dakota, San Francisco, Colorado, Idaho, Missouri, North Carolina, and Wyoming. Jurisdictions which have odor strength standards in statute, but which do not in practice enforce these standards include Chicago, Connecticut, and Louisiana. The reasons given for this lack of enforcement were the cumbersome nature of using odor-measurement equipment by inspectors. In Chicago and Connecticut, current odor enforcement is done with inspectors smelling the ambient air and, if an odor is detected, working through a facilitative process with the offending facility in order to redress the problem.

Requirement of Best Available Control Technologies: The installation of Best Available Control Technologies as a means of controlling odorous emissions is used by many agencies and jurisdictions as part of preventing odorous emissions during the permitting process, and responding to odor complaints when facilities are operating. Although such requirements are not typically part of statute or regulation, they are part of a best practices approach to the permitting process. Additionally, requirements for ensuring the proper operation of existing BACTs* or installing additional BACTS may be part of an enforcement proceeding.

*Not to be confused with the federal Prevention of Significant Deterioration program BACT analysis. See section 7.2.7

Requirement of Separation Distances: In the State of Minnesota, land use planning is almost always done at the city, county, and sometimes township level, with cities having authority in incorporated areas, and counties usually having authority in unincorporated, rural areas. Establishing separation distances or setbacks between certain land uses is often part of local land use planning efforts. Nearly half of Minnesota counties establish some type of separation distances for livestock facilities (*Summary of Animal-Related Ordinances in Minnesota Counties,* Minnesota Department of Agriculture, 2000).

Separation distances used throughout the state can be broken down into two types, simple and sliding scale. Simple separation distances do not account for the size of the facility or the number of animal units present, while sliding scale separation distances will vary the separation

distance required based on type of livestock, size of facility, best available control technologies (BACTs) employed, type of adjacent land use, and other measures (*Summary of Animal-Related Ordinances in Minnesota Counties,* Minnesota Department of Agriculture, 2000). Nicollet County in southwestern Minnesota uses a sliding-scale separation distance approach as part of their zoning.

Enhanced Nuisance-Based Approach: One approach that may be taken in odor regulation is to "enhance" the nuisance tort of common law in which it is claimed that the actions of another person or entity have caused a plaintiff material injury or annoyance. Since no other odor regulation currently exists in Minnesota, seeking relief under a claim of nuisance is currently the only legal recourse that exists in Minnesota.

The State of Texas' Commission on Environmental Quality (TCEQ) has a formal 'Nuisance Protocol', which is used to regulate odorous emissions (Part 30 TAC 101.4). This protocol is based on the state's nuisance law but expands the process for determining an odor nuisance and any necessary enforcement. Various categories of response are calculated by the TCEQ based on information gathered from the complainant including the allegation of adverse health impacts (see Section 5.3.3.6 for a further discussion of these prioritization categories). TCEQ staff attributed the success of the nuisance protocol program to the objectivity by which they could make a nuisance determination.

Community Odor Work: In considering the regulation of nuisance odors, a question before policy-makers is the need to accommodate "locally-acceptable" standards against the benefits of a uniform approach at a regional or statewide level. In other words, one community may accept odorous emissions from an industry upon which it is reliant, but this same industry, seeking to locate in another community, may be rejected on account of its potential to create nuisance odor complaints. Other regulatory agencies have attempted to account for the perceptions of communities using odor surveys. In Wisconsin statute, the findings of a community survey can be part of the process of substantiating the presences of an "objectionable odor" (see Section 5.3.2.1). In the cities of Des Moines and Sioux City, Iowa, the odor complaint substantiation process is tied to the number of odor complaints received. Involving the community at all points in the odor regulation process, starting with formulating the regulation itself and carrying through to the compliance and enforcement process, is important to its success.

7.2.4 Measurement Technology

Quantitative measurements of odor are performed using a calibrated sensory response of a trained technician or odor panel. The two quantitative units of odor strength that are used in a regulatory program are odor concentration (measured by diluting an odor sample to its threshold of detection) and odor intensity (measured by comparing an odor sample to a standard dilution a reference chemical). Measurement of odor concentration is referred to as olfactometry and can be performed in the field using a portable dilution device (known as a scentometer) or in a laboratory using dynamic olfactometry.

Method	Pros	Cons
Odor Concentration Field Measurement	– Cost, requires purchase of a field instrument (approximately $1, 500) and technician time. – Quick	– Does not directly relate to laboratory results – Relatively uncertain results
Odor Concentration Laboratory	– European standard provides statistical validation. – Can be performed on high strength samples – Results can be used in dispersion modeling	– Samples can degrade quickly – Cost (approximately $750) per sample – Can only analyze discrete samples, no long term sampling capability.
Odor Intensity	– Cost, requires purchase of reference chemical and technician time	– Results cannot be used in dispersion modeling.

Measurement of the mass concentrations of odorants or gas surrogates can be used to measure odors if the relationship between concentration and human perception is known. This work has been conducted by industrial hygenists for the purpose of using olfactory sensitivity to various chemical as a means to safeguard human health.

Qualitative measurements of odor can also be useful in a regulatory program. The goal of an odor assessment is often to determine whether an odor represents an objectionable situation or one that requires regulatory action. This can be accomplished through input from citizens in the form of complaints or surveys. A trained odor technician can also do a qualitative assessment. Advantages of qualitative assessment are that it relates directly to the annoyance of affected people, it can be done at a relatively low cost and it provides a realistic first assessment of the degree of a problem. Disadvantages of a qualitative assessment are that it may not hold under a challenge in a regulatory program and subjective mitigation or design goals are difficult to set and enforce.

7.2.5 Staff Training and Development

Complaint Substantiation Process

Over the past three years, the MPCA has averaged about 480 odor complaints per year (see Section 4.1 of the Odor Investigation Report). In the San Francisco Bay Area, 59 inspectors investigate approximately 2,600 odor complaints lodged every year (interview with Kelly Wee). This averages about 44 odor complaints managed by every inspector each year. The Bay Area Air Quality Management District does establish a standard for nuisance odor emissions based on a measurement of an odor's strength (using laboratory olfactometry) and also establishes emissions thresholds for various chemical surrogates for odor. The City of Chicago receives

approximately 20 complaints regarding nuisance odors each day, and has a total of 15 inspectors devoting approximately 70 percent of their time to nuisance odor complaint investigation (interview with Kevin Schnoes). None of the states or other agencies and jurisdictions that were part of the interview process for the odor investigation had inspectors whose sole responsibility was to follow up on nuisance odor complaints; rather, odor complaint substantiation was part of a general responsibility for inspecting all citizen complaints.

If the MPCA were to become more actively involved in the odor complaint investigation and substantiation process, this would have an impact on staffing for inspectors. In Missouri, where approximately 150 complaints are received per year, one staff person in each of their six districts is engaged in air quality issues, including odor issues. Since Minnesota receives about three times as many odor complaints in a year as does Missouri (480 compared to 150), this staffing complement may need to be increased. In addition to regional office staff, there would probably need to be coordinating staff with oversight for statewide issues. In Missouri, two staff people deal with odor issues in the central office.

7.2.6 Political and Legal Dimension

In Minnesota, there is currently no regulatory authority or agency with jurisdictional oversight of odor issues. Odor was previously regulated by the Minnesota Pollution Control Agency (MPCA) by the Air Quality Division under an odor rule established in 1970 (Minn. Rules Ch. 7011). This rule was intended to directly address odor by regulating emissions from industrial sources and did not regulate odor from feedlots or other agricultural source types. Since no other odor regulation currently exists in Minnesota, seeking relief under a claim of nuisance is currently the only legal recourse that exists for persons suffering from the effects of nuisance odor emissions in Minnesota.

Minnesota rules for regulating feedlots were first adopted by the MPCA in 1971 and have been amended in 1974, 1978, and 2000 (MPCA Legislative Update, 1998). These rules give the MPCA the authority to control pollution from livestock facilities. Odor is addressed as part of the registration and permit application for feedlots primarily through Air Emissions and Emergency Response Plans, which are required for facilities with 1,000 animals units or more, and for manure storage facilities capable of holding manure from 1,000 animals units or more. Minnesota Statute 116.0713 directs the MPCA to "monitor and identify potential livestock facility violations of the state ambient air quality standards for hydrogen sulfide and to take appropriate actions necessary to ensure compliance." Air Emissions and Emergency Response Plans only address odors resulting from emissions of criteria air pollutants and hydrogen sulfide. Nuisance odors continue to persist in some communities.

A brief review of Minnesota case law in which nuisance odor suits were pressed was conducted as part of this odor investigation. Minnesota court cases were compiled using a search engine from West Law, searching for all cases in which the words "nuisance" and "odor" were referenced.

Approximately 90 Minnesota cases originating from 1886 to the present were reviewed. Of these cases, approximately 19 dealt with a nuisance claim but did not include identification of an

odor problem. Thirty-nine cases dealt with nuisance claims in which at least a portion of the claim identified an odor problem. Sources of odor included confined animal feeding operations, livestock yards, horse barns, dog pounds, canneries, compost and dumping sites, fuel storage sites and spills, asphalt roofing materials, funeral homes and undertaking facilities, fertilizing and rendering plants, gas and electric plants, wastewater treatment facilities and raw sewage placement and overland water drainage. Twelve cases dealt with denial of new source permit applications where the source was determined to likely cause a nuisance.

The Minnesota Right-to-Farm law (Minn. Rule Chapter 561) makes it difficult for citizens to bring odor nuisance suits against nearby farmers by providing protection to farmers by "strengthen[ing] the legal position of farmers, when neighbors sue them for private nuisance and protect[ing] farmers from anti-nuisance ordinances and unreasonable controls on farming operations" (Farmland Information Center, 1998). Minn. Rule Chapter 561 states that an agricultural operation shall not be a nuisance if it was not a nuisance when it was established and if it is operating under generally accepted agricultural practices, is located within an agricultural zone, and is in compliance with federal and state statutes. As has been mentioned previously, AFOs can be in compliance with state ambient air emissions standards, but still be perceived as a nuisance to neighboring residents because odors may be detectable, although other air quality standards may be met.

7.2.7 Program Development and Long-term Costs

This element should include a discussion of resource allocation and potential long term costs (e.g. if we go with chemical surrogates, will we have to maintain an active air monitoring program? This will relate to cost over the lifespan of the policy.). This discussion is not intended to provide agency specific information about the budget and resource development tools, but rather, account for the fact that this issue must be assessed within the context the odor policy decision.

Regulation of Individual Compounds as Odor Surrogates: Long-term cost considerations for the MPCA in pursuing this regulatory strategy include whether the agency would need to maintain an active air monitoring program. In the San Francisco Bay Area, with an odor regulation setting standards for emissions of compounds in addition to setting standards for permissible odor concentrations, inspectors are free to use their knowledge of a source type when deciding whether air quality monitoring is needed or when laboratory olfactometry is merited in complaint substantiation.

Limits or Standards of Odor Strength: Long-term costs with a regulatory approach focused on setting standards for odor strength include the cost of maintaining any needed equipment used as part of the complaint substantiation process as well as the need to periodically train new inspectors and/or odor panelists. Depending on the type of standard referenced in the regulation, e.g., the butanol standard or dynamic olfactometry, long-term costs would likely vary.

Requirement of Best Available Control Technologies: There is little to no cost incurred by the MPCA in requiring BACTs for proposed facilities. Actual installation of odor control technologies is almost always paid for by the proposed facility or, if not, then by a local unit of

government who may be acting as a project proposer. Costs to the MPCA would relate to staff training and keeping staff apprised of emerging odor control technologies and their respective characteristics.

*Note: The use of the term BACT should not be confused with its use in the federal Prevention of Significant Deterioration (PSD) program. Within PSD, BACT analyses are applied under specific circumstances for certain affected sources, and odor is not addressed in this program. As used in this document, BACT is a more general and open ended assessment of the available technology.

7.2.8 Information Management

Enactment of an odor regulatory program that includes odor measurement will result in the collection of a considerable amount of data. The MPCA may store measurements and prediction of odor strength in a database for future access and reference.

The quantity of data and analysis requirements would likely be the greatest if odors were regulated using chemical surrogates. This type of regulation would require a great deal of data to support the relationship between concentrations of surrogates and perceived odors. In addition, monitoring for compliance would generate large amounts of chemical analysis data.

Direct or sensory measurement of odors would also generate substantial amounts of data. This type of measurement is less standardized than chemical analysis and therefore requires a through understanding of sample collection methods, the difference between laboratory and field measurements and other sources of uncertainty. Management and analysis of this data should include a relatively detailed description of the methods used to collect the data.

7.2.9 Enforcement

Enforcement of an odor strength standard whether it is based on a sensory measurement or limits of odor surrogates requires measurement of odors at specific locations. While "worst case" grab sampling can be conducted, long term monitoring is preferred to address the variation in odor levels due to the influence of meteorological conditions.

Chemical analysis for odor surrogates can be performed for long periods of time using field instrumentation. An example of this type of analysis is the hydrogen sulfide monitoring program currently conducted at AFOs by the MPCA. Long term chemical analysis provides information on odor impacts over a range of meteorological conditions that can be presented in a statistical time format (e.g. did not exceed x ppm for 99% of the monitoring period).

Long term compliance monitoring using sensory measurement is difficult. Measurement of odor concentration or intensity can be performed in a laboratory on samples that represent a particular condition at one moment. Little long term or statistical data is gained from this method. Field measurements of odor concentration or intensity can be conducted but field measurement is considered less sensitive and less repeatable than laboratory tests and long term monitoring would require the constant presence of an odor technician.

An odor standard using a "not to exceed" level could be used in conjunction with a sensory measurement. The drawback of this type of standard is that, during relatively rare meteorological conditions, it is possible for an odor plume to travel relatively long distances without significant dilution. A "not to exceed" standard may be seen as too difficult to achieve by odor sources or as too lenient by affected receptors. Nonetheless, this approach is currently used in a several states (see Section 5.3).

An enforcement program based on a subjective assessment by an odor technician is another option that is used by some states. This method appears to be effective in addressing a majority of odor problems; however contentious cases will likely require quantitative analysis.

7.2.10 Cross-Program Issues (e.g. Environmental Review and Permitting).

MPCA environmental review and permitting staff currently address odor impacts in a variety of ways. Potential odor impacts are analyzed in EIS and EAW documents using a variety of methods. A formal odor policy or statewide odor standards implemented by the MPCA would result in a more consistent approach in analyzing odor impacts and determining whether a proposed impact is acceptable.

Cross program coordination of an odor policy between Enforcement, Environmental Review and Permitting Programs would be accomplished by considering whether it is possible to measure the design goals, standards or conditions presented and analyzed in permits or review documents. For example, if an environmental review document used dispersion modeling to project that odor concentrations would not exceed 5 odor units 99% of the time, it would be difficult to address the permitting and compliance dimensions. However if the review document (or permit condition) specified a concentration of a chemical surrogate, compliance monitoring could be accomplished using long term chemical monitoring instrumentation.

7.3 Decision Outcomes and Alternatives

The last section of this document provides three general pathways for the policy maker.

- Provide Consistent Internal Guidance
- Internal Guidance Plus Statewide Policy
- Rule Making

1) Provide Consistent Internal Guidance

The lack of consistency in methods of odor analysis and the lack of guidance or standards makes it difficult for staff to respond to odor concerns. Responding on a case by case basis can be resource intensive. An internal guidance document could provide staff working in any program area with an introduction to the type of concerns raised by citizens and the policy and technical issues that define the boundaries for MPCA response to these issues.

Enforcement measures for existing odor problems at AFOs typically rely on enforcement of the hydrogen sulfide standard. Odor problems at CIM facilities are generally resolved through an MPCA mediation process and rely on the goodwill of the odor source to resolve the problem. These approaches have had reasonable success.

2) Internal Guidance Plus Statewide Policy

A formal MPCA odor policy could provide guidance to MPCA staff, affected citizens and to odor sources. The policy could outline a preferred odor assessment method for permitting and environmental review and define odor levels to be used as design goals, or enforcement thresholds.

Based on the survey of odor regulation performed for this document, there is no example of a functioning odor regulatory program that stands out as a reasonable, effective and comprehensive example. Rather, there is a patchwork of regulatory tools that can be used to regulate odors but would be best put to use in a flexible and adaptive program by trained and experienced staff. This type of regulation may be difficult to document and work with in a rule making scenario and may be best suited for a more flexible guidance and policy, particularly as it relates to community odor situations.

3) Rule making

As discussed above, it would be difficult to address the subjectivity and uncertainty of odor detection, measurement and assessment in a single rule. A rule would likely need to contain specific odor standards, enforcement protocol and methods of analysis and measurement. As discussed in Section 5.2, appropriate limits on odors or odorants would be case specific and often cannot be determined without an assessment of a particular case. Enforcement is most efficiently accomplished through a flexible mediation approach that starts simple and, if needed, relies on measurement and analysis. Odor measurement is also a rapidly changing technology that may be best tailored to each specific case.

APPENDIX A

Literature Review

MPCA Odor Investigation
Literature Review

SRF No. 034734

At the direction of and with the assistance of the Minnesota Pollution Control Agency, SRF Consulting Group, Inc. undertook a literature review of various sources of information regarding odor issues. Sources uncovered as part of this task are summarized here. Documented resources not been in the report were used as background reference material.

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APPENDIX B

MPCA County Survey on Odor Issues

APPENDIX B1

Responding Counties

Minnesota Counties Responding the MPCA Odor Survey

Paul Johnson
Sherburne
Environmental Specialist
13880 Highway 10
Elk River MN 55330

Gary L. Rice
Kittson
Director, Environmental Services Office
410 S 5th, Suite 104
Hallock MN 56728

Robert E. Olsen
Lincoln
Environmental Administrator
PO Box 66
Ivanhoe MN 56220

Jan Kaspari
Marshall
Water Plan Coordinator
208 E Colvin Avenu
Warren MN 56762

Minnesota Counties Responding the MPCA Odor Survey

Dave McNary
Hennepin
Senior Administrative Assistant
417 North Fifth Stre
Minneapolis MN 55401

Lisa Skipton
Goodhue
Land Use Director
509 West 5th Street
Red Wing MN 55066

Roger Berggren
McLeod
County Feedlot Officer
830 11th Street
Glencoe MN 55336

Mark Gernes
Winona
County Feedlot Officer
177 Main Street
Winona MN 55987

Don Adams
Stearns
Director, Environmental Service Department
705 Courthouse Squ
St. Cloud MN 56303

Minnesota Counties Responding the MPCA Odor Survey

Kyle Krier
Pipestone
Zoning Administrator
119 2ns Avenue SW
Pipestone MN 56164

Tim Magnusson
Clay
Director of Planning & Environmental Progra
807 N 11th Street
Moorhead MN 56560

Michael Hanan
Otter Tail
Director - Waste Management
121 West Junius Av
Fergus Falls MN 56532

Darrel Ellefson
Lac Qui Parle
Environmental Officer
Courthouse, 600 6th
Madison MN 56256

John Thompson
Faribault
County Auditor
P.O. Box 130
Blue Earth MN 56013

Minnesota Counties Responding the MPCA Odor Survey

Dan A. Holm
Becker
Administrator, Environmental Services
PO Box 787
Detroit Lakes MN 56502

John Boe
Meeker
Zoning Administrator
325 North Sibley A
Litchfield MN 55355

Warren Wilson
Dakota
Environmental Specialist
14955 Galaxie Aven
Apple Valley MN 55124

Randy Tuchtenhage
Freeborn
Director/Environmental Services Department
411 So. Broadway
Albert Lea MN 56007

Paul Z. Fairbanks
Cass
ESD Director
P.O. Box 3000
Walker MN 56484

Minnesota Counties Responding the MPCA Odor Survey

James R. Stannard II
Olmsted
Olmsted County Feedlot Technician
1421 3rd Avenue S
Rochester MN 55904

Wayne Smith
Nobles
Director of Environmental Affairs
P.O. Box 187
Worthington MN 56187

Tina Rosenstein
Nicollet
Nicollet County Environmental Services Dire
501 S Minnesota Av
St. Peter MN 56082

Rachel Matthews
Carver
Assistant Feedlot Administrator
600 E 4th Street
Chaska MN 55318

Chelle Benson
Benton
Director, Dept. of Development
531 Dewey Street, P
Foley MN 56329

Minnesota Counties Responding the MPCA Odor Survey

Richard A. Sigel
Lake
Land Use Administrator
601 3rd Avenue
Two Harbors MN 55616

Rick Frank
Houston
Zoning & Solid Waste Adm.
Houston Cty. Court
Caledonia MN 55921

Steven Sindelir
Lake of the Woods
Environmental Services Director
PO Box 808
Baudette MN 56623

Bonnie Finnerty
Crow Wing
County Planner/Feedlot Officer
200 S 4th Street
Brainerd MN 56401

Carla Dunkley
Kanabec
Environmental Services Technician
18 N Vine Street
Mora MN 55051

Minnesota Counties Responding the MPCA Odor Survey

Dan Hecht
Clearwater
Environmnetal Services Administrator
213 Main Avenue N
Bagley MN 56621

Wayne Bezenek
Wilkin
County Auditor
Box 409
Breckenridge MN 56520

Jeff Bredberg
Kandiyohi
Director Environmental Services
400 SW Benson Av
Willmar MN 56201

Scott Higgins
Martin
Coordinator
201 Lake Avenue
Fairmont MN 56031

Scott Fichtner
Blue Earth
Director, Environmental Services
410 South 5th Street
Mankato MN 56002

Minnesota Counties Responding the MPCA Odor Survey

Mary McGlothlin
Washington
Director, Dept. of Public Welfare and Environ
PO Box 6
Stillwater MN 55082

Spencer Pierce
Anoka
Manager, Environmental Services
2100 3rd Avenue, R
Anoka MN 55311

Jon Mitchell
Redwood
Environmental Director
PO Box 130
Redwood Falls MN 56283

Craig Oscarson
Mower
County Coordinator
201 1st Street NE
Autsin MN 55912

Joe Bloemendaal
Murray
Agriculture & Solid Waste Administrator
2500 28th Street, P
Slayton MN 56172

Minnesota Counties Responding the MPCA Odor Survey

Norm Craig
Fillmore
Zoning Administrator
PO Box 655
Preston MN 55965

Kevin Ruud
Norman
Environmental Services Administration
16 Third Avenue, R
Ada MN 56510

Arlene Vee
Jackson
Environmental Services Officer
405 4th Street
Jackson MN 56143

Darren Wilke
Big Stone
Environmental Officer
20 SE 2nd Street
Ortonville MN 56278

Jack Paul
Hubbard
County Coordinator
301 Court Avenue
Park Rapids MN 56470

Minnesota Counties Responding the MPCA Odor Survey

Michelle Warnberg
Morrison
County Feedlot Officer/Asst. 2A
213 1st Avenue SE
Little Falls MN 56345

Scott Golberg
Steele
Env. Services Dir.
630 Florence Avenu
Owatonna MN 55060

Marion Heemsberge
Chisago
Env. Services Director
Chisago Co. Gov. C
Center City MN 55084

Terry Neff
Aitkin
Environmental Services Director
290 2nd St. NW
Aitkin MN 56431

William J. Patnaude
Beltrami
Beltrami County Env. Health Dir.
619 Beltrami Avenu
Bemidji MN 56601

Minnesota Counties Responding the MPCA Odor Survey

Charlie Pazdernik
Mahnomen
County Commissioner
PO Box 379
Mahnomen MN 56557

Andrew Dahlgren
Pope
Feedlot Officer
130 East Minnesota
Glenwood MN 56334

Allen Frechette
Scott
Env. Health Manager
200 4th Avenue W,
Shakopee MN 55379

Lisa Davies
Le Sueur
Env. Resource Specialist
88 S Park Avenue
LeCenter MN 56057

Bruce Johnson
Watonwan
Environmental Services Director
Courthouse, Box 51
St. James MN 56081

Minnesota Counties Responding the MPCA Odor Survey

Matt Huddleston
Mille Lacs
Acting Zoning Administrator
635 2nd Street SE
Milaca MN 56353

Jane Starz
Brown
Zoning Administrator
Courthouse, P.O. Bo
New Ulm MN 56073

APPENDIX B2

Summary of Responses

Minnesota Pollution Control Agency

Survey of Minnesota Counties on Nuisance Odor Impacts

Responder Information:

Name: _____

Title: _____

Address: _____

_____

County: _____

Phone: _____

FAX: _____

E-mail: _____

Section One: Odor Complaints and Processes

Question One: Has your county received complaints from residents regarding nuisance odors in the past year?

- ❑ Yes
- ❑ No (skip to Question Four)

Question Two: How frequently were these complaints received?

- ❑ Less than 1 complaint per month
- ❑ Approximately 1 to 5 complaints per month
- ❑ Approximately 6 to 10 complaints per month
- ❑ More than 10 complaints per month

Question Three: To what source are odor complaints attributed? (Please check all that apply)

- ❑ Automotive Repair or Other Services
- ❑ Ethanol Production
- ❑ Feedlots
- ❑ Other Food Processing Industries
- ❑ Other (please describe)

  _____

  _____
- ❑ Paper Mill
- ❑ Printing/Laminating/Coating
- ❑ Restaurant/Retail Food
- ❑ Soybean Processing
- ❑ Sugar Beet Processing
- ❑ Wastewater Treatment Facilities

Question Four: When nuisance odor complaints are received, to whom in your county are they routed?

- ❑ Planning and Zoning Administrator
- ❑ County Feedlot Officer
- ❑ County Administrator
- ❑ County Commissioners
- ❑ Environmental Health
- ❑ Solid Waste
- ❑ Other (please describe)

  _____

  _____

Question Five: Does your county have a standard policy in place for responding to nuisance odor complaints?

- ❑ Yes (please attach a copy of this policy)
- ❑ No (skip to Section Two)

Question Six: On what criteria is your complaint-response policy based? (Please check all that apply)

- ❑ Duration (i.e., length of time a person has been exposed to the nuisance odor)
- ❑ Severity (i.e., if the complaint stipulates an associated impact on health)
- ❑ Frequency (i.e., how often a person has experienced the nuisance odor over a period of time)
- ❑ Number of Complaints Received
- ❑ Source Type (please list)

  _____

  _____
- ❑ Other (please describe)

  _____

  _____

Section Two: Odor Regulations and Processes

Question One: Does your county have regulations in place to minimize nuisance odor emissions?

- ❑ No (skip to Section Three)
- ❑ Yes (please attach a copy of these regulations)

Question Two: What source types are covered in your regulations? (Please check all that apply)

- ❑ Automotive Repair or Other Services
- ❑ Ethanol Production
- ❑ Feedlots
- ❑ Other Food Processing Industries
- ❑ Other (please describe)

  _____

  _____
- ❑ Paper Mill
- ❑ Printing/Laminating/Coating
- ❑ Restaurant/Retail Food
- ❑ Soybean Processing
- ❑ Sugar Beet Processing
- ❑ Wastewater Treatment Facilities

Question Three: Do you require applicants to estimate potential impacts of nuisance odor emissions during any of your permitting or licensing processes?

- ❑ No
- ❑ Yes (please attach a copy of these requirements)

Section Three: Nuisance Odor Regulation

Question One: Do you believe that outdoor nuisance odors should be regulated by the Minnesota Pollution Control Agency (currently, there is no such rule in place)?

- ❑ No
- ❑ Yes

Question Two: If you answered YES, why do you believe nuisance odors should be regulated? (Please check all that apply)

- ❑ To ensure a good quality of life
- ❑ To protect property values
- ❑ To improve the environment
- ❑ To protect public health
- ❑ Other (please describe)

_____

_____

Question Three: If you answered NO, why do you believe nuisance odors should NOT be regulated? (Please check all that apply)

- ❑ Regulation is not needed
- ❑ Regulation is unenforceable
- ❑ Regulation would cost taxpayers too much
- ❑ Regulation would be a burden on private industry
- ❑ Other (please describe)

_____

_____

Question Four: If state nuisance odor regulations are enacted, what resources would your county need to enforce them?

_____

_____

_____

_____

_____

APPENDIX B3

Responses by MPCA Region

Metro Region

County
Anoka

Has the County Received Nuisance Odor Complaints in the Past Year?
☑

Complaint Frequency
Approximately 1 to 5 complaints per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☑	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities
☐

Other
Roofing Company

Is State Regulation of Nuisance Odors by the MPCA Needed?
☐

County
Carver

Has the County Received Nuisance Odor Complaints in the Past Year?
☑

Complaint Frequency
Approximately 1 to 5 complaints per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities
☑

Other
Industrial areas in cities.

Is State Regulation of Nuisance Odors by the MPCA Needed?
☐

Metro Region

County
Chisago

Has the County Received Nuisance Odor Complaints in the Past Year?
☑

Complaint Frequency
Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☐	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities
☐

Other
Landspreading of Septage.

Is State Regulation of Nuisance Odors by the MPCA Needed?
☑

County
Dakota

Has the County Received Nuisance Odor Complaints in the Past Year?
☑

Complaint Frequency
Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☑

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities
☐

Other
Compost -- yard waste facilities metal/aluminum processing facility, burning garbage, apartment -- variety of complaints.

Is State Regulation of Nuisance Odors by the MPCA Needed?
☑

Metro Region

County
Hennepin

Has the County Received Nuisance Odor Complaints in the Past Year?
☐

Complaint Frequency

Automotive Repair/Other Services ☐
Ethanol Production ☐
Feedlots ☐
Other Food Processing Industries ☐

Paper Mill ☐
Printing/Laminating/Coating ☐
Restaurant/Retail Food ☐
Soybean Processing ☐
Sugar Beet Processing ☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☐

County
Scott

Has the County Received Nuisance Odor Complaints in the Past Year?
☑

Complaint Frequency
Less than 1 complaint per month

Automotive Repair/Other Services ☑
Ethanol Production ☐
Feedlots ☐
Other Food Processing Industries ☐

Paper Mill ☐
Printing/Laminating/Coating ☐
Restaurant/Retail Food ☐
Soybean Processing ☐
Sugar Beet Processing ☐

Wastewater Treatment Facilities ☑

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

Metro Region

County
Washington

Has the County Received Nuisance Odor Complaints in the Past Year?
☑

Complaint Frequency
Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☐	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities
☐

Other
Land disposal septic system/sewage solid/hazardous waste odors

Is State Regulation of Nuisance Odors by the MPCA Needed?
☐

North Central Region

County Sherburne

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☑

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☑

Other

MSW Lanfill, C&D Landfill

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

County Stearns

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Approximately 1 to 5 complaints per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☑	☐	☑	☑

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☑	☐	☐	☐	☐

Wastewater Treatment Facilities ☑

Other

Manure application spraying pesticides.

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

North Central Region

County Cass

Has the County Received Nuisance Odor Complaints in the Past Year? ☐

Complaint Frequency

Automotive Repair/Other Services ☐ **Ethanol Production** ☐ **Feedlots** ☐ **Other Food Processing Industries** ☐

Paper Mill ☐ **Printing/Laminating/Coating** ☐ **Restaurant/Retail Food** ☐ **Soybean Processing** ☐ **Sugar Beet Processing** ☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

County Benton

Has the County Received Nuisance Odor Complaints in the Past Year? ☐

Complaint Frequency

Automotive Repair/Other Services ☐ **Ethanol Production** ☐ **Feedlots** ☐ **Other Food Processing Industries** ☐

Paper Mill ☐ **Printing/Laminating/Coating** ☐ **Restaurant/Retail Food** ☐ **Soybean Processing** ☐ **Sugar Beet Processing** ☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☐

North Central Region

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Crow Wing ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Kanabec ☐

Complaint Frequency

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☐	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

North Central Region

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Morrison ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☐

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Mille Lacs ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

Northeast Region

County Lake

Has the County Received Nuisance Odor Complaints in the Past Year? ☐

Complaint Frequency

Automotive Repair/Other Services ☐ **Ethanol Production** ☐ **Feedlots** ☐ **Other Food Processing Industries** ☐

Paper Mill ☐ **Printing/Laminating/Coating** ☐ **Restaurant/Retail Food** ☐ **Soybean Processing** ☐ **Sugar Beet Processing** ☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

County Aitkin

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services ☐ **Ethanol Production** ☐ **Feedlots** ☐ **Other Food Processing Industries** ☐

Paper Mill ☐ **Printing/Laminating/Coating** ☐ **Restaurant/Retail Food** ☐ **Soybean Processing** ☐ **Sugar Beet Processing** ☐

Wastewater Treatment Facilities ☐

Other

Peat processing, septic systems, compost sites

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

Northwest Region

County Kittson

Has the County Received Nuisance Odor Complaints in the Past Year? ☐

Complaint Frequency

Automotive Repair/Other Services ☐ **Ethanol Production** ☐ **Feedlots** ☐ **Other Food Processing Industries** ☐

Paper Mill ☐ **Printing/Laminating/Coating** ☐ **Restaurant/Retail Food** ☐ **Soybean Processing** ☐ **Sugar Beet Processing** ☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

County Marshall

Has the County Received Nuisance Odor Complaints in the Past Year? ☐

Complaint Frequency

Automotive Repair/Other Services ☐ **Ethanol Production** ☐ **Feedlots** ☐ **Other Food Processing Industries** ☐

Paper Mill ☐ **Printing/Laminating/Coating** ☐ **Restaurant/Retail Food** ☐ **Soybean Processing** ☐ **Sugar Beet Processing** ☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

Northwest Region

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Clay ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☑

Wastewater Treatment Facilities

☑

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Otter Tail ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☐	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Land application of manure

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

Northwest Region

County Becker

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Agricultural Issues

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

County Lake of the Woods

Has the County Received Nuisance Odor Complaints in the Past Year? ☐

Complaint Frequency

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☐	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

Northwest Region

County Clearwater

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Septic Systems - failed

Is State Regulation of Nuisance Odors by the MPCA Needed? ☐

County Wilkin

Has the County Received Nuisance Odor Complaints in the Past Year? ☐

Complaint Frequency

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☐	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☐

Northwest Region

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Norman ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☑

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Hubbard ☑

Complaint Frequency

Approximately 1 to 5 complaints per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☐	☑

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Perfumes in Public Places.

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

Northwest Region

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Beltrami ☐

Complaint Frequency

Automotive Repair/Other Services **Ethanol Production** **Feedlots** **Other Food Processing Industries**

☐ ☐ ☐ ☐

Paper Mill **Printing/Laminating/Coating** **Restaurant/Retail Food** **Soybean Processing** **Sugar Beet Processing**

☐ ☐ ☐ ☐ ☐

Wastewater Treatment Facilities

☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Mahnomen ☐

Complaint Frequency

Automotive Repair/Other Services **Ethanol Production** **Feedlots** **Other Food Processing Industries**

☐ ☐ ☐ ☐

Paper Mill **Printing/Laminating/Coating** **Restaurant/Retail Food** **Soybean Processing** **Sugar Beet Processing**

☐ ☐ ☐ ☐ ☐

Wastewater Treatment Facilities

☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

Northwest Region

County
Pope

Has the County Received Nuisance Odor Complaints in the Past Year?
☑

Complaint Frequency
Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities
☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?
☐

Southeast Region

County Goodhue

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency
Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other
Composting

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

County McLeod

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency
Approximately 1 to 5 complaints per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☑

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

Southeast Region

County Winona

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Sandblasting Facility

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

County Faribault

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Rendering plant.

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

Southeast Region

County Freeborn

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Approximately 1 to 5 complaints per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☑	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☑

Other

Food Processing Plants

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

County Olmsted

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

Southeast Region

County Nicollet

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☐

County Houston

Has the County Received Nuisance Odor Complaints in the Past Year? ☐

Complaint Frequency

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☐	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

Southeast Region

County Martin

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Feedlot operations storing food processing byproducts.

Is State Regulation of Nuisance Odors by the MPCA Needed? ☐

County Blue Earth

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☐

Southeast Region

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Mower ☑

Complaint Frequency

Approximately 1 to 5 complaints per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Fillmore ☑

Complaint Frequency

Approximately 1 to 5 complaints per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☑	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

Southeast Region

County Steele

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☑

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Garbage

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

County Le Sueur

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☑

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

Southeast Region

County Watonwan

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

County Brown

Has the County Received Nuisance Odor Complaints in the Past Year? ☐

Complaint Frequency

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☐	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☐

Southwest Region

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Lincoln ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☑

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Pipestone ☐

Complaint Frequency

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☐	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

Southwest Region

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Lac Qui Parle ☐

Complaint Frequency

Automotive Repair/Other Services **Ethanol Production** **Feedlots** **Other Food Processing Industries**

☐ ☐ ☐ ☐

Paper Mill **Printing/Laminating/Coating** **Restaurant/Retail Food** **Soybean Processing** **Sugar Beet Processing**

☐ ☐ ☐ ☐ ☐

Wastewater Treatment Facilities

☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Meeker ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services **Ethanol Production** **Feedlots** **Other Food Processing Industries**

☐ ☐ ☑ ☐

Paper Mill **Printing/Laminating/Coating** **Restaurant/Retail Food** **Soybean Processing** **Sugar Beet Processing**

☐ ☐ ☐ ☐ ☐

Wastewater Treatment Facilities

☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

Southwest Region

County Nobles

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

Complaint Frequency
Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☑

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☑

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

County Kandiyohi

Has the County Received Nuisance Odor Complaints in the Past Year? ☐

Complaint Frequency

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

Southwest Region

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Redwood ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☐	☑

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Burning

Is State Regulation of Nuisance Odors by the MPCA Needed? ☑

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Murray ☑

Complaint Frequency

Approximately 1 to 5 complaints per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities ☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed? ☐

Southwest Region

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Jackson ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☐	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☐

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Big Stone ☑

Complaint Frequency

Less than 1 complaint per month

Automotive Repair/Other Services	Ethanol Production	Feedlots	Other Food Processing Industries
☐	☑	☑	☐

Paper Mill	Printing/Laminating/Coating	Restaurant/Retail Food	Soybean Processing	Sugar Beet Processing
☐	☐	☐	☐	☐

Wastewater Treatment Facilities

☑

Other

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

APPENDIX B4

Summary of Counties with High Complaints

Counties with High Complaints

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

McLeod ☑

How Frequently were Complaints Received?

Approximately 1 to 5 complaints per month

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

Why do you believe nuisance odors should be regulated?

Quality of Life	Protect Property Values	Improve Environment	Protect Public Health
☑	☐	☐	☑

Other6

Why do you believe nuisance odors should NOT be regulated?

Regulation Not Needed	Regulation Unenforceable	Costs Too Much	Private Industry Burden
☐	☐	☐	☐

Other5

Counties with High Complaints

County Stearns

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

How Frequently were Complaints Received?

Approximately 1 to 5 complaints per month

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

Why do you believe nuisance odors should be regulated?

Quality of Life	Protect Property Values	Improve Environment	Protect Public Health
☐	☑	☐	☐

Other6

Why do you believe nuisance odors should NOT be regulated?

Regulation Not Needed	Regulation Unenforceable	Costs Too Much	Private Industry Burden
☐	☐	☐	☐

Other5

To protect an individual's right to enjoy their property.

Counties with High Complaints

County Freeborn

Has the County Received Nuisance Odor Complaints in the Past Year? ☑

How Frequently were Complaints Received?

Approximately 1 to 5 complaints per month

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

Why do you believe nuisance odors should be regulated?

Quality of Life	Protect Property Values	Improve Environment	Protect Public Health
☑	☑	☐	☑

Other6

Why do you believe nuisance odors should NOT be regulated?

Regulation Not Needed	Regulation Unenforceable	Costs Too Much	Private Industry Burden
☐	☐	☐	☐

Other5

Counties with High Complaints

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Carver ☑

How Frequently were Complaints Received?

Approximately 1 to 5 complaints per month

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

Why do you believe nuisance odors should be regulated?

Quality of Life	Protect Property Values	Improve Environment	Protect Public Health
☐	☐	☐	☐

Other6

Burden on farmers. Odor is subjective and often times a personal issue is the problem, not the odor.

Why do you believe nuisance odors should NOT be regulated?

Regulation Not Needed	Regulation Unenforceable	Costs Too Much	Private Industry Burden
☐	☑	☑	☑

Other5

Counties with High Complaints

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Anoka ☑

How Frequently were Complaints Received?

Approximately 1 to 5 complaints per month

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

Why do you believe nuisance odors should be regulated?

Quality of Life	Protect Property Values	Improve Environment	Protect Public Health
☐	☐	☐	☐

Other6

State agencies lack capacity and flexibility to respond efficiently in local situations--see below.*

Why do you believe nuisance odors should NOT be regulated?

Regulation Not Needed	Regulation Unenforceable	Costs Too Much	Private Industry Burden
☐	☐	☐	☐

Other5

Counties with High Complaints

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Mower ☑

How Frequently were Complaints Received?

Approximately 1 to 5 complaints per month

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

Why do you believe nuisance odors should be regulated?

Quality of Life	Protect Property Values	Improve Environment	Protect Public Health
☐	☐	☐	☐

Other6

Why do you believe nuisance odors should NOT be regulated?

Regulation Not Needed	Regulation Unenforceable	Costs Too Much	Private Industry Burden
☐	☐	☐	☐

Other5

Probably should be regulated, but not by MPCA. To prevent a livable threshhold standard for both livestock producers and non-producures

Counties with High Complaints

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Murray ☑

How Frequently were Complaints Received?

Approximately 1 to 5 complaints per month

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

Why do you believe nuisance odors should be regulated?

Quality of Life	Protect Property Values	Improve Environment	Protect Public Health
☐	☐	☐	☐

Other6

Farming

Why do you believe nuisance odors should NOT be regulated?

Regulation Not Needed	Regulation Unenforceable	Costs Too Much	Private Industry Burden
☐	☐	☐	☑

Other5

Counties with High Complaints

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Fillmore ☑

How Frequently were Complaints Received?

Approximately 1 to 5 complaints per month

Is State Regulation of Nuisance Odors by the MPCA Needed?

☑

Why do you believe nuisance odors should be regulated?

Quality of Life	Protect Property Values	Improve Environment	Protect Public Health
☑	☐	☑	☑

Other6

Why do you believe nuisance odors should NOT be regulated?

Regulation Not Needed	Regulation Unenforceable	Costs Too Much	Private Industry Burden
☐	☐	☐	☐

Other5

Counties with High Complaints

County **Has the County Received Nuisance Odor Complaints in the Past Year?**

Hubbard ☑

How Frequently were Complaints Received?

Approximately 1 to 5 complaints per month

Is State Regulation of Nuisance Odors by the MPCA Needed?

☐

Why do you believe nuisance odors should be regulated?

Quality of Life	Protect Property Values	Improve Environment	Protect Public Health
☐	☐	☐	☐

Other6

Not by MPCA. Why can't the counties do this. Each county is different. Let each county do it--don't need MPCA

Why do you believe nuisance odors should NOT be regulated?

Regulation Not Needed	Regulation Unenforceable	Costs Too Much	Private Industry Burden
☐	☐	☐	☐

Other5

APPENDIX C

Odor Interviews

APPENDIX C1

Contact List

MPCA Odor Investigation
Contact List

Location	Name	Agency	Phone	Status
Local				
1. City of Minneapolis	Jennifer Tschida	Mpls. Environmental Management	(612) 673-5874	Interview on 5-07-03
2. City of St. Paul	Bill Gunther	Licensing, Inspection, Environmental Protection	(651) 266-9132	Voicemail response on 5-9-03
3. City of Bloomington	Erik Solie	Bloomington Env. Health Services	(952) 563-8978	Interview on 5-5-03
4. MCES	Lisa Wolfert	MCES-Air Quality	(651) 602-4870	Interview on 5-8-03
5. Renville County	Eric Van Dyken		(320) 523-3664	Interview on 4-25-03
6. Nicollet County	Tina Rosenstein	Nicollet Cty. Environmental Services	(507) 934-0250	Interview on 4-25-03
7. Kandiyohi County	Kim Larson	Kandiyohi Cty. Environmental Services	(320) 231-6229	Interview on 5-2-03
8. Blue Earth County	George Leary	Blue Earth Cty. Environmental Services	507-389-8381	Interview on 5-6-03
Other States and Cities				
9. Chicago	Kevin Schnoes	Department of Environmental Protection	(312) 744-4034	Interview on 5-5-03
10. Sioux City, Iowa	Aaron Kraft		(712) 279-6957	Interview on 4-28-03
11. Des Moines, Iowa	Steve Gunson		(515) 237-1343	Interview on 5-9-03
12. Dakota Resource Council	Mark Trechock		(701) 583-2851	Interview on 5-8-03
13. Sioux Falls, SD	Phil Kappen		(605) 367-4204	Interview on 5-2-03
14. San Francisco – Bay area	Kelly Wee	Bay Area Air Quality Management	(415) 749-4760	Interview on 5-1-03
15. Colorado	Kirsten King	Supervisor	(303) 692-3111	Interview on 5-21-03

16. Connecticut	Bill Wihbey	Dept. of Environmental Protection	(860) 424-3447	Interview on 5-1-03
17. Idaho	Tim Teater	Dept. of Environmental Quality	(208) 373-0457	Interview on 5-1-03
18. Louisiana	Jane LaCour	Office of Environmental Services	(225) 765-0572	Interview on 5-6-03
19. Massachusetts	Don Squires	Dept. of Environmental Protection	(617) 292-5618	Interview on 5-6-03
20. Missouri	Paul Myers	Dept. of Natural Resources	(573) 526-1549	Interview on 5-2-03
21. Oregon	Scott Manzano	Dept. of Environmental Quality	(503) 229-6821	Interview on 5-6-03
22. North Carolina	Gary Saunders	Dept. of Environment and Natural Resources	(919) 733-1497	Interview on 5-1-03
23. North Dakota	Gary Haberstroh	Department of Health	(701) 328-5206	Interview on 5-9-03
24. Rhode Island	Terrence Gray	Dept. of Environmental Management	(401) 222-6677	
25. South Carolina	Marion Sadler	Department of Health and Environmental Control	(803) 898-4167	Interview on 5-5-03
26. South Dakota	Jeannie Votava		(605) 773-3351	Interview on 4-25-03
27. Texas	Mike Gould	Texas Commission on Environmental Quality	(512) 239-1097	Interview on 4-28-03
28. Vermont	Jon Anderson	Natural Resources Conservation Council	(802) 828-4192	Interview on 5-7-03
29. Wyoming	Dennis Hemmer	Department of Environmental Quality	(307) 777-7391	Interview on 5-14-03
International				
30. Australia – Western Australia	Stuart Anthony	Dept. of Environment	618 9278 0616	E-mail on 6-9-03
31. Australia-Victoria	Marilyn Olliff	Atmosphere and Energy Unit—EPA	03 9695 2648	E-mail sent on 5-21-03
32. Canada, Quebec	Monique Gilbert	City of Montreal	(514) 280-4433	Interview on 5-15-03
33. Canada, Ontario	Guillermo Azocar	Ministry of Environment		Interview on 5-15-03

APPENDIX C2

Discussion Guide

If it is nuisance-based, do they use any odor measurement methodology to substantiate the severity of a complaint?

(prompts) – Is your agency responsible for rule administration?

If you delegate authority, to whom do you delegate?

Does your agency administer any permitting requirements as part of this rule/regulation?

If yes, please describe.

On average, how many odor complaints would you say your agency handles each year.

Is there one type of emitter from whom the majority of the current odor complaints are generated?

What is your typical response process when an odor complaint is received.

Of what does the odor measurement technology consist?

How did the need for the regulation come about?

Can we get a copy of the regulation?

Is the regulation proactive or reactive, i.e., complaint-based or are odors addressed before it becomes a problem (i.e. permits)?

What sources are regulated? (i.e., feedlots or industries) What sources are excluded?

Is odor addressed in any required permits?

Do you feel your regulation is successful? What elements do you think make your regulation successful?

Has there been any backlash from industry or feedlot operators?

How many staff members does it take to implement the regulation and to follow up on complaints?

Requirements

Do odor producing industries require a setback from other land uses such as residential or commercial? Are there setbacks for feedlots from residential or commercial uses?

Are facilities required to use BACT? Does the agency keep a list of current BACT for reference?

Is a special odor permit required? Is there anything odor related that is required under air/water quality permits?

Are facilities required to have an odor management plan? If so, what is involved in such plans?

Measurement

How is odor measured?

What compliance criteria are used (standards/limits)?

What compounds, if any are regulated?

Are there any agency officials who are trained in odor detection?

Enforcement

Which agency is responsible for enforcing the regulation?

Which agency handles odor complaints?

Is the regulation enforced only when there is a complaint? How many complaints does it take in order for action to be taken?

How is the facility notified of violations that have occurred?

Is the public notified when a facility violates the odor regulation?

What steps must a facility take in order to come back into compliance with the regulation?

What are the penalties for being out of compliance?

Are there any exclusions to the enforcement mechanism? For example if a facility notifies the appropriate agency that they will be doing cleaning/maintenance and odors will be emitted, are they excluded from the regulation?

If a citizen is bothered by odor, what process should they follow to report the odor?

If an inspector goes out to inspect, must they smell the odor in order for a complaint to be valid? How are complaints verified?

Are there penalties for non-compliant facilities? Are those penalties ever less than the cost of reducing odor, so a facility just pays the penalty because it is more cost effective?

Are there regular inspections of odor causing facilities or only if there has been a complaint?

SRF
CONSULTING GROUP, INC.

Minnesota Pollution Control Agency
Survey of Regulators on Nuisance Odor Issues

Responder Information:

Name: _____

Organization: _____

Address: _____

_____

Phone: _____

FAX: _____

E-mail: _____

Does your agency administer any rule regulating the emission of odors?

- ❑ No
- ❑ Yes

If yes, please describe.

Is odor regulated under air or water quality, or on its own?

(prompts) – is the rule based on regulation of an emission of a particular chemical substance like Hydrogen Sulfide or is it purely nuisance based?

APPENDIX C3

Interview Notes

MPCA Odor Investigation
Victoria, Australia e-mail Interview

Date: May 21, 2003
Name: Marilyn Olliff
Organization: Environment Protection Agency
Title:
Phone: 0011 61 3 9695 2648
e-mail: marilyn.oliff@epa.vic.gov.au

- The SEPP (AQM) identifies odor as an unclassified air quality indicator of local amenity and aesthetic enjoyment of the air environment. Design criteria and standards are set for pollutants including odor. The dilution threshold for odor is 1 odor unit, which is measured in mg/m^3 on a 3-minute averaging time at the property line. This threshold is for new and expanded sources.

- Industries involving intensive animal husbandry (CAFOs) certain other criteria can be used to avoid odor issues. Odor emissions should be modeled to demonstrate that the maximum odor level does not exceed 5 times the odor detection threshold at and beyond the property boundary.

- Modeling may be required for sources with odorous emissions, for which design standards and criteria have not been established. According to Marilyn Oliff of the Environment Protection Authority (EPA), dispersion modeling can be required for any source that may generate odors.

- Complaints are investigated by trained EPA officers based on their own judgment. The use a checklist for characterizing the odor which includes: hedonic tone, intensity, frequency, etc. Staff is trained and have their noses calibrated to ensure that they fall within the 'normal' range.

- The Australian/New Zealand Standard for dynamic olfactometry (AS4323.3) is used to take odor measurements at discrete (point) sources.

- Design standards and criteria for chemicals, which are highly odorous at low levels of concentration where adverse health impacts would not be expected, are set based on prevention of offensive odors with human health protected as a consequence.

- This is vice versa to what happens in Minnesota where odor is minimized as an indirect result of standards based on human health.

SRF No. 034734

MPCA Odor Investigation
Australia Survey Interview (e-mail)

Date: June 9, 2003
Name: Anthony Stuart
Organization: Western Australian Department of Environment
Title:
Phone: 618 9278 0616
e-mail: Anthony.stuart@environ.wa.gov.au

- Western Australia (WA) has guidance on assessment of odor impacts from new facilities. It is not a regulation, but provides the basis of evaluation by the WA Environment Protection Authority for new/expanded facilities.

- Section 49 of the WA Environment Protection Act makes "unreasonable" odor emissions an offense however, prosecutions under this Section are rare.

- WA DOE guidance is purely nuisance based.

- To verify the complaint of an existing odor source, source measurement and dynamic olfactometry may be required. It is on a case by case basis.

- There are no permitting requirements

- Odor may be addressed in an operating license, but quantitative limits are generally not specified. For some sources where odor is an ongoing problem, odor concentration limits based on dynamic olfactometry have been applied.

- Dispersion modeling is used in the assessment of odor, usually the Gaussian plume models.

- There are hundreds of complaints received each year from a wide range of sources.

- There are three stages to a typical response to an odor complaint: assessment of whether the department or local government should investigate, obtain background info such as description, identify nearby industries, wind direction, time of day etc, visit the site to determine offensiveness.

- If odor is deemed offensive then the facility could be prosecuted under Section 49, but as mentioned before this rarely happens. More commonly, an Environmental Field Notice is sent to the polluter who must respond to the notice. Field officers also assess potential health impacts of the odor.

- There are 5 Dept. staff who deal with all field investigations including odor. A low priority is assigned to odor investigations relative to other incidents that threaten public safety.

- All staff are trained in assessing odor.

SRF No. 034734

MPCA Odor Investigation
Bay Area Interview

Date: May 1, 2003
Name: Kelly Wee and Tim Underwood
Organization: Bay Area Air Quality Management
Title: Air Quality Compliance Enforcement
Phone: (415) 749-4760 and (415) 749-4612
e-mail: kwee@baaqmd.gov and tunderwood@baaqmd.gov

Kelly Wee: The Bay Area Air Quality Management District does administer rules regulating odorous emissions. Regulation 1 covers public nuisance, which may be used, but Regulation 7 specifically covers emissions of odorous substances.

- Regulation 7 takes a two-pronged approach to odorous emissions regulation: emissions standards are laid out for certain compounds; however, there is recourse for simple "smelly conditions", that may not be tied to emissions exceedances of any of the regulated compounds.

- Regulation 7 states that complaints from 10 or more complainants must be received within a 90-day period in order to enact the "limitations of this Regulation;" however, Kelly says that in practice they do respond in some manner to every complaint received.

- When the BAAQMD receives a complaint, the investigators must first determine in what way to attempt to substantiate the claim. In other words, through monitoring of compounds emissions or by sampling the air and using their dynamic olfactometer to measure the presence of odors. The choice of tool is usually made by the inspector based on their knowledge of the particular facility, and the likelihood of whether the odor is caused by the emission of regulated compounds or by some other combination of compounds.

- The BAAQMD does use dynamic olfactometry and have been doing so since the rule was enacted in 1973. This works by, as stated earlier, first determining what tool to use when substantiating a complaint. If it is determined that the odors may not be directly related to exceedances of regulated compounds, then the dynamic olfcactometry process is used. First sampling of the air takes place. This is typically done at the facility boundary in a downwind position. Stinky air is drawn into a bag using an evacuated cylinder; filling the bag takes about 3 minutes to accomplish. Typically one bag is taken for each complaint. Two bags may be taken if it is thought that odorous conditions may be present because of a combination of uses. In this instance, one bag is taken upwind and another downwind to determine to what extent the facility being tested may or may not contribute to odorous conditions that are already present. The sample bag(s) is then brought back to the BAAQMD office.

- The bag must be sampled by the odor panelists within 3 hours of the sample having been taken. The bag is placed into the dynamic olfactometer, and the air expelled. Stinky air is diluted with clean air at a ratio of 4 to 1 and then expelled into a mask, which the panelist inhales.

- There are three odor panelist to evaluate every sample. All the odor panelists are BAAQMD staff. This is so for two reasons, 1) liability concerns and 2) the need to have people available to sniff the air quickly (within 3 hours of the sampling). The room in which the dynamic olfactometer sits is bare and painted white, so there is no visual stimulation. Each odor panelist is seated separately, and talking is kept to a minimum so there are no distractions from the evaluation.

- Panelists are chosen by testing, in which odorous substances are diluted and presented to subjects in the same way they would be presented if they were on the odor panel. Noses that are on the high range of sensitivity and noses on the low range are eliminated, leaving panelists who have average sensitivity to odors.

- The BAAQMD has a 24-hour hotline which is answered either by a staff person, or, after hours, by an answering service. After receiving a complaint, the inspector will first call the complainant in order to get more details. When making an on-site visit, the inspector checks to see if an odor is detectable in the air, and, if so, if the source can be pinpointed. The typical response to a complaint is to notify the offender and work with the source to facilitate a solution. If five substantiated (by field checks) odor complaints are received against the same offender, then a nuisance citation is issued.

- After being issued a nuisance citation, the offender must provide the BAAQMD with documentation of how the violation occurred, in addition to how they intend to institute corrective action. After this action, then the BAAQMD forwards the particulars of the complaint on to their legal staff for determination of the penalty assessment against the offender. Following the date in which the offender said they would take action, a compliance check is made to ensure the action was, in fact, taken.

- In Kelly and Tim's opinion, the dynamic olfactometry process works quite well as a means of putting an objective measurement to a rather subjective experience like odor.

- The BAAQMD has 59 inspectors. According to Kelly, approximately 12-15 percent of their time is spent following up on nuisance odor complaints. Kelly estimated that the BAAQMD receives an average of 2,600 odor complaints per year.

SRF No. 034734

MPCA Odor Investigation
City of Bloomington

Date: May 5, 2003
Name: Erik Solie
Organization: Bloomington Environmental Health Services
Title:
Phone: 952-563-8978
e-mail: esolie@ci.bloomington.mn.us

The City of Bloomington regulates odor under the city's public health nuisance ordinance.

Complaints

The City can receive complaints through a general city number, which in essence is Erik's office phone number. The City receives approximately 12-18 complaints/year.

Source types that receive the most complaints in the City are industries such as Hitchcock Industries (metal foundry) and Adirondack Candles.

The companies are very proactive regarding odor complaints and odor issues, and the City feels they have a very congenial relationship with the industries in the area.

Erik follows up on every complaint and once a complaint is filed he will take the following steps to resolve the issue:

1. Contact the complainant to collect background information about the odor
    -what time of day the odor is detected
    -is it a recurring smell
    -what does it smell like
    -what are the weather conditions
    -what is the potential source

2. Site visit to detect odor, visit with plant manager to see if there have been any upsets in operating systems or changes in operating procedures.

3. Erik tries to work directly with the industry to resolve the problem, but if he finds the odor to have been emitted intentionally he will write a nuisance violation order.

Permitting

Odor is not formally addressed in any of the permitting done through the City. If a facility has a chemical evacuation system, paint booth, or other potentially odorous operation, the Building Inspections Dept. will inspect annually to ensure that they meet

the specific requirements of the air quality permit. The City also has what is known as a "reduction emission plan," which is part of the general air quality permitting.

Training

Some but not all inspectors have been formally trained through odor conferences.

SRF No. 034734

MPCA Odor Investigation
Chicago Interview

Date: May 5, 2003
Name: Kevin Schnoes
Organization: Department of Environmental Protection
Title: Director of Planning and Research
Phone: (312) 744-4034
e-mail: kschnoes@cityofchicago.org

- Chicago does enforce an ordinance dealing with the "control of odorous effluent." This is enforced only on a complaint basis.

- Chicago has a delegation agreement with the state so that the City is the RGU enforcing the Clean Air Act. All permitted facilities get inspected once a year. Chicago classifies four categories of emitters in their air quality program, based on tons of pollutants emitted per year.

- The policy is to follow up on every complaint lodged. The first step is to visit the site and determine if an odor is present. If the complaint is substantiated (by the inspector smelling an odor), then the facility may be inspected. If the facility is not operating in accordance to prior permitting agreements, then the facility may be issued a ticket.

- Although the Chicago ordinance does discuss Scentometer testing at various dilution thresholds based on adjacent land uses, Kevin indicated that in practice is based on a subjective test of odorous conditions—there is no methodology used other than an inspector's judgment in validating a complaint. Kevin did indicate that an inspector may occasionally use a photo-ionization detector or a Jerome meter (used to measure mercury).

- Chicago has been challenged in court because of the subjective nature of this nuisance odor determination.

- Kevin indicated that the majority of offending sources are cooperative in terms of working through the process to address odor issues. Enforcement options for those that may not be include writing additional tickets, with associated fines, until the problem is effectively addressed.

- There is a flexible time period established to address nuisance odor violations, based on the individual situation.

- Chicago does not have an odor hotline, but they do have a general complaint hotline.

- Inspectors are sent to Odor School, as taught by the USEPA in Region 5. Out of a total of 15 inspectors, approximately 5 have taken this training.

- Chicago receives about 20 complaints regarding nuisance odors every day. They have 15 inspectors in the field, and approximately 70 percent of these inspectors' time is taken up by following up on odor complaints. In addition to the inspectors, there are 3 central office staff, about 3 administrative assistants and typically about 4 to 5 interns.

SRF No. 034734

MPCA Odor Investigation
Colorado Interview

Date: May 21, 2003
Name: Kirsten King
Organization: Department of Public Health and the Environment
Title: Supervisor for the Compliance and Support Program
Phone: (303) 692-3111
e-mail: Kirsten.king@state.co.us

- Colorado does regulate odor emissions under their air quality program. The rule has been in place since 1971, and was amended in 1999 to include swine operations (other than swine operations, agricultural operations are exempt from the regulation).

- Scentometers are used in the complaint substantiation process, with a 7 to 1 dilution threshold for areas within city limits and a 15 to 1 threshold for rural areas.

- For swine operations, a 7 to 1 standards is used at the property line, with a 2 to 1 standard enforced at receptor locations (basically, the residence of a complainant).

- There are no permitting processes that deal with odor emissions. Any enforced setbacks from swine operations are established at the local level, or with other land use authorities.

- All odor inspectors go through training, both to learn how to use the device (Scentometer) but also to test for the "average nose". People who are either too sensitive or too insensitive to odors are disqualified as inspectors.

- There is a complaint hotline people can call to lodge complaints; they can also lodge complaints via an e-mail link from the health department's website.

- Every complaint is investigated. If the inspector does not detect an odor (using the Scentometer) then the case is closed out. If an odor is detected, then the inspector attempts to determine the source of the odor and the owner. The owner is then contacted and a notice of violation is issued.

- When a "notice of violation" is received, the source owner must submit documentation of how they intend to address the odor problem. Fines may be levied against the source, although Kirsten state that they typically don't fine a first-time offender. Fines vary based on the presence of other aggravating factors, like water pollution problems. Kirsten stated that, since odor is often an indicator of something not working properly, these other violations were frequently found.

- Kirsten stated that she did not believe that the odor regulation was an unmitigated success. She believed that the inspectors did not like having the use the Scentometers and found them cumbersome. Also, when appealed to the Department of Health and Environment Commissioners, policy-makers did not view Scentometers too favorably as a means of substantiating complaints.

- Kirsten said that approximately 1 to 2 complaints per year were lodged against sources other than pig operations. Pig operations averaged about 50-70 per year.

- Colorado has 12 inspectors statewide, however, a relatively small percentage of their time is devoted to odor issues.

SRF No. 034734

MPCA Odor Investigation
Connecticut Interview

Date: May 1, 2003
Name: Bill Wihbey
Organization: Department of Environmental Protection
Title: Field Inspection Officer
Phone (860) 424-3447
e-mail: william.wihbey@po.state.ct.us

- Connecticut does have regulations for the control of nuisance odors. It is a complaint-driven process based on four criteria: 1) intensity, 2) characteristics, 3) duration, and 4) frequency.

- Although the use of scentometers is referenced in the regulation, as a matter of practical enforcement they were found to be unsuitable. In Bill's opinion, it was too difficult to obtain reliable samples for use by an olfactometry panel outside the field. Instead they have come to rely on the use of on-site visits, and staff trained to do field observations who judge whether any odors present in the air are objectionable.

- As part of Connecticut's regulations, there are standards established for emissions of certain compounds (chlorine, ethyl acrulate, ethyl mercaptan, formaldehyde, hydrogen sulfide, methyl ethyl ketone, methyl mercaptan, methyl methcrylate, perchloroethylene, phenol, styrere, toluene).

- Every complaint lodged with the DEP is followed up on. If a nuisance is substantiated through a field check, then a notice of violation is issued. Even if a nuisance odor complaint is not substantiated, the offending source is notified in order to determine whether a temporary change in practices may have occurred that may be remediated. If a nuisance is substantiated, then the offender notifies the state in writing about the cause of the nuisance, and the steps that will be taken to remediate, which must be done within 30 days of notice. A compliance inspection is made after the fact to ensure that the issue has been addressed.

- Eric estimated that the staff complement to enforce this regulation at the state level is approximate 12 to 13 FTE, although these inspectors do also deal with other complaints than odor.

SRF No. 034734

MPCA Odor Investigation
Des Moines Interview

Date: May 9, 2003
Name: Steve Gunson, Steve Drane, Phil Delafield
Organization: City of Des Moines
Title: Assistant to the City Manager, Lead Inspector, Permitting Specialist
Phone: (515) 237-1343
e-mail: sagunson@dmgov.org

- Des Moines does have an ordinance regulating nuisance odor emissions (attached), which was enacted in 1991.

- The ordinance was enacted as part of a grassroots effort by citizens, mainly in the SE quadrant of Des Moines, who were affected by nuisance odors emanating from this area, mainly related to meat-packing/processing industries.

- Malcolm Pierney, an east-coast consulting firm, was retained to draft a city odor ordinance. This ordinance identifies a Citizen Odor Board, establishes an odor hotline, states how and when a source will be identified as a "Significant Odor Generator", and the process a source must follow when so deemed.

- The City does maintain a 24-hour odor hotline. Calls are taken by an answering service at all times, not just during business hours. Since the process of deeming a source a "Significant Odor Generator" hinges on the calling of three odor alerts (receipt of 10 or more calls within a six-hour period) within a 90-day period, the City found that there were communication lapses with a change-over from a night answering service to a day-shift City worker. So the answering service personnel have been trained to identify when the City should be notified of a potential odor alert situation.

- Complaint follow-up is only done during an odor alert situation.

- After an alert is declared, then the inspector will go on-site (as soon as possible after an alert declaration, even if after-hours) in order to substantiate the source that is generating the odor. The odor inspector will verify whether the odor descriptors are similar to the odors he or she smells. If this is the case, the complaint is substantiated and, if the source has been identified, then the inspector notifies the source type that an odor violation has occurred.

- If three odor alerts have been declared for one facility within 90 days, then they are deemed a Significant Odor Generator, for which the ordinance spells out a compliance process.

- McGinley does the training for Des Moines' odor inspectors, and also is available to work with Significant Odor Generators in order to come up with an odor compliance plan.

- A citizen odor board was an important part of Des Moines odor ordinance. It brought together sources and citizens (I don't believe that city staff were formally represented) and worked as part of the facilitated solution process.

- There are no special, source type exemptions to the Des Moines odor ordinance.

- To a certain extent, the Des Moines permitting process does account for odor in that their city zoning code allows the City to ask a permittee to hire an engineer to provide recommendations on what BACTs must be in place for a particular facility prior to getting an operating permit. I believe McGinley may be involved in this, as well.

- Steve Drane (Lead Inspector), said that in the early years of the ordinance, the City typically received 140 complaints per month, from 3 major sources.

- Now the City typically receives only 20-30 complaints per month. This is due to better compliance in some instances. In one instance, one of the significant odor generators decided to close up shop.

- There are no financial penalties for being out of compliance, although there are abilities to revoke operating permits ("Suspension and Revocation of Permit").

- Once deemed a "Significant Odor Generator", a facility can be taken off that list, if they are deemed to be fully in compliance.

- Steve did give an example of a coffee roaster that was in danger of being deemed a significant odor generator, where the city, after notifying the roaster of odor alerts, then encouraged the source to meet with complainants and figure out how to address the issue. Since that meeting took place, there have been no further odor alerts for the roaster.

SRF No. 034734

MPCA Odor Investigation
Idaho Interview

Date: May 1, 2003
Name: Tim Teater
Organization: Idaho Department of Environmental Quality
Title: Air Toxics Program Analyst
Phone: (208) 373-0457
e-mail: tteater@deq.state.id.us

- Idaho had classified odors as an air pollutant but, for many years, did not have any policy in place to manage odorous emissions. In 2000, procedures for responding to nuisance odor complaints were codified.

- Every complaint is followed up on by sending 2 staff people out to do a field check. Idaho uses ASTM Standard E544-99 with Butanol used as a baseline odor, and ambient air judged in relation to the Butanol sample. Idaho uses an 8-point scale to evaluate odor. If odors are judged at level 4 or above, then the odor complaint is judged to be "valid".

- All attempts are made to do the air testing under similar conditions to those that pertained when the odor complaint occurred (i.e., time of day, weather conditions, etc.).

- Idaho did not decide to use olfactometry. Tim said that it was thought to be too expensive both in terms of equipment needed and the training for staff people.

- If an odor complaint is substantiated, then the offending source is contacted. Idaho staff will meet with facility, and the complainant to discuss mitigation, whether practices or equipment, to manage the odors.

- Approximately 12 inspectors are out in the 6 regional DEQ offices. However, not all inspection activities pertain to odor. Tim estimated that about 15 percent of these inspectors' time is spent on pursuing odor complaints.

- All complaints regarding agricultural operations are routed to the Idaho Department of Agriculture. The majority of odor complaints do arise from agricultural operations, but the Idaho legislature was quite specific about the fact that ag operation were outside the purview of the DEQ.

- In Tim's opinion, Idaho's procedures have worked quite well, and been accepted reasonable well by industries.

SRF No. 034734

MPCA Odor Investigation
Kandiyohi County Interview

Date: May 2, 2003
Name: Kim Larson
Organization: Kandiyohi County Environmental Services
Title: Feedlot Officer
Phone: (320) 231-6547

- Kim indicated that new and expanded feedlot facilities in Kandiyohi County are permitted through the Conditional Use process.

- Kandiyohi County is zoned into two distinct zones. The southern half of the county (Zone A1) is an agricultural preference area, with residential development allowed at a density of one unit per 40 acres. The northern half (Zone A2) is zoned with preference to residential development, since this area contains the County's lake areas, which are attractive to retirees and others.

- The zoning describes above gives preference to agricultural operations in the southern portion of the county and provides for a great separation of more dense residential areas from agricultural uses.

- In Kim's opinion, their system of zoning has worked quite well and he did not see the need for any changes.

SRF No. 034734

MPCA Odor Investigation
Louisiana Interview

Date: May 6, 2003
Name: Jane LaCour
Organization: Department of Environmental Quality
Title: Director of Industrial Agricultural and Stormwater Permitting
Phone: (225) 765-0572
e-mail: jane_l@ldeq.org

- Although Louisiana has a relatively sophisticate odor rule on their books (attached), Jane indicated that Louisiana does not really enforce the rule.

- The rule is based on perceived odor intensity based on an eight-point butanol scale, with no facility allowed to permit the emissions of odor surpassing a ranking of six or greater beyond their property lines.

- According to the regulations, complaints are substantiated by taking a sample of the odorous air and convening an odor panel of eight members chosen by the Department. Panelists then compare the sample and rank according to the butanol scale.

MPCA Odor Investigation
Massachusetts Interview

Date: May 6, 2003
Name: Don Squires, John Winkler
Organization: Department of Environmental Protection
Title: Branch Chief, Business Compliance; Permit Chief
Phone: (617) 292-5618, (508) 946-2779
e-mail: Donald.squires@state.ma.us

- Massachusetss does have a rule in place restricting odorous emissions. It is based on odor, not measurable emissions of compounds. The rule was enacted in 1972.

- In general, Don noted that Massachusetts is trying to take the state out of the enforcement business and instead put the onus of enforcement onto local jurisdictions.

- Don did state that their policy is still to follow-up on every complaint received. No odor measurement technology is used during complaint substantiation beyond an inspector's judgment of the presence of an odor.

- Massachusetss does have a draft policy in place during their permitting processes, whereby permittees have to substantiate that their operations will not exceed 5 d/t, (I believe at their property line). John Winkler is mailing a copy of this draft odor policy to SRF.

- In speaking to John Winkler regarding the draft policy establishing odor emissions during permitting, John indicated that, although still a draft policy, it is used by the Department. The ICST model (approved by the EPA) is used in this emissions modeling process.

- During the enforcement process, once an odor complaint has been substantiated against a business, the business is responsible for proposing a solution. Massachusetts assists in this process as necessary, but it is the businesses responsibility to take action.

- There are no exemptions to the odor regulation.

- There is training available for inspectors, although not all the staff has received it, due to resource considerations.

SRF No. 034734

MPCA Odor Investigation
MCES Interview

Date: May 8, 2003
Name: Lisa Wolfert
Organization: Metropolitan Council Environmental Services
Title: Senior Environmental Scientist
Phone: (651) 602-4870
e-mail: lisa.wolfert@metc.state.mn.us

- The MCES does not have an odor emissions standard to which they hold themselves. They do have an Environmental Quality Assurance Team that is currently analyzing system operations. Part of this effort is an Odor-Control Strategy Sub-Team that may be recommending better ways to track and manage their complaint process and communications back to the public regarding the same.

- The MCES does not have a unified complaint-response policy system-wide. Oftentimes, when complaints are lodged, they are called into the offending facility. If they are called into the general odor complaint hotline, then complaints are typically routed to the regional office. Persistent complaints regarding one source/facility are managed through the Air Quality division of MCES.

- If staff is available, the offending facility will typically send a staff person off site to confirm the presence of an odor. This is done using the inspector's nose, and not with any other odor detecting equipment.

- Routine odor monitoring is currently performed at 31 sites around the Twin Cities. Sampling of air is done at the source. This samples is then presented to an odor panel, made of 8 citizens, using ASTM Standard 679-91. The MCES uses the St. Croix Sensory Olfactometer. Lisa indicated that the most useful part of this process is that the panelists can give a characterization of the odor that may enable the MCES to determine the cause of the odor.

SRF No. 034734

MPCA Odor Investigation
City of Minneapolis

Date: May 7, 2003
Name: Jennifer Tschida
Organization: Minneapolis Environmental Management
Title: Environmental Inspector II
Phone: 612-673-5874
e-mail: Jennifer.tschida@ci.minneapolis.mn.us

The City of Minneapolis regulates odor under the nuisance regulation. The section of the regulation dealing with odor states:

"Odors shall be deemed unlawful if one or more air contaminants migrate from the premises from which it originated for a period exceeding 30 minutes duration and interferes with the reasonable and comfortable use and enjoyment of property."

Complaints

This is a complaint driven process. There is a 24 hour complaint hotline, as well as an online complaint form to fill out and submit. During business hours, the Environmental Management Department can be contacted and Jennifer will eventually receive the call.

The complaint is logged in a computer database. The policy is that every complaint is followed up on. Because odor is a time sensitive emission, it is not always possible to make a site visit to follow up on each and every complaint.

When a complainant calls in background information is gathered regarding weather conditions, what time the odor is detected, whether it is a one-time instance or recurring, what the odor smells like etc.

Jennifer estimated that depending on the time of year the City receives 5-10 odor complaints/week.

Source types that receive the most complaints in the City are industries such as Davis Frost (paint), Interplastics (plastic), Leef Brothers Services (industrial laundry), Owens Corning (asphalt).

Once the complaint is logged, the inspector will go to the site and have a sniff. No other measurement technique is used. The inspector determines that an odor exists not whether it is good or bad.

The City prefers to work with the industry to resolve any odor situations that may occur. If it is a recurring offender and a source that receives many complaints, Jennifer tries to

work with the MPCA to resolve the odor issue through a permitting process as Jennifer believes that all odors are secondary to a larger problem.

If the complaint is against a residential property, Jennifer can send a letter citing the alleged violation to the property owner.

The City does have the authority to ticket violators of the nuisance ordinance, but with large industries it does not have much of an effect. A large industry thinks nothing of paying a $70 fine, and so Jennifer would prefer to facilitate a solution with the industry to get them into compliance. After a verbal agreement is come to as to what the solution will be and when it will be implemented, the City will do a compliance check to make sure everything is operating as agreed upon. If not, the City has the authority to pull a facility's business license.

Jennifer said that handing out nuisance violation tickets is not effective because the nuisance ordinance does not hold up well in court.

Permitting

Odor is not formally addressed in any of the permitting done through the City. Odor could be addressed during plan review if the committee recognizes a particular facility might be a source of odor issues. If this is recognized, the committee would speak with Jennifer regarding how it might be handled to prevent odor problems from occurring.

Staffing

Jennifer receives all odor complaints and is the one to respond unless she is out of the office or otherwise busy. There are approximately 12 other staff members in the department and they can cover for each other if a site visit is needed. Jennifer mentioned that the City would like to work on a more formal permitting process which includes odor emissions.

Training

Jennifer has been through some odor training through various conferences.

Comments

Jennifer says that the City's process works relatively well but there is always room for improvement. She thinks that if the MPCA would consider odors during its air quality operating permit process it would be make her job easier. She said the MPCA has authority for more than what they currently require.

SRF No. 034734

MPCA Odor Investigation
Minnehaha County Interview

Date: May 2, 2003
Name: Phil Kappen
Organization: Minnehaha County Planning Department
Title: Assistant Planning Director
Phone (605) 367-4204
e-mail: pkappen@minnehahacounty.org

- Minnehaha County does not specifically address nuisance odors in their nuisance ordinance as, in Phil's opinion, there is no good available objective means for measuring odors.

- However, their nuisance ordinance does address the application of manure, specifically that it can't be spread on the surface of a field within 300 feet of a residence, unless it's immediately incorporated.

- Minnehaha County does address the siting of CAFOs in their zoning ordinance. Their zoning ordinance was amended in 1998, after a public process involving citizens, pork and beef producers. Various "criteria" are analyzed during the permitting process, including the size of the facility (based on animal units), the topography, surrounding land uses, etc. Based on these criteria, a setback is established by the County Planning Commission. Phil stressed the need to be flexible in establishing setbacks, and that this flexibility has worked well in Minnehaha County, both for producers, as well as residents.

- Prior to the 1998 zoning ordinance amendment, there was little if any means of regulating land uses in areas zoned for agricultural use. The county realized the potential problems this could create when a land owner proposed siting a hog operation near some adjacent residences in an area that was zoned for agriculture.

- If complaints against existing operations are lodged, then Phil follows up, through an informal process, that includes contacting the offender, identifying the source/cause of the odor event, and stressing the need to follow good agricultural management practices.

SRF No. 034734

MPCA Odor Investigation
Missouri Interview

Date: May 2, 2003
Name: Paul Myers
Organization: Missouri Department of Natural Resources
Title: Environmental Specialist
Phone: (573) 526-1549
e-mail: nrmyer@mail.dnr.state.mo.us

- The State of Missouri does enforce rules regulating odorous emissions. There are four separate rules, each one covering different geographic areas of the state. All portions of the state are covered by one of these rules.

- The rule covering the portion of the state containing the City of St. Louis is the oldest, and was enacted in 1967. This rule is also the one that differs by the greatest amount from any of the other three rules.

- Missouri does use a scentometer to establish a violation of their odor rule. The dilution threshold they use is 7-1 (i.e., 7 parts of clean air to one part "stinky air. If the odor is detected at that level, then a violation has occurred).

- The scentometer process works by having an inspector make a field visit after receiving an odor complaint. The inspector goes on site, identifies the odor plume, then returns to the source with a scentometer. He or she will then take two readings, allowing for at least a 15-minute gap between readings but not more than 1 hour.

- It should be noted that CAFOs, and all other agricultural uses are exempted from this regulation. However, Missouri recently did enact some measure of testing for Class 1A CAFOS, covering CAFOs that exceed 7,000 animal units (note: that is NOT a typo. They do have CAFOs over 7,000). All Class 1A CAFOs must develop an odor control plan.

- For Class 1A CAFOs, Scentometer testing is used as a screening evaluation, not as a substantiation of a nuisance odor complaint. If the scentometer test registers an odor to the inspector, then a sample of the "stinky air" is taken and sent to a laboratory under contract to the State. The laboratory then assembles an odor panel, which is used to come up with a collective assessment of whether nuisance odors can be substantiated, using the Butanol standard. This method of testing nuisance odors from CAFOs is relatively new to Missouri, so Paul did not have an opinion as to how effective it was.

- Paul felt that the scentometer method of field-testing non-agricultural source odors worked quite well.

- Paul indicated that all nuisance odor complaints are followed up on, and that he believed that approximately 20 to 30 percent of complaints are substantiated using the scentometer-testing method.

- If the nuisance odor is substantiated, then the offender is given notice of violation. State staff then work with the offender to establish a plan to address the issue and establish a plan for remediation. Compliance checks are usually made, but not always.

- Fines are assessed to offenders; however, the dollars go to the local school district in which the offender is located, not the State.

- Paul estimated that the state receives approximately 10-20 complaints per month during the summer, with an average of around 100-150 complaints per year.

- There was (at least one) court challenge to the use of the Scentometer method to establish a nuisance violation; however, its use was upheld in court.

- Paul estimated the staff complement in order to manage and enforce this rule to be about 1 staff person per regional office (of which, Missouri DNR has 6) engaged in air quality issues. Following up on odor complaints would be simply one part of this person's responsibility. At the Central Office level, Paul said there were 2 staff persons who dealt with odor emissions issues. Again, this is not full time, but a portion of these 2 staff person's time.

MPCA Odor Investigation
Montreal, Canada Interview

Date: May 15, 2003
Name: Monique Gilbert
Organization: City of Montreal
Title: Engineer
Phone: 514-280-4433
e-mail: Monique.gilbert@cum.qc.ca

- The City of Montreal does regulate nuisance odors, and has done so since the 1970s. A new law, Law 90, was enacted in 1997.

- There are also province-wide rules, although within the city, Montreal's ordinance has precedence. The statewide rules are currently less stringent than the city rules, although Monique stated that the province is in the midst of revising their rules.

- Montreal does regulate the emissions of certain compounds, such as toxics and classes of VOCs, however, they also limit odors in general.

- During the permitting process, review staff tries to ensure that BACTs will be in place to regulate odorous emissions. In doing so (review of BACTs), the staff rely on their knowledge of industries' and their potential to emit odors. For source types with which staff has no experience, they turn to the provincial EPA for assistance.

- Although for certain, known "stinky" source, routine odor checks are done, in other instances, enforcement is complaint based. Complaints against facilities are lodged by phone. Every complaint is followed up on. Questions of complainants are asked re: odor intensity, duration, severity, and characterization.

- When an inspector goes out to follow up on complaints, to testing methodology is used other than their judgment of odors present in the ambient air (i.e., no Scentometer testing).

- The inspector will attempt to identify the offending source, and even what process may be ongoing that is creating the odor. If the complaint is deemed credible, the source will be notified of the complaint.

- If the offending source is a permitted one, then the permit may be checked as part of the enforcement process; if the source is a new one that is not permitted (because they may not have known of the need to get a permit) then the inspector will inform them of the need to get a permit. This process begins in a facilitative manner.

- If problems are not being addressed and odor complaints persist, then a more formal complaint substantiation process is enacted. This consists of odor sampling (if a point source, at the chimney; if an area source, at the property line). The offending facility can be required to do its own sampling by paying a consultant pre-approved by the City.

- Air samples are administered using dynamic olfactometry to an odor panel of 5 persons. City staff must be present when the test is administered. Montreal's standard is 1:1 dilution threshold.

- Monique stated that Montreal typically receives 2,000 odor complaints per year. Although most of these complaints are lodged against 5 facilities.

- Typically, odor sampling using a test panel and dynamic olfactometry is used about 15 times per year.

- Staffing consists of about 10 inspectors (who also deal with water issues), 5 technicians, and 5 engineers.

- Monique indicated that prosecutors don't like the dynamic olfactometry method of substantiating odor violations, and that they would prefer the City used the European CEM model.

SRF No. 034734

MPCA Odor Investigation
Nicollet County Interview

Date: April 25
Name: Tina Rosenstein
Organization: Nicollet County
Title: Environmental Services Director
Phone (507) 931-6800
e-mail: trosenstein@co.nicollet.mn.us

- Nicollet County does enforce regulation dealing with nuisance odors, specifically as part of their county zoning ordinance -- feedlot sections. This ordinance relies on the OFFSET model. Tina believes that Nicollet is the only county that has incorporated the OFFSET model into their ordinances, although she believes that other counties may use it as part of their permitting processes.

- The feedlot section of the zoning ordinance was adopted by Nicollet County in December 2000. Tina was part of the Feedlot Manure Management Committee that first recommended that a model be developed by the University of Minnesota, and sites within Nicollet County were used by the U of M as part of the initial investigation database to develop the model.

- After adoption of the OFFSET model, Tina believes the permitting process is greatly simplified. The County is the "keeper of" the model. People seeking a feedlot permit submit the required "input" information to the County which, in turn, runs the model to arrive at the "output" or recommended setbacks. If recommended setbacks cannot be met due to the proximity of existing land uses, then the County works with the permittee to identify BACTs which, when accounted for in the model, may eventually result in adequate setback distance due to decreases in the potential for odor emissions.

- Since adopting the OFFSET model, no one has petitioned for an EAW (for facilities < 1,000 animal units).

- Since adopting OFFSET, 11 facilities have been permitted and no complaints have been lodged against these facilities.

- Reciprocal setbacks are used in the county (i.e., if a developer wants to build a residential subdivision and an existing feedlot is in the area, then it is incumbent on the developer to ensure that an adequate setback is provided from the residential area to the feedlot).

- Tina indicated that OFFSET was not envisioned as a regulatory tool. It has worked very well for Nicollet County because of the flexibility it provides to suggest BACTs and the ability to work with operators ahead of time to ensure that BACTs are in place to reduce odorous emissions.

- When a complaint is lodged, Tina (or a staff person) tries to discover as much information as possible (weather conditions, time of day, duration, etc.). The next step is to talk to the facility operator to determine if any practices may have changed and, if so, if it is a temporary change/occurrence. If yes, then the facility operator is just reminded to revert to their previous course of managing odors. If it is not a temporary change, or if no information is forthcoming, then Tina will send a "tracking sheet" (in the file) to the complainant and ask them to start keeping an "odor log". If it can be demonstrated that the facility is not meeting a 93 percent annoyance free odor rated (based on the OFFSET model, as stipulated in the zoning ordinance), then the County can intervene.

- Tina indicated that she does not hear about complaints from any other source type for odors. She did say that perhaps some of the cities in Nicollet County, such as North Mankato and St. Peter, did receive complaints due to other source types, but she is not privy to these city matters.

- Tina was interested to know why the MPCA did not accept OFFSET model results as part of their EAW permitting process.

- Tina also mentioned that Nebraska is developing their own version of the OFFSET model, and that Larry Jacobson and Dave Schmidt at the U of M have received grant money to do modeling of H2S emissions.

SRF No. 034734

MPCA Odor Investigation
North Carolina Interview

Date: May 1, 2003
Name: Gary Saunders
Organization: Department of Environment and Natural Resources
Title: Special Project Engineer
Phone: (919) 733-1497
e-mail: gary.saunders@ncmail.net

- North Carolina does administer rules regulating nuisance odor emissions. They are regulated under Air Quality. There are actually two rules; one dealing with agricultural emissions, the other rule dealing with other source types.

- The first rule passed was that addressing agricultural nuisance odors. This resulted from the concentration of hog feedlots in three counties in South Carolina. It is interesting to note that tourism industries, and others related to tourism, really drove this legislation as the offensive odors were thought to be impacting, or have the potential to impact, tourist travel.

- The rule regulating other industrial sources was mainly advocated for by environmental groups.

- North Carolina offers training courses for farm workers. State employees who deal with compliance are urged to take this course so that, during inspections, they will know if best practices are being instituted.

- Enforcement of these rules is based on complaints…if no complaints are lodged, then no enforcement actions are taken. When complaints are lodged, the complainant is asked to keep a log book. Field tests are then done under similar circumstances (i.e., time of day, weather conditions, etc.) to those that are noted in the log book.

- Rules are "two-pronged", with emissions standards addressed for certain compounds, but with the possibility for "other evidence" to be submitted to substantiate an odor exceedance. "Other evidence" includes odor log books in which odor incidents are logged by a complainant with weather conditions, time of day, duration of odor, and other particulars noted.

- North Carolina uses ASTM Standard E544-99, in which Butanol is used as baseline odor type (sniffed using a mask) and then ambient air is sniffed to establish the odor intensity on the ASTM Odor Intensity Referencing Scale. This is done by a comparison of the odor intensity of the sample to the odor intensities of a series of concentrations of the reference odorant, which is 1-butanol (-

butanol). North Carolina uses the 5 standard method. Staff members are trained in this technique, and it is used in the field to substantiate odor complaints.

- In Gary's opinion, the ASTM Standard is working quite well in North Carolina. He did not believe that olfactometry would allow for the ease in use and training that the ASTM standard allows.

- If an objectionable odor finding is made in the field, then state staff work with the facility operator to institute a Best Management Plan. It is incumbent on the facility to propose a plan to alleviate nuisance odors. Only if odor problems persist does the State step in to initiate Maximum Feasible Controls (as referenced in their Odor Rules, as attached). This last step is seen as rather dire by the industries and as of yet, a situation has not deteriorated to the point where this was instituted.

- Gary saw a great drop-off in complaints lodged against hog operations after 1999, when the new rules for agricultural operations were enacted.

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MPCA Odor Investigation
North Dakota Interview

Date: May 9, 2003
Name: Gary Haberstroh, Gary Kline
Organization: North Dakota
Title: Gary Kline is involved in enforcement
Phone: (701) 328-5206
e-mail: glkine@state.nd.us; ghaberst@state.nd.us

- North Dakota does have an odor rule in place. It is aimed at limiting objectionable odors; however, it does establish thresholds for hydrogen sulfide (0.05 ppm).

- The standard described in the regulation for odorous emissions not related to hydrogen sulfide is that nuisance odors cannot exceed seven odor concentration units (as measured by a Scentometer at a 7:1 dilution threshold) outside the property boundary (this pertains to cities or portions of cities where a city exercises extraterritorial zoning.

- Outside of city limits, they have thresholds based on land use, and distance from the odor source. Basically, there is a buffer area of ½ mile from the odor source in which the state would not measure odor limits. They do have "reciprocal" language in their ordinance, giving protection for sensitive sites, like residences, churches, or public parks that are within the ½ mile buffer if they were located prior to the source going in. If they locate after the source is in place, then it would be a "coming to the nuisance" situation, and they would have no protection.

- Prior to an odor rule amendment, effective June 2001, the standard had been 2 odor units, in terms of determining the presence of a nuisance odor (or a 2:1 dilution threshold on a Scentometer). This was changed in recent years as it was felt to not give enough protection to businesses.

- Enforcement of the rule is done on a complaint-driven basis. An odor survey (trained odor inspector in the field with a Scentometer) is done for every complaint lodged.

- Annual site inspections of permitted facilities also include an odor survey.

- Inspectors must be trained (as spelled out in the state rule). Currently there are 50-60 people certified as odor evaluators. Gary Kline is the person who does this training. Since Gary Kline said the Department only received 5 complaints per year over the past 5 years, there are clearly plenty of odor inspectors to go around. NOTE, for a different take on this, please refer to Dakota Resource Council Interview notes.

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MPCA Odor Investigation
Ontario Interview

Date: May 15, 2003
Name: Guillermo Azocar
Organization: Ministry of the Environment
Title: Source Assessment Officer
Phone: 416-327-6403
e-mail: Guillermo.azocar@ene.gov.on.ca

- Quebec does regulate odorous emissions under the province's air quality act (Regulation 346).

- Compliance with odor standards is required during the permitting process, including Ontario's version of an Environmental Assessment. The firm seeking the permit is required to provide documentation of compliance.

- There are four options that can be chosen (depending on applicability) in documenting the emissions factor during permitting. These are 1) Mass Balance, 2) AP 42, 3) Engineering Assessment, and 4) Source Testing.

- Dispersion models used by the MOE are, for a single source, the USEPA Screen III model and Aeromod. For multiple sources it is the ISC 3. All of these models are US EPA approved; however, Ontario uses a 10-minute average, rather than a one-hour average.

- The permittee (facility) does the inventory based on a list of 87 regulated contaminants, using a dispersion model.

- Any permitted facility, after beginning operations, is required to do testing about 2-3 months after opening (after operations are routinized) in order to ensure that they are within their permitted emissions limits. If the facility is not within their limits, then they must draft a plan for coming into compliance.

- Routine testing of certain types of permitted facilities is done in order to ensure they are within their permitted limits of emissions.

- Ontario's odor standard is a 1:1 d/t.

- Every complaint lodged is followed up on. Critical information to receive from the complainant includes place, time, and characteristics of the odor event. No

equipment, other than the judgment of the inspector using his or her nose, is used to substantiate the odor complaint.

- Even if the inspector cannot detect an odor, the facility will be contacted and a facilitative process of identifying the cause of the odor emissions and redressing any ongoing problems will begin. The facility is responsible for documentation of issue and any follow-up steps, if necessary.

- Typically, a facilitative process is used to address issues. However, in extreme instances, sampling of odorous air at the source is done (four samples are taken), and an odor panel is convened (consisting of people not from the area so not accustomed to odor). To test the air sample using dynamic olfactometry. The "average nose" is tested for. Samples are tested within 24 hours of having been taken.

- Guillermo did not know details of all complaints lodged in Ontario, since the MOE is decentralized in 12 different regions; however, he estimated that approximately 40 complaints per year lead to sampling and dynamic olfactometry testing.

- About 80 staff people in Ontario have some part of their job responsibilities dedicated to odor issues.

- Odor regulations are all based off-property, unless it's a public institution (i.e., university, library, etc. and some of their processes are stinky on their grounds).

- Exemptions are in place for some farming operations; however, the Ministry of Agriculture is in the midst of studying agricultural operations and perhaps amending standards.

MPCA Odor Investigation
Oregon Interview

Date: May 6, 2003
Name: Scott Manzano
Organization: Department of Environmental Quality
Title: Environmental Analyst
Phone: (503) 229-6821
e-mail: manzano.scott@deq.state.or.us

- Oregon does enforce nuisance odor requirements. A nuisance situation is determined based on 1) frequency, 2) duration, 3) strength or intensity, 4) number of people impacted, 5) suitability of each party's use to the character of the locality, 6) extent and character of the harm to complainants, and 7) source's ability to prevent or avoid harm.

- Nuisance is actually managed in Oregon through the Small Business Assistance Program. NOTE: this seems quite unique in that the approach is proactive in how to assist businesses, not penalize them.

- The rule has been in place since 2001 and was the result of a permitting rules streamlining process, whereby all rules affecting permitting were combined and streamlined. Nuisance rules were formerly found to be one of the primary culprits in delaying the permitting process.

- Complaints regarding nuisance odors are lodged by telephone. The policy is to follow up on every complaint. No measurement technology is used in substantiating a complaint, beyond the inspector's judgment of ambient air quality. Scott indicated that Oregon found odor measurement technology to be unreliable and was not a valuable part of the process.

- If a nuisance is substantiated, then a Best Practices Agreement to remediate the nuisance situation is entered into. If the use is a permitted use, the permit is amended to reflect the Best Practices Agreement. If the facility is not permitted, then the Best Practices Agreement is a stand-alone document.

- Nuisance odor complaints arising from CAFOs are handled through the state Department of Agriculture.

- Scott does not deal in day-to-day enforcement and did not know approximately how many complaints are received per year. He did estimate that it takes about 1-2 FTEs to administer and enforces this rule statewide.

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MPCA Odor Investigation
Renville County Interview

Date: April 25
Name: Eric Van Dyken
Organization: Renville County
Title: Environmental Officer/Feedlot Officer
Phone (320) 523-3664

- Renville County does not currently administer any rule regulating the emission of nuisance odors. At one point in time, the county was discussing a formal process for managing nuisance odors that would have been codified under their nuisance law ordinance, but this discussion has been tabled for now.

- Of complaints that Eric receives, the majority of them are arising from feedlot operations. Other source types include sugarbeet processing (Southern MN Beet Sugar Cooperative), and ethanol plants (although complaints against ethanol plants are not very common). Eric speculated that the reason he rarely receives complaints lodged against ethanol plants are due to the fact that these are located in cities in Renville County and that the cities may be receiving any complaints that are generated.

- When complaints are lodged, Eric logs the complaint in the county database, and then forwards the complaint details on to the regional MPCA office. The county does have an odor hotline, referenced as such, but it is basically just Eric's work phone #. Renville County doesn't own any odor measurement devices. MPCA staff will come out to the county and work with Eric to go on-site and take air quality readings with the Jerome meter, when odor complaints are lodged. Eric will also call the facility to inform them of the complaint and discuss with them whether practices may have temporarily changed and, if so, for how long.

- Most of the complaints that Eric deals with for feedlots come from the operations with lagoons.

- In Eric's opinion H2S monitoring/measurement is not an effective measurement of odor. Especially for sugarbeet operations, he has seen that H2S emissions can be well within standards, while odor is still prevalent. Another reason for that H2S emission monitoring is limited is that it is limited to monitoring at the property line. This is a "hard and fast" rule, so that an operator may have located their facility near a property line. The property line may abut a use from which odor complaints could not reasonably be lodged, such as roadway right-of-way (as was the case with Valadco), however, it is still incumbent on the operator to meet H2S emissions. Due to the proximity of the facility to the property line, this may not be feasible, violating the letter of the law, but not the spirit (i.e., if no sensitive use is being impacted, then it's a "no harm, no foul" situation).

- The county does use setbacks for feedlots as a means of managing the impacts of nuisance odor emissions. Other source types are dealt with through the county's conditional use permitting process.

- Setbacks are a function of the number of total animal units proposed on a new facility and the adjoining land uses, i.e., for a 300-1000 unit facility, setbacks of ¼ mile are enforced. For 1000 to 2000 animal units, setbacks of ½ mile are enforced. The county does not allow feedlot operations greater than 2000 animal units.

- Reciprocal setback standards are enforced.

- In Eric's opinion, the OFFSET model is of limited usefulness because it is so specific that it is not flexible enough to account for new and emerging BACTs.

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MPCA Odor Investigation
Rhode Island Interview

Date: May 6, 2003
Name: Stephen Majkut
Organization: Office of Air
Title: Chief of Office
Phone: (401) 222-4700 x7010
e-mail: smajkut@dem.state.ri.us

- Rhode Island does have a regulation in place controlling nuisance odor emissions (attached). This was enacted in 1977.

- Steve said that this rule is based on a subjective test of odorous conditions—there is no methodology used other than an inspector's judgment in validating a complaint.

- Rhode Island uses a complaint prioritization process, whereby complaints are prioritized according to a staff person's familiarity with the offending source (i.e., if the source is one against which many complaints have been lodged in the past, it would receive a higher priority ranking), the potential severity of the complaint (i.e., if it had the potential to affect human health), and other criteria.

- Although some complaints may receive a lower-priority ranking than another, all complaints are eventually responded to.

- Complaints are validated by sending an inspector to the site and having him or her determine whether an objectionable odor is present (as indicated above, done by using the inspector's judgment). Inspectors will do tests both downwind and upwind of the source.

- Odor evaluation training is given to inspectors by a consultant with whom the state contracts.

- Offending sources are notified if the complaint is found to be valid. The inspector with then work with the source to address any persistent problem causing odors.

- The follow-up to complaint validation is to first work informally, in a facilitative process. Documentation may be required from the offending source regarding the means by which they intend to address the problem. Penalties may be assessed as per regulation (not the odor regulation attached.)

- Steve estimated that the staffing complement to enforce Rhode Island's regulation is about 2 ½ FTE (2 in the field and ½ in CO). RI receives approximately 1,000 odor complaints per year.

- Rhode Island's permitting process does look at odor emissions (may want to follow up).

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MPCA Odor Investigation
Sioux City Interview

Date: April 28, 2003
Name: Aaron Kraft
Organization: Sioux City
Title: Assistant Environmental Services Director
Phone: (712) 279-6957
e-mail: Akraft@sioux-city.org

- Ten years ago, Sioux City worked with various citizen interest groups, known as the Citizen Odor Committee to come up with protocol for how to address nuisance odor issues in the city. They established an Odor Emissions Control Program (as attached).

- Aaron indicated that the Citizen Odor Committee is no longer in existence.

- There are many potential nuisance odor emitting industries in Sioux City, including ag-related industrial processing such as meat-packing, rendering, Knox Gelatin and others.

- The city has established an odor hotline, which is routed to the Environmental Services department. Every complaint is followed up on, with notification given to the offending source.

- In Aaron's opinion, the City has been very successful in working with the industries in Sioux City to abate the problem of nuisance odors by instituting BACTs.

- During the summer, the city will average 3-4 complaints per week, with about 3-4 complaints per month in the winter.

MPCA Odor Investigation
South Carolina Interview

Date: May 5, 2003
Name: Marion Sadler
Organization: Department of Health and Environmental Control
Title: Director of Industrial Agricultural and Stormwater Permitting
Phone: (803) 898-4117
e-mail: sadler.mf@dhec.sc.gov

- Marion indicated that, in South Carolina, odor is dealt with by whatever agency is responsible for permitting. The state does not have a rule or regulation in place specifically dealing with nuisance odors.

- Marion's area of expertise is in agricultural operations. The State of South Carolina does have comprehensive standards for the permitting of agricultural animal facilities. These standards are attached.

- All new animal facilities (after 1998, when the regulation were enacted) are required to have an odor abatement plan/waste management plan in place before they are permitted to open.

- When developing the standards for the permitting of agricultural animal facilities, the state DHEC worked very closely with the NRCS (Natural Resources Conservation Service) with the South Carolina Coastal Management District, the Sierra Club, major banks involved in agricultural/farm lending and with Poultry, Dairy and Pork producers. This collaborative model paid off in having some acceptance of the regulations.

- The NRCS acts as a consultant to the farmer, preparing the Waste Management Plan/Odor Abatement Plan and generally facilitating the permitting process. (NOTE: I am not certain whether they charge anything for these services, or whether it's a sliding scale fee based on farmer's ability to pay).

- The motivating force behind developing the regulations was a fear in South Carolina of turning into North Carolina, which has 10,000,000 hogs in comparison to South Carolina's 300,000. But while wanting to avoid concentrations of large industrial farms, they did now want to be too prohibitive to agriculture.

- Routine inspections of facilities are part of the agricultural animal facility permitting process.

- All agricultural animal facility permits are issued centrally, with inspectors based in the DHECs district offices.

- When complaints lodged about animal facilities are received, the policy is to follow-up on them within 48 hours. Validation of nuisance odor complaints is done in the field with inspectors detecting the presence of odors (no measurement technology used other than their nose). An inspector can check out the facility, determine whether there may be some temporary occurrence, or if it may be an ongoing lapse in best agricultural management practices.

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MPCA Odor Investigation
South Dakota Interview

Date: April 25, 2003
Name: Jeanie Votava
Organization: Department of Environment and Natural Resources
Title: Natural Resources Engineer
Phone: (605) 773-3351

- Jeanie indicated that the state of South Dakota is not involved in nuisance odor regulation or enforcement.

- South Dakota does have a state nuisance law, so that nuisance odors may be handled through that process, although Jeanie was not aware of how that process may be administered.

- Jeanie also stated that South Dakota has a state law prohibiting the state from adopting any environmental standards that are more stringent than Federal Standards.

- Since Jeanie did not believe that anybody at the state level would have much information regarding nuisance odor issues, she referred me to Minnehaha County, stating that they had one of the more advanced means of addressing nuisance odor complaints.

MPCA Odor Investigation
Texas Commission on Environmental Quality Interview

Date: May 9, 2003
Name: Evette
Organization: TCEQ
Title: Air Complaint Call Line and Investigator
Phone: (512) 239-7035

Odor Regulation

- The jurisdiction has had an odor regulation since the inception of its air quality rules under Air Quality General Rules Part 30.TAC 101.4 (1976). This rule is basically a nuisance rule prohibiting any odor from any source. This is applied through what the agency calls a "Nuisance Protocol."
- The odor regulation is reactive and proactive. The reactive portion is handled with the Nuisance Protocol. New source processes are reviewed by field investigators and made publicly (sometime through public hearing) known for citizen comment prior to construction and operating.
- The regulation is evenly applied to all populations - no specific population is protected more than others from odors.
- The state feels the regulation's application through the Nuisance Protocol is successful because it breaks down the common law application of nuisance with tools such as a ranking system for prioritizing the investigation of odors and a ranking system for identifying criteria to judge the severity of the odor. Also, there is an established process from the initial identification of the odor to enforcement. The system overall takes a fairly subjective common law application and makes it more objective.
- The entire TCEQ agency handles odor complaint investigation. Depending on the source (water, air, waste) of the odor complaint, calls are processed by the appropriate department of the TCEQ and investigated. There is not limited or well defined staff.

Process for Handling Odor Complaints

- Citizens call the TCEQ complaint line to report an odor.
- Complaints are prioritized by impact on complaintee (health issues, etc) and then investigated in the field by TCEQ staff.
- There are complaint logs for the program that either the agency keeps or they request neighbors keep in areas with severe odor problems.
- On e odor complaint can initiate action if the impact warrants.
- The TCEQ has very few complaints a year but this can vary depending on source problems. For instance, one year there were many issues with landfills and rendering plants. From the agency's viewpoint, once correction begins, the source types all consider correction opportunities.
- There are no odor sources that really have a lot of complaints. Again, a few years ago landfills and rendering plants were having problems.

- There is no setback requirement but distance from receptor to facility is considered during site review.
- Facilities are required to use BACT but this is part of initial permitting and operating permits. As well special odor management plans may be required as part of permitting (for instance for wastewater facilities).

Odor Identification

- Odors are measured by human perception using a criteria table provided by the agency including identification of such elements as the impact to investigator's health upon perceiving. Table available on TCEQ webpage.
- Compliance criteria are handled as part of permits for construction and operation.
- No specific compounds are regulated under this program.
- Odor investigators do field investigations often enough that they are familiar with the odor criteria chart. There is no special training otherwise.

Enforcement

- TCEQ is responsible for enforcement of Nuisance Protocol.
- Complaints from citizens as well as field observation by a TCEQ investigator, independent from a complaint. can initiate further investigation of an odor.
- A flow chart for the types of odors (based on the criteria ranking) outlines the process for correction of an odor and enforcement (available on TCEQ webpage).
- There are no exclusions from the Nuisance Protocol. As previously identified, all odors are prohibited in TX.
- Facilities that have had problems may be monitored until correction by the TCEQ otherwise record logs are provided to neighbors to track continued problems.

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MPCA Odor Investigation
Vermont Interview

Date: May 7, 2003
Name: Phil Etter
Organization: Department of Environmental Conservation
Title: Environmental Analyst
Phone: (802) 241-3847

- Vermont does enforce a rule prohibiting nuisance odors. Agricultural uses are exempted from nuisance laws.

- Although, in extraordinary circumstances, Vermont has done odor surveys (hiring a person to survey odors and categorize them based on intensity and duration using their judgment based on odors in the ambient air) and convened odor panels to sample air using a butanol scale, they most typically simply use inspectors in the field with no measurement tools other than the nose to verify odor complaints.

- Part of their finding of nuisance is to verify whether a considerable number of people will be impacted. If this is not the case, then Vermont is reluctant to deem it a "public" nuisance.

- Their policy is to respond to every complaint lodged. An inspector will be sent out in the field to sniff the ambient air. If the inspector detects an odor and can verify the source, the next step is to work with the offending source to determine the reason for the occurrence. If appropriate, then the installation of control devices, or changing practices may be recommended.

- Penalties are only rarely levied.

- Phil said that, on average, Vermont receives about 15 to 20 nuisance odor complaints per year. Staff needed to enforce this rule is about 1 FTE.

- Operating permits will try to account for the potential to emit odors. If the permittee is an obvious odor source, then various control measures may be required to be in place prior to issuance of an operating permit.

- Typical source types for odor complaints in Vermont include coffee roasters, landfills, and agricultural uses (although these sources are exempt from the rule). Since Vermont is so rural and not densely populated, the scope of odor issue is not very broad.

MPCA Odor Investigation
Wisconsin Interview

Date: May 16, 2003
Name: Colin Duffy
Organization: Department of Natural Resources
Title: Compliance Enforcement Team Leader
Phone: (608) 266-9767
e-mail: colin.duffy@dnr.state.wi.us

- Wisconsin does enforce odor emissions in a regulation covering "Malodorous Emissions and Open Burning."

- The Wisconsin DNR has 5 regions throughout the state. Each region has latitude in determining how they will respond to complaints.

- Inspectors following up on odor complaints don't use any measurement technology other than their nose and their judgment of the ambient air.

- Colin stated that Wisconsin received less than 100 complaints per year, and that the most common source type for complaints is open burning.

- During the investigation, the inspector will talk to the facility, in an attempt to determine what may have caused the odor, if it was a temporary problem or one that was ongoing, and how to address the problem, if warranted.

- In extreme instance, Wisconsin has administered a random sample survey to persons living within the "odorshed" of a source. Colin said that he would send a copy of such a survey to SRF for review. Wisconsin regulations state that, if 60 percent of more of a random sample of persons exposed to an odor find it objectionable based on the nature, intensity and duration, then it is considered an "objectionable odor" for purposes of regulation.

- There are no penalties for being out of compliance with the Wisconsin regulations.

MPCA Odor Investigation
Wyoming Interview

Date: May 14, 2003
Name: Bob Gill
Organization: Department of Environmental Quality
Title: Compliance Program Manager
Phone: (307) 777-3774
e-mail: rgill@state.wy.us

- The majority of odor issues/complaints in Wyoming occurs in the southeastern portion of the state, and is attributed to CAFOs. Although, there are other industrial odors for which complaints are lodged, these are far fewer than for swine facilities.

- Wyoming does have emissions standards for hydrogen sulfide, in addition to other ambient air standards. Part of this regulation is ambient standards for odors.

- Most typically, all enforcement of odor standards is done on a complaint-based process.

- There is a general complaint phone # that complainants call. An inspector will then investigate and try to determine the source of the odor. Every complaint is followed up on. Some complainants are asked to, or volunteer to, keep a complaint log.

- Sources are notified if a complaint has been lodged against them.

- In substantiating an odor complaint, a Scentometer is used, set at a 7 to 1 dilution threshold. In Bob's opinion, the Scentometer was a useful tool in the complaint substantiation process.

- Bob said that no permitting processes currently account for odor emissions.

- For substantiated complaints, a violation notice is issued. Bob stated that currently the process to resolve these violations is not working well, and that the state is currently in litigation with the hog farms.

- Bob said that, for his region of Wyoming (SE region), about 500 complaints were received in the last 2 to 3 years for hog operations, with about a 12 lodged against cattle operations. Other complaint sources were negligible.

- Approximately 2 FTEs, and one assistant, deal with odor issues in the SE region.

APPENDIX C4

Summary Table of State and National Regulatory Findings

APPENDIX C4
SUMMARY TABLE OF STATE AND NATIONAL REGULATORY FINDINGS

State	Regulation	Authority	Complaint Verification	Determination Criteria	Notices of Violation	Penalties	Remedies	Permitting	Exclusions	Modeling	Staffing
Connecticut	Control of Odors	Department of Environmental Protection	-All complaints followed up on -Field observations by trained -No measurement technology or standards used	-strength -frequency -duration -characteristics	Issued when staff determines a nuisance exists	None	-Offending source notifies state within 30 days of its remediation steps -Compliance check	Air Quality?	-Mobile sources Residences with -6 or less dwelling units -Agricultural operations	Not used in permitting	12-13 FTEs
Oregon	Visible Emissions and Nuisance Requirements	Department of Environmental Quality (Small Business Assistance Program)	-All complaints followed up on -Field observations by trained -No measurement technology or standards used	-strength -frequency -duration -# of people impacted	Issued when staff determines a nuisance exists	Yes	Best Practices Agreement-implement abatement practices	Air Contaminant Discharge Permits	-Agricultural operations (handled by Oregon Department of Agriculture)	Not used in permitting	1-2 FTEs
Missouri	Restriction of Emission of Odors (geographic areas)	Department of Natural Resources	-All complaints followed up on -Scentometer 7:1 DT (non-ag) 5.4:1 DT (Class 1A CAFOs) 4:1 DT (St. Louis metro area)	-ambient odor criteria -annoyance criteria (St. Louis metro area)	Issued when staff determines a nuisance exists	Yes-monetary	Class 1A CAFOs—air monitoring quality assurance project plan & monitoring	Class 1A CAFOs—odor control plan Other sources—none required	-Agricultural operations	Not used in permitting	1 FTE per regional office
Idaho	Policy for Responding to Odor Complaints	Department of Environmental Quality (Regional Offices)	-Field observation -ASTM standard for butanol	-complaint criteria -intensity thresholds (level 4, butanol)	-If odor is substantiated, source is contacted -NOV can be issued when complaint is referred to State DEQ	Yes, through State DEQ enforcement process	Odor Management Plan	Odor Management Plans are required in order to receive an operating permit	Agricultural operations are handled by the Idaho Department of Agriculture	None	15% of 12 people's time
Rhode Island	Air Pollution Control Regulations No. 17 Odors	Division of Air Resources	-Complaint prioritization process -Field observation by trained staff -No measurement technology used or standards used	-annoyance criteria	-Source is notified if staff finds complaint to be valid	Yes	-state works with offending source to address problem -odor management plan	Air Quality Operating Permits	None identified in regulation	None	2.5 FTEs
North Carolina	Control and Prohibition of Odorous Emissions	Division of Air Quality	-All complaints followed up on -Staff trained in ASTM E54-99 determine if odor is objectionable	-intensity thresholds level 5	-Notified to implement best management plan -Notified to implement maximum feasible controls as a last resort	No	-state will work with source to develop a best management plan -If source does not comply, state can implement maximum feasible controls	None	Pulp mills, agricultural operations, mobile sources, wastewater treatment plants, restaurants, single-family homes, painting operations	None	??
North Carolina	Control and Prohibition of Odorous Emissions (animal operations)	Division of Air Quality	-All complaints followed up on -Staff trained in ASTM E54-99 determine if odor is objectionable	-intensity thresholds level 5	-Notified to implement best management plan	No	Best Management Plan	After 3 failures of the BMP, Air Quality permit is required	None	Required after 3 failures of BMP	??

APPENDIX C4
SUMMARY TABLE OF STATE AND NATIONAL REGULATORY FINDINGS

State	Regulation	Authority	Complaint Verification	Determination Criteria	Notices of Violation	Penalties	Remedies	Permitting	Exclusions	Modeling	Staffing
South Carolina		Department of Health and Environmental Control	-All complaints are followed up on within 48 horus -Field observations -No measurement technology or standards used	-complaint criteria				-Odor abatement plan is a permit requirement		None	
Vermont	Nuisance Law	Department of Environmental Conservation	-Field observations -No measurement technology -In the past surveys and panels were used	-complaint criteria -# of people impacted		Rarely used	State works with the offending source to remedy the odor problem	Agricultural operations		None	
Louisiana	This rule is not enforced	Department of Environmental Quality	-Odor panel	-intensity threshold level 6						None	
Massachusetts		Department of Environmental Protection	-All complaints are followed up on -Field observations -No measurement technology or standards used	-annoyance criteria			Offending source proposes a solution	Draft policy which requires sources to demonstrate that they will not exceed 5:1 DT	None	ICST modeling	
North Dakota			All complaints followed up on with an odor survey (inspector & scentometer)	-ambient odor criteria (7:1 DT) setbacks (outside city limits)						None	50-60 trained odor evaluators
Wyoming	Hydrogen Sulfide Regulation Ambient Air Standards	Department of Environmental Quality	All complaints followed up on (inspector & secntometer)	-ambient odor criteria 7:1 DT	Source is notified when a complaint is filed. If complaint is verified, notice of violation is issued			No		None	2 FTEs 1 assistant
South Dakota	-State does not regulate odor -State a law prohibiting them from adopting environmental standards, which are more stringent than Federal standards. -Odors could possibly be regulated under state nuisance law.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wisconsin	Malodorous Emissions and Open Burning	Department of Natural Resources	No measurement technology employed Random odorshed surveys	-complaint criteria	None	None	DNR will work with facility to determine the problem	None	None	None	DK

APPENDIX C4
SUMMARY TABLE OF STATE AND NATIONAL REGULATORY FINDINGS

Country	Regulation	Authority	Complaint Verification	Determination Criteria	Notices of Violation	Penalties	Remedies	Permitting	Exclusions	Modeling	Staffing
Australia (Victoria)	State Environment Protection Policy	Environment Protection Agency	-olfactometry samples taken from point sources -trained inspectors follow up on complaints	-dilution threshold criteria at source -ambient odor criteria (inspector in field)		Verification of a complaint can lead to prosecution		Yes-based on thresholds	Existing facilities	Yes	300 over the entire state
Western Australia	No regulation, only guidance for odor assessment	Department of Environmental Protection	-trained inspectors verify if odor is offensive -source sampling and dynamic olfactometry may be required	-annoyance criteria -dilution threshold	Environmental Field notice is sent to the offending source	Prosecution under Section 49 of the Environment Protection Act is possible, but rarely used	None addressed	Yes	Existing facilities	Yes	5 PTE odor complaints given low priority relative to other incidents.
Canada (Ontario)	Regulation 346	Ministry of the Environment	-all complaints followed up on -no measurement technology used	-contaminant thresholds -dilution threshold	Facility will be contacted even if inspector cannot detect odor. A facilitative process will be initiated to deal with the odor issue.	None mentioned	-Facilitative process -Extreme cases require source sampling using olfactometry	-mass balance -AP 2 -engineering assessment -source testing	Agricultural operations	-USEPA Screen III -Aeromod -ISC 3 10-min avg. -models based on 87 regulated contaminants	80 staff whose responsibilities include odor issues
Canada (City of Montreal, Quebec)	Law 90	City of Montreal	-all complaints followed up on -no measurement technology used in initial follow-up	-dilution threshold -emissions standards for VOCs, toxics, and other compounds	If inspector substantiates the complaint, source is notified	None mentioned	-permitting -source sampling using dynamic olfactometery	Yes	None	Yes	10 inspectors who deal with water and air issues

APPENDIX D

Technical Memorandum on Odor Measurement Technology

A Detailed Assessment of
The Science and Technology of Odor Measurement

Prepared By:
St. Croix Sensory, Inc.
P.O. Box 313
3549 Lake Elmo Ave. N.
Lake Elmo, MN 55042
1-800-879-9231
stcroix@fivesenses.com

30 June 2003

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A Detailed Assessment of
The Science and Technology of Odor Measurement

Prepared by: St. Croix Sensory, Inc.
30 June 2003

1.0 INTRODUCTION

Odors remain at the top of air pollution complaints to regulators and government bodies around the U.S. and internationally. Ambient air holds a mixture of chemicals from everyday activities of industrial and commercial enterprises.

A person's olfactory sense, the sense of smell, gives a person the ability to detect the presence of some chemicals in the ambient air. Not all chemicals are odorants, but when they are, a person may be able to detect their presence. Therefore, an odor perceived by a person's olfactory sense can be an early warning or may simply be a marker for the presence of air emissions from a facility. For whatever reason, it is a person's sense of smell that can lead to a complaint.

When facility odors affect air quality and cause citizen complaints, an investigation of those odors may require that specific odorants be measured and that odorous air be measured using standardized scientific methods. Point emission sources, area emission sources, and volume emission sources can be sampled and the samples sent to an odor laboratory for testing of odor parameters, such as odor concentration, odor intensity, odor persistence, and odor characterization. Odor can also be measured and quantified directly in the ambient air, at the property line and in the community, using standard field olfactometry practices, e.g. odor intensity referencing scales and field olfactometers.

Standardized measurement of odors from municipal, industrial and commercial facilities is typically required for the following purposes:

1. Monitoring for compliance assurance as part of permit requirements.
2. Determination of compliance for permit renewal.
3. Determination of baseline status for facility expansion planning.
4. Determination of specific odor sources during complaint investigation.
5. Monitoring operations for management performance evaluation.
6. Comparison of operating practices when evaluating operating alternatives.
7. Monitoring specific events or episodes for defensible, credible evidence.
8. Comparison of odor mitigation measures during tests and trials.
9. Determination of an odor control system's performance for warranty testing.
10. Verification of estimated odor impacts from dispersion modeling.

The stakeholders for standardized odor measurement are: regulators, industries, citizens, environmental control equipment manufacturers, consultants, and researchers.

Presently, international standards are in place, which dictate the scientific methods and practices of odor measurement. These international standard methods for quantifying odor are: objective, quantitative, dependable, and reproducible.

From ASTM International:

- ASTM E679-91: *Standard Practice for Determination of Odor and Taste Threshold by a Forced-Choice Ascending Concentration Series Method of Limits*

- ASTM E544-99: *Standard Practice for Referencing Suprathreshold Odor intensity*

From the Comité Européen de Normalisation (CEN)

- EN13725:2003: *Air Quality – Determination of Odour Concentration by Dynamic Olfactometry*

The following odor limits may be incorporated into odor regulations or into facility permits as compliance determining criteria when the standard odor testing methods are applied.

Ambient Odor Limits:

- Odor concentration as D/T or
- Odor intensity as part per million butanol.

Source Odor Limits:

- Odor concentration as odor units per cubic meter or
- Odor rates as odor units per second.

The intent of this report is to presents the basics of measuring odorous air. A brief explanation of "nasal anatomy" is presented in Section 2. In Section 3 odor parameters are defined and the basics of laboratory olfactometry are presented, including a description of odor panels. Section 3.7 presents the applicability of laboratory olfactometry including costs. Section 4 describes the history and present day practices of field olfactometry, including applicability. Section 5 presents how specific chemical odorants can be tested and the costs associated with their analysis. Section 6 introduces the subject of community odor studies and outlines several odor study methods. This report has seven appendices that include: odor terminology; methods for sampling odorous air; example odor analysis; statistics of odor data; details of odor intensity and persistency; examples of odor characterization; and a case study involving a community odor survey.

2.0 OLFACTORY ANATOMY

Of the five senses, the sense of smell is the most complex and unique in structure and organization. While human olfaction supplies 80% of flavor sensations during eating, the olfactory system plays a major role as a defense mechanism by creating a natural aversion response to malodors and irritants. Human olfaction is a protective sense, protecting from tainted food and matter, such as rotting vegetables, putrefying meat, and fecal matter. This is accomplished with two main nerves. The olfactory nerve (first cranial nerve) processes the perception of chemical odorants. The trigeminal nerve (fifth cranial nerve) processes the irritation or pungency of chemicals, which may or may not be odorants.

During normal nose breathing only 10% of inhaled air passes up and under the olfactory receptors in the top, back of the nasal cavity. When a sniffing action is produced, either an involuntary sniff reflex or a voluntary sniff, more than 20% of inhaled air is carried to the area near the olfactory receptors due to turbulent action in front of the turbinates. These receptors, in both nasal cavities, are ten to twenty-five million olfactory cells making up the olfactory epithelium. Cilia on the surface of this epithelium have a receptor contact surface area of approximately five square centimeters due to the presence of many microvilli on their surface. Supporting cells surrounding these cilia secrete mucus, which acts as a trap for chemical odorants.

Chemical odorants pass by the olfactory epithelium and are dissolved into the mucus at a rate dependent on their water solubility and other mass transfer factors. The more water-soluble the chemical, the more easily it is dissolved into the mucus layer. Sites on the olfactory cells, assisted by specialized proteins, receive the chemical odorant. The response created by the reception of a chemical odorant depends on the mass concentration, i.e. the number of odorant molecules. Each reception creates an electrical response of the olfactory nerves. A summation of these electrical signals leads to an action potential. If this action potential has high enough amplitude (i.e. threshold potential), then the signal is propagated along the nerve, through the ethmoidal bone between the nasal cavity and the brain compartment where it synapses with the olfactory bulb.

All olfactory signals meet in the olfactory bulb where the information is distributed to two different parts of the brain. One major pathway of information is to the limbic system, which processes emotion and memory response of the body. This area also influences the signals of the hypothalamus and the pituitary gland, the two main hormone control centers of the human body. The second major information pathway is to the frontal cortex. This is where conscious sensations take place as information is processed with other sensations and is compared with cumulative life experiences for the individual to possibly recognize the odor and make some decision about the experience.

Frequently the terms **odor** and **odorant** are used interchangeably and, often incorrectly. There is a distinct difference between these two terms, which is fundamental to the

discussion of odor and odor nuisance. See Figure 2.1, Chemical Odorant vs. Odor Perception, which illustrates how an odorant creates the odor perception. The term **odor** refers to the perception experienced when one or more chemical substances in the air come in contact with the various human sensory systems (odor is a human response). The term **odorant** refers to any chemical in the air that is part of the perception of odor by a human (odorant is a chemical). Odor perception may occur when one odorant (chemical substance) is present or when many odorants (chemical substances) are present.

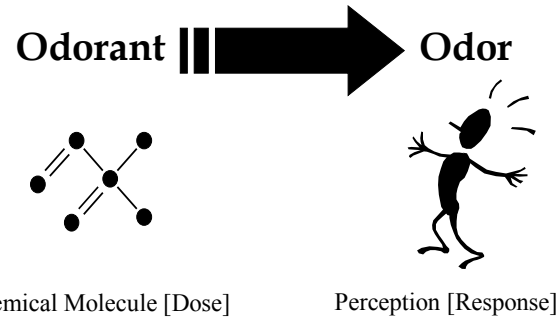

Figure 2.1 Chemical Odorant versus Odor Perception

An analogy that helps to understand what is happening with odor perception in the olfactory system is to envision the receptor nerves like keys on a piano. As a single chemical odorant hits the piano keyboard (the olfactory epithelium) a tone is played (odor perception). When multiple chemical odorants are present and hit the piano keyboard the result is a chord (odor perception). For example, if keys 1, 3, and 7 are hit by three different odorants, the brain may perceive earthy. Likewise, if keys 4, 6, and 12 are hit by three different odorants, the brain may perceive sewer. The greater the number of odorant molecules present (higher concentrations), the louder the chord is played. The loudness of the chord is analogous to the intensity of the odor perception.

3.0 LABORATORY OLFACTOMETRY

3.1 Overview of Odor Parameters

Odor is measurable using scientific methods. Odor testing has evolved over time with changes in terminology, methods, and instrumentation. Odor terminology is linked to standard methods and the instrumentation used in these standard methods. A clear understanding of odor terminology is needed in order to discuss the uses of odor measurements. See Appendix I for a detailed listing of odor terminology.

Four measurable, objective parameters of perceived odor are:

1. **Odor Concentration** – measured as dilution ratios and reported as detection threshold or recognition thresholds or as dilution-to-threshold (D/T) and sometimes assigned the pseudo-dimension of odor units per cubic meter.
2. **Odor Intensity** – reported as equivalent parts per million butanol, using a referencing scale of discrete butanol concentrations.
3. **Odor Persistence** – reported as the dose-response function, a relationship of odor concentration and odor intensity.
4. **Odor Character Descriptors** - what the odor smells like using categorical scales and real exemplars (e.g. fruity → citrus → lemon: from a real lemon).

These odor parameters are objective because they are measured using techniques or referencing scales dealing with facts without distortion by personal feelings or prejudices.

Additional measurable, but subjective, parameters of perceived odor are:

1. **Hedonic Tone** - pleasantness vs. unpleasantness.
2. **Annoyance** - interference with comfortable enjoyment of life and property.
3. **Objectionable** - causes a person to avoid or causes physiological effects.
4. **Strength** - word scales like "faint to strong".

These odor parameters are subjective because individuals relying on their interpretation of word scales and relying on their personal feelings, beliefs, memories, experiences, and prejudices to report them. Written guidelines for subjective odor parameter scales assist individuals (citizens and air pollution inspectors) in reporting observed odor, however, the nature of these parameters remains subjective.

3.2 Odor Panels

The origins of sensory evaluation and nasal organoleptic testing are in the trade industry. Products such as perfumes, coffee, tea, wine, liquors, meats and fish were sniffed or tasted to determine the quality of the product. Eventually, individuals became known as expert judges and were used to rate or grade products.

In the 1940's and 1950's great advancements took place in sensory testing by researchers performing sensory evaluation for developers of U.S. government war rations. Since that time, panels of trained sensory assessors have been the preferred method of evaluating sensory characteristics of products in a laboratory setting.

In the field of environmental engineering, odorous air samples can be collected from emission sources. Appendix II presents a case study of odorous air sample collection methods. Odor evaluation of odorous air samples is conducted under controlled laboratory conditions following standard industry practices using trained panelists known as assessors.

An odor laboratory is an odor-free, non-stimulating space. Each odor assessor, when working on odor evaluations, focuses on the task of observing the presented odor sample. Noise and distracting activities in the evaluation area can break the focus of the odor assessor. Odor panel sessions are organized and scheduled in order to maintain panel lengths not to exceed a period of 3-hours. Limiting panel length minimizes panelist fatigue.

Attention to the assessors' comfort and working environment nurtures their commitment and dedication to quality performance. The waiting area of the assessors is separated from the testing area. The assessors are provided water for drinking during the waiting time between sample testing. The assessors are not permitted to eat, chew gum, or drink beverages during a panel session. A comfortable and relaxing waiting area enhances a low stress environment for the assessors. A variety of activities are available to the assessors to help occupy their time, i.e. reading, puzzles, etc.

Odor assessors are recruited from the community at large. From a pool of on call assessors, five to twelve assessors are selected for a scheduled odor panel. Odor panels consist of assessors that are selected and trained following the "Guidelines for Selection and Training of Sensory Panel Members" (ASTM Special Technical Publication 758) and EN13725 (ASTM, 1981; CEN, 2003). A person who smokes, who uses smokeless tobacco, who may be or is pregnant, or who has chronic allergies or asthma is excluded as a candidate for the odor panel.

Standing **odor panel rules** are part of the assessor's agreement to participate in odor testing. Assessors:

1. Must be free of colds or physical conditions that may affect the sense of smell;
2. Must not chew gum or eat at least 30 minutes prior to the odor panel;
3. Must refrain from eating spicy foods prior to the odor panel;
4. Must not wear perfume, cologne, or after shave the day of the odor panel;
5. Must wear unscented deodorant the day of the odor panel;
6. Must avoid other fragrance cosmetics, soaps, etc. the day of the odor panel;
7. Must have their hands clean and free of odors the day of the odor panel;
8. Must have their clothes odor free the day of the odor panel;
9. Must keep the odor panel work confidential; and
10. Must not bias the other panelists with comments about the observed samples.

Each odor assessor is tested to determine their individual olfactory sensitivity using standard odorants, e.g. n-butanol and hydrogen sulfide. The assessor receives training that consists of olfactory awareness, sniffing techniques, standardized descriptors, and olfactometry responses.

With proper training of odor panelists, the communication between the panelists and the panel leader is clear, concise, and efficient. A well-organized efficiently conducted odor panel ensures quality odor evaluation work.

3.3 Determination of Odor Concentration in the Laboratory

The most common odor parameter determined by odor testing is odor concentration. Odor concentration is determined using an instrument called an olfactometer and is expressed as a dilution factor (dilution ratio). Odor concentration is reported as the Detection Threshold (DT) and Recognition Threshold (RT). Several advances in technology and standard practice have changed the science of olfactometry over the last 50 years and the new millennium began with the publication of a new internationally accepted standard for determination of odor concentration.

In the 1950's, sensory evaluation in the laboratory came into practice to quantify the strength of odorous air emissions. Laboratory olfactometry involves diluting the odorous air sample at varying concentrations then presenting the diluted odor to human assessors to determine the threshold of the odorous emission. The laboratory dilution process simulates the dilution of the odor in the ambient air. Figure 3.1, "Dilution of Odor in the Ambient Air", illustrates how the wind dilutes odorous air emissions.

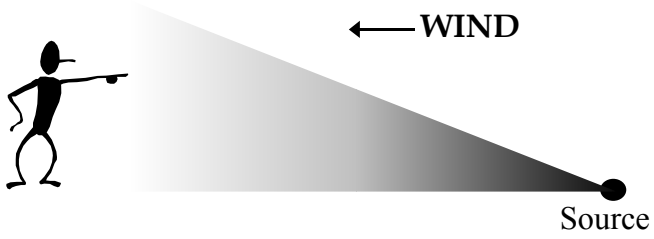

Figure 3.1 Dilution of Odor in the Ambient Air.

3.3.1 ASTM D1391

In 1957, the ASTM International E-18 Sensory Evaluation Committee approved and published a method for measuring environmental odors in a laboratory setting, which was originally developed by the Los Angeles Air Pollution Control District (Mills et. al., 1963). The ASTM standard D1391 was called, "Measurement of Odor in Atmospheres" (ASTM, 1978). The D1391 standard came to be known as the syringe static dilution method because it used 100-mL glass syringes to dilute the odorous air with odor free air. The practice involved presenting assessors syringes of diluted odorous air samples with syringes of odor-free air. The assessors would then report which syringe contained the odor sample (Benforado, 1969).

The cumbersome nature of static dilution methods, like ASTM D1391, led to the development of dynamic olfactometers, which were designed to perform the dilutions of the odorous air automatically and continuously.

3.3.2 ASTM E679

In 1979, ASTM International published E679-79, "Standard Practice for Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series Method of Limits." This method was based on the use of dynamic olfactometry to automatically perform the dilutions of the odorous air and then present the dilution mixture to the human assessors. In March 1985, the ASTM E18 Committee officially withdrew the "Syringe Method", D1391, from publication. The dynamic dilution method, E679, was subsequently revised in late 1991 and later re-approved in 1997.

The ASTM E679 procedure is based on a presentation method called 3-alternative forced-choice (3-AFC) or triangular forced-choice (TFC). Each assessor performs the odor evaluation task by sniffing the diluted odor from an olfactometer. The assessor sniffs three sample presentations; one contains the diluted odor while the other two are blanks (odor-free air). Figure 3.2 shows one assessor (left) sniffing from the olfactometer nasal mask while the test administrator (right) operates the olfactometer. The assessor is required, or forced, to choose one of the three presentations. The assessor acknowledges their choice as a guess, a detection or recognition. As defined by E679 a response of detection is determining the selection is different from the other two, and a recognition response is that the sample smells like something.

Figure 3.2 Assessor (left) sniffing at a dynamic dilution olfactometer.

The assessor is then presented with the next dilution level. The assessor is again presented with three sample choices, one of which is the diluted odor sample. However, this next dilution level presents the odor at a higher concentration (e.g. two times higher). This is one-half the dilution ratio. The first dilution level presented to the assessors is below the odor thresholds (sub-threshold). The assessor proceeds to higher levels of sample presentation following these methods. The statistical approach of increasing the concentration is called "ascending concentration series."

The convention of calculating dilution factors for olfactometry is based on the ratio of Total Volumetric Flow divided by Odorous Sample Flow (Turk, 1973; Dravnieks et. al., 1979, 1980, 1986; ASTM, 1978; ASTM, 1991; AWMA, 1995, CEN, 2003):

$$Dilution\_Factor = \frac{V_d + V_o}{V_o} = Z$$

Where V_d is the volumetric flow rate of odor-free, dilution air and V_o is the volumetric flow rate of the odorous air sample. The dilution factor, 'Z', is used in modest honor of H. Zwaardemaker, a Dutch scientist and early investigator in olfactometry.

Alternative terminology in use includes: Dilution-to-Threshold Ratio (D/T), Odor Unit (OU), and Effective Dose at 50% of the population (ED50) (ASTM, 1991).

A large dilution ratio (e.g. 65,000) represents a high dilution of the odor sample. A high dilution of odor is similar to a person standing at a great distance from the odorous emissions. A small dilution ratio (e.g. 8) represents a small dilution of the odor sample. A small dilution of the odor is similar to a person standing close to the odorous emissions.

The odor concentration results from olfactometry testing are expressed as a detection or recognition threshold. The detection threshold (DT) is an estimate of the number of dilutions needed to make the actual odor emission non-detectable. The recognition threshold (RT) represents the number of dilutions needed to make the odor sample faintly recognizable.

A detection threshold for an odorous air sample is larger than its recognition threshold value, because more dilutions with odor-free air are needed to make the odor non-detectable compared to making the odor faintly recognizable. A large value of odor concentration (DT or RT) represents a strong odor. A small value for odor concentration represents a weak odor.

The odor panel used for the ASTM E679 test procedure consists of 6-12 trained and experienced human assessors. The assessors are selected from the general population as assessors with no specific hypersensitivity or Anosmia (lack of sensitivity) to odors. The assessors are selected and trained following standard procedures (ASTM, 1981). The

odor concentration is a number derived from the panel of assessors' responses to the laboratory dilution of odorous air samples. Appendix III provides a detailed example of the determination of the odor concentration, detection and recognition thresholds, of one odorous air sample.

3.3.3 EN13725

During the 1980's, countries in Europe began developing standards of olfactometry. Some of these standards developed and published include:

France	AFNOR X-43-101 (drafted in 1981 & revised in 1986)
Germany	VDI 3881, Parts 1-4 (drafted in 1980 & revised in 1989)
Netherlands	NVN 2820 (drafted in 1987 & issued in 1995)

Various inter-laboratory studies as well as collaborative projects involving multiple odor testing laboratories in the '80's showed that laboratory results still differed significantly even with these standard practices (Heeres et. al., 1990).

The development of a draft odor testing standard in the Netherlands led to an International Laboratory Comparison study organized in 1989 (Hermans, 1989). N-butanol and hydrogen sulfide were used as standard odorants for the study. Through 1990 to 1992, the results of this Dutch Inter-Laboratory study led to the development of strict assessor performance criteria. During the first year, the inter-laboratory repeatability was in the range of factors from 3 to 20. An analysis of the data from the first year showed the majority of variability was between assessors. Individual assessors were repeatable within a factor of 3 to 5.

Van Harresveld presents a clear conclusion resulting from this study in his 1999 publication in the Journal of the Air & Waste Management Association, "A Review of 20 Years of Standardization of Odor Concentration Measurement by Dynamic Olfactometry in Europe." He states: "The notion that the panel should be representative of the general population was explicitly abandoned…" The researchers found that the only way to meet the agreed upon repeatability criteria was to control the instrument sensor, the human assessors, by selecting assessors who were all similar in sensitivity (van Harresveld, 1999).

Standards were then set for assessor performance to a standard odorant, n-butanol. Only assessors who met predetermined repeatability and accuracy criteria were allowed to continue as assessors (average n-butanol odor threshold of 20-80ppb and log standard deviation of <2.3). Over the next two years, these new criteria were implemented within each of the laboratories involved in the study.

In 1993, a final round of testing yielded an inter-laboratory repeatability of a factor of 2 to 3. The Dutch inter-laboratory study from 1989 to 1993 showed a convergence towards

the agreed upon n-butanol reference threshold through the improved repeatability of results. The results in March 1993 showed the benefit of all laboratories implementing assessor selection criteria (Klarenbeek, 1995).

The work of this inter-laboratory study led to the final Dutch standard released in 1995 and set the foundation for the development of a new European odor testing standard.

A working group formed within the Comité Européen de Normalisation (CEN), Technical Committee 264 – "Air Quality", to develop a unified European olfactometry standard. This working group saw a need to help the industry and regulators develop a consistent basis for monitoring and testing odors, and, thus help determine the potential for odor nuisance. This was to be accomplished by developing a method that:

1. Improved consistency within each laboratory (repeatability);
2. Achieved comparable results among laboratories (reproducibility); and
3. Connected the results to a traceable reference material, e.g. n-butanol (accuracy)

In order to achieve these goals, the committee focused on the following issues:

1. Sampling procedures,
2. Sample containers,
3. Olfactometer construction and operation,
4. The olfactometer and assessor interface,
5. The odor testing room,
6. Methods of data processing, and
7. Assessor selection, training, and performance.

The first complete draft of the European olfactometry standard was released in 1995. Then in the spring and summer of 1996, nineteen laboratories from five countries participated in an Inter-Laboratory Comparison of Olfactometry ("ICO") study. The purpose of the study was to validate the requirements, methods, and procedures outlined in the draft standard. The conclusions of this study were:

1. All quality requirements and performance criteria were attainable for all testing methods studied (Forced-Choice and Yes/No); and

2. Those labs following the standard for the longest period of time performed the best with regards to accuracy and repeatability (van Harreveld, 1999).

The CEN olfactometry standard was released to the public at the end of 1999 through the standard organizations of each participating country. The standard was released as Proposed CEN standard #13725 (prEN13725) "Air Quality – Determination of Odour Concentration by Dynamic Olfactometry" (CEN, 1999). A public comment period closed at the end of January 2000. Comments were submitted to each country's standardization body separately. These comments were reviewed in early 2000. The

working group met in 2000 to review all comments and issue a final revision of the standard. The final revision was sent to the CEN organization in 2001 for final translation and official voting. The standard was approved and published in 2003 (CEN, 2003).

The approval of this final version of the CEN standard, EN13725, obligates all countries of the European Union to adopt the standard and withdraw any conflicting or redundant national standards. These countries include: Austria, Belgium, Denmark, Finland, France, Greece, Germany, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

The final standard was published in three official languages: English, French, and German. The standards are distributed through the individual country standardization organizations. For example, an English language copy can be obtained from the British Standards Institute (BSI), www.bsi.org.uk, under the designation "BS EN 13725:2003."

3.3.4 International Standardization

The new European standard has been adopted by Standards Australia and Standards New Zealand as AS/NZS 4323.3:2001 (AS, 2001). The standard has also been referenced by national organizations in Singapore, Thailand, and several other S.E. Asian countries. Furthermore, government agencies and universities throughout North America are following or are working towards adoption of the EN13725 standard. Examples of the government agencies include:

1. Agriculture Canada
2. City of Los Angeles, California
3. Los Angeles County, California
4. Metropolitan Council in St. Paul, Minnesota

Examples of the universities include:

1. Duke University
2. Iowa State University
3. Purdue University
4. University of Alberta
5. University of Illinois
6. University of Manitoba
7. University of Minnesota
8. West Texas A&M University

Therefore, EN13725 has become the de facto international standard for odor testing.

In 2000, an inter-laboratory comparison study was conducted involving 28 laboratories from four countries. This study involved each laboratory testing four standard odorants: n-butanol, hydrogen sulfide, tetrahydrothiopen, and a coffee odor mixture. The 28

laboratories were grouped into three categories based on their level of adherence to the draft standard, prEN13725:

Class 1: *Compliant*.	The laboratory fulfills all the quality criteria of prEN13725.
Class 2: *Essential Compliant.*	The lab observes the most important quality criteria of prEN13725.
Class 3: *Non-compliant.*	The lab does not adhere to the requirements of prEN13725.

The results of this study were reported at the 2001 International Water Association (IWA) First International Odour Conference (Mannebeck, 2001). This study confirmed that laboratories working in compliance with the requirements of prEN13725 achieved a significantly better repeatability than the labs that were not compliant. The results produced by these laboratories were also closer to accepted thresholds for the reference compounds.

In 1995, the Air & Waste Management Association (A&WMA) EE-6 Odor Committee formed a subcommittee on the "Standardization of Odor Sampling and Measurement." The EE-6 subcommittee developed "Guidelines for Odor Sampling and Measurement by Dynamic Dilution Olfactometry" and submitted a final draft, dated 23 August 2002, for review by the ASTM International E18 Sensory Committee.

In 2003, the E18 Sensory Committee is conducting a comprehensive review of ASTM E679, the elements of the A&WMA guidelines, and the EN13725 standard. Furthermore, researchers from several university agricultural engineering departments have formed a committee within the American Society of Agricultural Engineers (ASAE) to develop a set of agricultural odor sampling and measurement standards based on EN13725. The basic elements of this new standard are being developed as part of a large study, called "Ariel Pollutant Emissions from Confined Animal Buildings," investigating air quality related to feedlot operations currently involving five university odor laboratories in the U.S. (Iowa State University, Purdue University, University of Illinois, University of Minnesota, and West Texas A&M University).

Ultimately, it is critical to understand that if a laboratory follows the EN13725 test method using a 3-Alternative (triangular) Forced-Choice presentation method, the laboratory will be meeting all requirements of ASTM E679 and the A&WMA EE-6 Odor Committee Guidelines. The additional requirements of EN13725 will improve the repeatability, reproducibility, dependability, and accuracy of all odor analyses performed by the laboratory.

3.4 Odor Intensity

Perceived odor intensity is the relative strength of the odor above the recognition threshold (suprathreshold). Odor intensity is measured using several methods including: descriptive word category scales, magnitude estimation, and referencing scales.

Descriptive word category scales have the assessor rate the odor on a scale. One such scale used is a 5-point scale where zero is "no odor" and the other five points correspond to "barely perceptible," "slight," "moderate," "strong," and "very strong." The shortcomings of this approach are that the five points on the scale do not represent a linear increase in perception and that each assessor may interpret the scale differently, regardless of the assessor's training.

Magnitude estimation is a procedure where the intensity of one odor is compared to another odor. For example, the assessor would be presented odor sample A. The assessor would give the intensity of this odor an arbitrary value such as "50." The assessor would then be presented with sample B, and they would provide a rating based on sample A. Therefore, if sample B were perceived as half as intense as sample A, the assessor would give sample B an intensity of "25." This method is very difficult to compare across many odors. It is best suited for comparing similar odors.

ASTM E544-99, "Standard Practice for Referencing Suprathreshold Odor Intensity," presents two methods for referencing the intensity of ambient odors to a standard scale: Procedure A – Dynamic-Scale Method and Procedure B – Static-Scale Method. The Dynamic-Scale Method utilizes an olfactometer device with a continuous flow of a standard odorant (n-butanol) for presentation to an assessor. The assessor compares the observed intensity of an odorous air sample to a specific concentration level of the standard odorant from the olfactometer device. The Static-Scale Method utilizes a set of bottles with fixed dilutions of a standard odorant in a water solution. Field investigators commonly use the Static-Scale Method and it has also been incorporated as a standard practice by odor laboratories, because of its low cost of set-up compared to an olfactometer device (Turk, 1980).

The butanol referencing method of quantifying odor intensity is the most commonly used method in evaluating environmental odors. Butanol concentrations are a referencing scale for purposes of documentation and communication in a reproducible format. For this method, the odor intensity result is expressed in parts per million (PPM) of n-butanol. A larger value of butanol means a stronger odor. A small value of butanol means a weaker odor.

Another important aspect of the butanol intensity referencing scale is the variety of available scales. Figure 3.3, Example Odor Intensity Referencing Scales (OIRS), presents four common scales. The specific olfactometer device determines the dilution levels of the Dynamic-Scale Method used by laboratories and field investigators. The 8-point OIRS is the common dynamic scale used by odor laboratories. Further, the dilution levels of the Static-Scale Method used by laboratories and field investigators is

determined from interpretation of the ASTM Procedure B, which accepts numerous scale choices. The starting point of the scale and the geometric progression of the concentration series are selected by the laboratory or field investigator. Common scales used include starting points of butanol concentration in air as low as 10-ppm to as high as 25-ppm. Many scales use a geometric progression of 2 (i.e. each dilution level twice concentration of the previous); however, some scales use a geometric progression of 1.5 or 3. All laboratories and investigators presenting the odor intensity data should reference a butanol concentration in air (PPM butanol) to allow comparison of results from different data sources.

12 Point Scale	8 & 10 Point Scales	5 Point Scale
1 < 10 >	1 < 12 >	
2 < 20 >	2 < 24 >	1 < 25 >
3 < 40 >	3 < 48 >	
4 < 80 >	4 < 96 >	2 < 75 >
5 < 160 >	5 < 194 >	
6 < 320 >	6 < 388 >	3 < 225>
7 < 640 >	7 < 775 >	4 < 675 >
8 < 1280 >	8 < 1550 >	
9 < 2560 >	9 < 3100 >	5 < 2025 >
10 < 5120 >	10 < 6200 >	
11 < 10240 >		
12 < 20480 >		

KEY: < XXX > is Parts Per Million n-Butanol Equivalent Odor Intensity

Figure 3.3 Example Odor Intensity Referencing Scales (OIRS)

3.5 Odor Persistency

Odor is a psychophysical phenomenon. Psychophysics involves the response of an organism to changes in the environment perceived by the five senses (Stevens, 1960). Examples of psychophysical phenomenon include how the human body perceives sound loudness, lighting brightness, or odor intensity.

In the 19th Century, E.H. Weber proposed that the amount of increase in a physical stimulus, to be just perceivably different, was a constant ratio. This relationship can be expressed as:

$$\Delta I/I = \Delta C/C = k$$

Where:

I is the stimulus intensity,
C is the measurable amount or concentration of stimulus, and
k is a constant that is different for every sensory property and specific stimulus.

As an example, this expression means that there would be the same perceived increase in intensity when changing a concentration of sugar in water from 10% to 11% as when changing the concentration from 20% to 22%.

In 1860, G.T. Fechner expressed the Weber law somewhat differently by plotting the perceived intensity versus the stimulus magnitude on a semi-log scale (Fechner, 1860). Fechner's Law was expressed as:

$$I = k \log C + b$$

In the 1950's and 1960's, through his work at Harvard University, S.S. Stevens proposed that apparent odor intensity grows as a power function of the stimulus odorant. Stevens showed that this Power Law (Steven's Law) follows the equation (Stevens, 1957, 1962):

$$I = k C^n$$

Where:

I is the odor intensity,
C is the mass concentration of odorant (e.g. milligrams/cubic meter, mg/m^3), and
k and **n** are constants that are different for every specific odorant or mixture of specific odorants.

As shown in Figure 3.4, "Power Law for a Single Odorant", this equation is a straight line when plotted on a log-log scale. The x-axis is the mass concentration (mg/m3) of the single odorant. The upward slope of the graph illustrates that the odor intensity of the single odorant increases as the mass concentration increases. The slope of the power law is less than one for odors since it takes a larger and larger increase in concentration to maintain a constant increase in perceived intensity. Steven's Law has been used most often in modern odor science (Dravnieks, 1979; O'Brien, 1991; Prokop, 1992).

Odor Persistency is a term used to describe the rate at which an odor's perceived intensity decreases as the odor is diluted (i.e. in the atmosphere downwind from the odor source). Odor intensities decrease with dilution at different rates for different odors. Figure 3.5, "Dose-Response of an Odor Sample", illustrates how odor intensity decreases as the odor is diluted. Odor intensity is related to the odor concentration (dilution ratio) by the Power Law (Steven's Law):

$$I = k C^n$$

Where:

I is the odor intensity,
C is the dilution ratio and
k and **n** are constants for each odor sample.

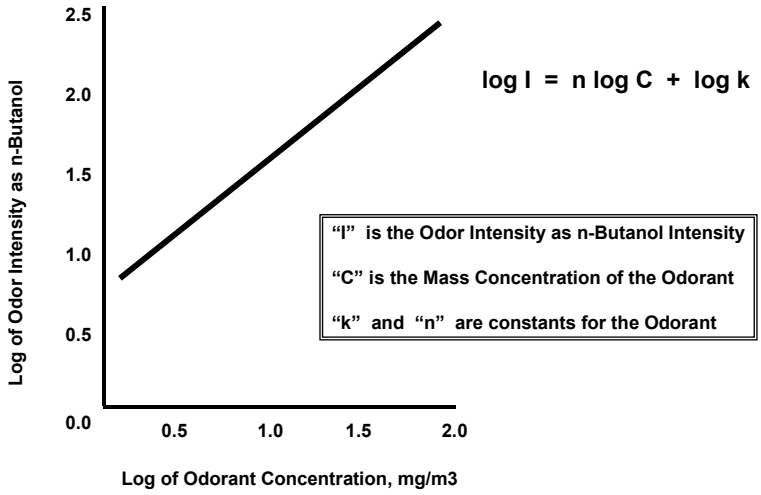

Figure 3.4 Power Law of a Single Odorant

Through logarithmic transformation this function can be plotted as a straight line as illustrated in Figure 3.5:

$$\log I = n \log C + \log k$$

Therefore, the persistency of an odor can be represented as a Dose-Response function. The Dose-Response function is determined from intensity measurements of an odor at various dilutions and at full strength (Dravnieks, 1980). Plotted as a straight line on a log-log scale, the result is a linear equation specific for each odor sample. The odorant concentration (Dose), expressed as the log of the dilution ratio, and the odor intensity (Response), expressed as the log of n-butanol PPM, produces the log-log plot with negative slope. The slope of the line represents the relative persistency. The logarithm of the constant k is related to the intensity of the odor sample at full strength (Dravnieks, 1986), i.e. the y-axis intercept.

Note that comparing Figure 3.4 to Figure 3.5, Figure 3.4 has a positive slope, because the concentration (x-axis) is the mass concentration in mg/m^3 of the odorant, e.g. hydrogen sulfide. The log-log plot in Figure 3.5 has a negative slope because the concentration (x-axis) is the dilution ratio of an odor sample. See Appendix V for example odor intensity and persistency data and related dose-response graphs.

Other researchers have investigated other relationships between odor intensity and dilution ratios (Cain et. al., 1974). For example, in 1999 Chen et.al. found that while the Power Law and the less common Beidler model described the data effectively, the Beidler model showed the best fit of the relationship between odor intensity and the threshold dilution ratio for the hog manure in the study (Chen et. al., 1999).

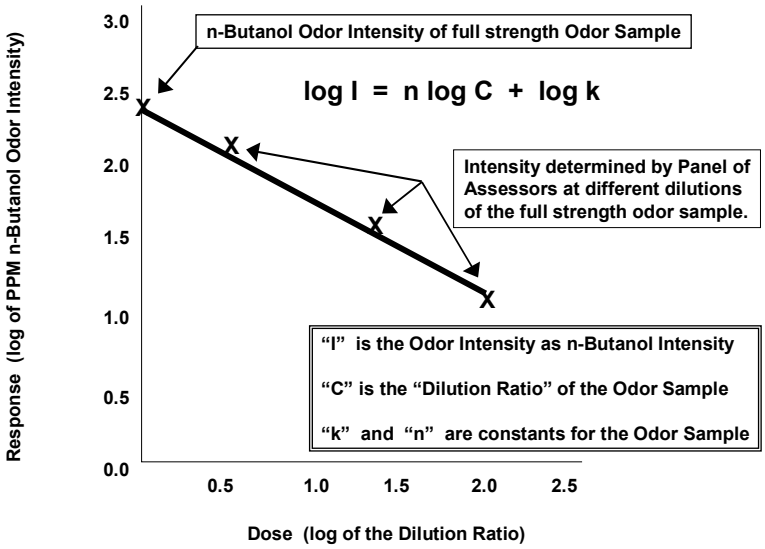

Figure 3.5 "Dose-Response" plot of an Odor Sample

3.6 Odor Characterization

Descriptive analysis is a sensory science term used to describe the action of a panel of assessors describing attributes about a product or sample (qualitative) and scaling the intensity of these attributes (quantitative). The food, beverage, and consumer product industries have formally used descriptive analysis to obtain detailed information about the appearance, aroma, flavor, and texture of products for well over 50 years.

The earliest perfumers and chemists used their senses to characterize chemicals in their industry. Experts in wine, tea, coffee, and other industries have long used their senses to characterize their products for trade and commerce. The first formal, systematic descriptive procedure was the Flavor Profile Method developed at A.D. Little Corp. in the late 1940's.

Odor character, often called odor quality, is a nominal scale of measurement. Odors can be characterized using reference vocabulary. Standard practice has been to provide assessors with a standard list of descriptor terms, which are organized with like terms in groups. Similarly, terms with negative connotation (unpleasant) would be grouped with other negative terms and positive (pleasant) terms with other positive terms (Harper, 1968).

In the 1970's American and British brewing and sensory scientists developed a "Beer Flavor Wheel" as a tiered system for describing the flavor (taste and odor) of beers (Meilgaard, et.al., 1982). In the 1980's, the California wine industry developed a wine aroma wheel for the characterization of wines (Noble, 1984).

A descriptor wheel is organized with general descriptors at the center of the wheel and more specific characters are listed towards the wheel rim. For example, an assessor may identify a flavor as **fruity** (general first tier description) and move out on the wheel through **berry** and **raspberry**.

A similar descriptive analysis approach has been used in the environmental odor evaluation industry. Numerous standard odor descriptor lists are available to use as a reference vocabulary by assessors. In 1986, the International Association on Water Pollution Research and Control (IAWPRC) proposed eight major odor descriptor categories for describing odors from natural waters and illustrated the eight categories in an odor wheel: vegetable, fruity, floral, medicinal, chemical, fishy, offensive, and earthy (AWWA, 1987; Bartels, et. al., 1989). At around the same time, ASTM published a document titled, "DS-61: Atlas of Odor Character Profiles," which published a standard odor descriptor list of 146 terms (Dravnieks, 1985).

This list of 146 terms was condensed down from a master list of 800 terms. The ASTM International E18 Sensory Evaluation Committee originally compiled this master list of 800 terms from published literature and industrial organizations (Dravnieks, 1985). The Committee organized a group of 100 professionals from several different industries to rate the usefulness of the terms and create a more manageable standard list (Dravnieks, 1978).

The standard lists are used as a basis for description of environmental odorous air samples. Figure 3.6, is an odor descriptor wheel developed by St. Croix Sensory for use with environmental odor samples. The eight main odor categories are based on the original IAWPRC odor wheel for water samples.

Each of the eight major categories has specific descriptors, which can be presented in training using exemplars. For example, the major category **vegetable** consists of a vocabulary of words that are illustrated with real life items known as exemplars: e.g. celery, cucumber, garlic, onion, tomato, etc.

Assessors observe the odorous air sample and report which general and specific odor descriptors they notice.

When an odor descriptor is assigned to an odor, the main odor descriptor categories can be rated in relative intensity on a 1 to 5, faint to strong, scale (0=not present). The odor testing descriptor data can then be plotted on a spider plot (radar plot) format with the distance along each axis representing the 0-5 scale for each of the categories. The plot creates a pattern that can be readily compared to spider plots for other samples. See Appendix VI for example character descriptor spider plots. Specific odor descriptors can be presented also in a histogram where each reported descriptor is listed along with the percent of reporting assessors.

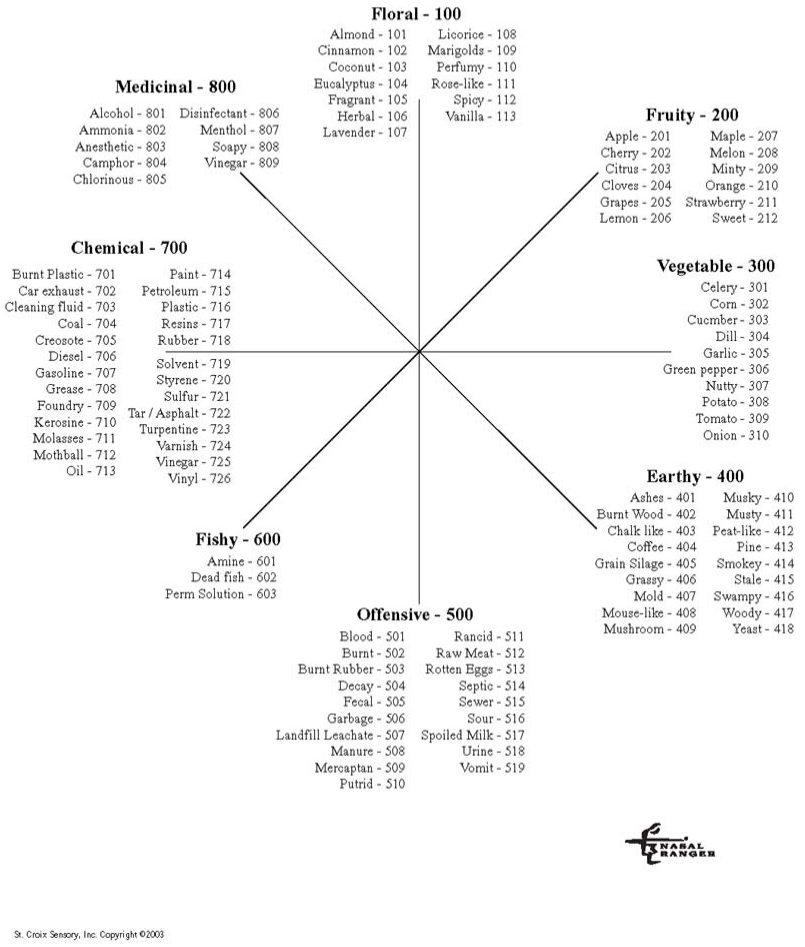

Figure 3.6 Odor Character Wheel Developed by St. Croix Sensory from other Standard Odor Character Lists.

Beyond character descriptors, other attributes of the odor can be characterized using similar profiling methods. For example, the perception of taste is sometimes experienced in evaluation (sniffing) of certain odors. The four (4) recognized taste descriptors are salty, sweet, bitter, and sour. Assessors may rate the strength of these taste descriptors noticed while observing the odor. The Trigeminal Nerve (Fifth Cranial Nerve), located throughout the nasal cavity and the upper palate, and other nerves sense the presence of some odors (i.e. "feels like…" rather than "smells like…"). Eight (8) common sensation descriptors that can be used include: itching, tingling, warm, burning, pungent, sharp, cool, and metallic. Again, assessors can rate the strength of the presence of these attributes.

3.7 Applicability of Laboratory Olfactometry

3.7.1 Odor Investigations and Studies

When odor is present in the ambient air and causes citizens to complain, investigation by trained personnel is prescribed. Investigators verify citizen complaints through actions of complaint response and surveillance of the probable sources of odor. Laboratory olfactometry often is a part of or follows field odor investigations and studies. Investigators use field olfactometry (See Section 4.0) to measure and quantify the odor in the ambient air and to identify the probable odor source(s).

The collection of whole-air odor samples (See Appendix II) and the testing of the samples in an odor (olfactometry) laboratory may be:

(1) Part of a developing investigation (i.e. enforcement actions),
(2) Part of an odor study (i.e. comparing or ranking odorous processes),
(3) Part of an odor control system performance test (i.e. manufacturer's guaranty), or
(4) Part of a routine performance test at a facility (i.e. compliance test required by permitting authorities).

Odorous air samples are collected from point emission sources (i.e. stack or vent) and from surface emission sources (i.e. liquid surface or solid surface). Whole-air odor samples are typically collected in 10-liter Tedlar gas sample bags ($20.00 sample bag cost) and express-transported (i.e. priority overnight via FedEx or UPS) to an odor-testing laboratory.

Odor laboratory analysis of whole-air odor samples is cost effective for determination of:

- Odor concentration,
- Odor intensity,
- Odor character (descriptors), and
- Odor persistency (dose-response function).

Per sample analysis cost for odor testing is approximately $200 for one sample analysis to determine odor concentration. The approximate cost to determine odor intensity, odor character and odor persistency, in addition to odor concentration, is approximately $100. Therefore, the approximate total cost for a full odor analysis is approximately $300 per whole-air odor sample.

Engineers, managers, and regulators who are planning odor mitigation can use the results of laboratory olfactometry odor testing to assist in their decision-making.

3.7.2 Odor – Air Dispersion Modeling

Odor concentration is an estimate of the number of dilutions needed to make the actual odor emission non-detectable. The dilution of the actual odor emission is the physical process that occurs in the atmosphere down wind of the odor source(s). See Figure 3.1, Dilution of Odor in the Ambient Air. The receptor (citizen in the community) sniffs the ambient air that has the diluted odor. If the receptor detects the odor, then the odor in the ambient air is said to be at or above the receptor's detection threshold level for that odor.

Odor concentration values are dilution factors (dilution ratios) and are, therefore, dimensionless values. However, the pseudo-dimension of **odor units per cubic meter** is commonly used for odor dispersion modeling, taking the place of grams per cubic meter in the air dispersion model. The odor concentration value (odor units per cubic meter) can then be multiplied by the airflow rate of the emission source, i.e. cubic meters per second, resulting in the pseudo-dimension of odor units per second for the odor emission rate, analogous to grams per second in the air dispersion model.

Because odor concentration values are actually dimensionless, odor concentration from different sources cannot be added nor can they be averaged. Therefore, odor modeling must be conducted with caution. Air dispersion models typically have outputs of concentration (e.g. micrograms per cubic meter) at specific receptors or plotted as isopleths. These standard modeling outputs need to be converted to the pseudo-dimension odor units per cubic meter with proper treatment of the decimal place. The resulting odor concentration value of 1–odor unit per cubic meter, calculated by the dispersion model, represents the odor detection threshold (i.e. 0.5 probability of detecting a difference in the air). A value less than "1" represents no odor or sub-threshold and a value greater than "1" represents odor at supra-threshold.

Practitioners in the technology of odor study and abatement often use regulatory models, e.g. SCREEN3, ISCST3, CAL PUFF, and AERMOD and sometimes use non-regulatory models, e.g. puff or spill models, or proprietary models. Some practitioners use the recognition threshold values determined in olfactometry in lieu of detection threshold odor concentration values. A number of other important issues need to be considered when selecting and using air dispersion models for odor applications: averaging time(s); peak-to-mean ratio(s); stability classes; terrain features; unique building features; variations in area source emission rates; and special/sensitive receptors.

These model approaches assist is decision making to identify and mitigate odors. Further, an odor regulation or permitting process might use odor (air) dispersion modeling to back-calculate an emission source maximum (i.e. odor concentration) from ambient odor criteria, i.e. '4' or '7' D/T ("dilution-to-threshold" or "odor units per cubic volume").

3.7.3 Olfactometry Data used as Compliance Criteria

Odors from a facility's emission sources (i.e. point, area, and volume sources) can be sampled and tested to determine odor concentration and other odor parameters using laboratory olfactometry following standard practices (ASTM E679-91 and EN13725). The results of the odor testing would be an odor emission inventory or an odor control system performance/compliance test that might be required by an odor regulation or a permit.

A facility's permit might place odor concentration limits on the emission sources of the facility. An example of an odor concentration limit for an odor control system is 250 (detection threshold as odor units per cubic meter) determined using laboratory olfactometry in accordance with ASTM E679-91 and EN13725.

A permit might also require a facility to conduct periodic source sampling and odor testing to verify compliance or conformance to best management practices (i.e. industry standards). The permit might also require odor (air) dispersion modeling to estimate the ambient odor concentration at the facility's fence line and in the ambient air in the community. The method of back-calculating from an ambient odor limit or guideline, i.e. '4' or '7' D/T (dilution-to-threshold), can be used to set source emission odor concentration limits in a permit.

4.0 FIELD OLFACTOMETRY

4.1 Overview of Field Olfactometry Methods

Odor can also be measured and quantified directly in the ambient air by trained inspectors using one of two standard practices. The first method uses a standard odor intensity referencing scale (OIRS) made up of the standard odorant, n-butanol, to quantify odor intensity. The second method utilizes a field olfactometer, which dynamically dilutes the ambient air with carbon-filtered air in distinct dilution ratios known as Dilution-to-Threshold dilution factors (D/T's).

4.2 Olfactory Performance of Odor Inspectors

An odor inspector's olfactory sensitivity is a factor when using field olfactometry methods to measure odor in the ambient air. A standardized nasal chemosensory test method would determine the olfactory threshold of an individual (e.g. odor inspector) and allows comparison of the individual's olfactory sensitivity to normative values (normal olfactory thresholds).

In the routine clinical evaluation of patients with olfactory disorders, one commercially available psychophysical testing method is known as Sniffin' Sticks. Sniffin' Sticks, manufactured by Burghart of Germany, are odor-dispensing felt tip marker pens. One

nasal chemosensory testing mode can determine a person's odor threshold based on the standard odorant n-butanol.

The results of a published multi-clinic investigation of 1,000 subjects provides normative values for the general population and was used to develop performance criteria for field inspectors (Kobal, et. al., 2000).

It is assumed that olfactory sensitivity varies as a result of random fluctuations in factors such as alertness, attention, fatigue, health status, and the possibility of variable presentation techniques of the testing stimulus source. Therefore, even though the determination of an individual's olfactory threshold is a definable task, the precision of the result is based on the number of times the individual takes the test. Further, an individual's general condition of health, i.e. common cold and seasonal allergies, needs to be considered in the timing and applicability of the testing.

4.3 Ambient Odor Intensity

Field air pollution inspectors (field odor inspectors), using a standard odor intensity referencing scale, can provide measured, dependable, and repeatable observations of ambient odor intensity.

Odor intensity of the ambient air can be measured objectively using an Odor Intensity Referencing Scale [OIRS] (ASTM, 1999). Odor intensity referencing compares the odor in the ambient air to the odor intensity of a series of concentrations of a reference odorant. As with laboratory intensity determination, the standard reference odorant for ambient measurement is n-butanol. The air pollution inspector, plant operator, or community odor monitor observes the odor in the ambient air and compares it to the OIRS. The person making the observation should use a carbon-filtering mask to refresh the olfactory sense between observations (sniffing). Without the use of a carbon-filter mask, the observer's olfactory sense may become adapted to the surrounding ambient air or become fatigued from any odor in the surrounding air. The adaptation of an observer's olfactory sense is a common phenomenon when attempting to evaluate ambient odors, i.e. wastewater treatment plant operator monitoring treatment plant odors off-site.

ASTM E544-99, "Standard Practice for Referencing Suprathreshold Odor Intensity", presents two methods for referencing the intensity of ambient odors: Procedure A - Dynamic-Scale Method and Procedure B - Static-Scale Method. Field inspectors commonly use the Static-Scale Method because of its ease of handling and low cost of set-up compared to a dynamic-scale olfactometer device (Procedure A).

Practicing the procedures of ASTM E544 is nearly identical to the standard method of quantifying the opacity of smoke plumes. In April 1975 the U.S. Environmental Protection Agency (EPA) published "Guidelines for the Evaluation of Visible Emissions" (EPA-340/1-75-007), as part of the Stationary Source Enforcement Series. The training course, Visible Emissions Evaluation Field Certification and Classroom Lecture Program, provides a field investigator with an understanding of visible emissions and

confidence in quantifying the opacity of a visible emission using the calibrated, unaided eye.

The ability to calibrate one's senses is a learned technique, not unlike the calibration of the sense of hearing in the field of music. Air pollution investigators who are familiar with opacity reading can readily learn to calibrate their sense of smell to the ASTM E544 Odor Intensity Referencing Scale (OIRS). Persons who have not received training in opacity reading can learn the ASTM E544 OIRS procedure with training and field practice (McGinley, et. al., 1995).

Using the OIRS, the intensity of the observed ambient air is expressed in "parts per million" (PPM) of n-butanol. A larger value of butanol means a stronger odor. It is important to know that a variety of OIRS are available. Common butanol static-scales include:

- 12-point scale starting at 10-ppm butanol with a geometric progression of two;
- 10-point scale starting at 12-ppm butanol with a geometric progression of two;
- 8-point scale starting at 12-ppm butanol with a geometric progression of two;
- 5-point scale starting at 25-ppm butanol with a geometric progression of three;

The OIRS serves as a standard practice to quantify the odor intensity of the ambient air objectively. To allow comparison of results from different data sources and to maintain a reproducible method, the equivalent butanol concentration is reported or the number on the OIRS is reported with the scale range and starting point. See also, Figure 3.3, "Example Odor Intensity Referencing Scales," presents four OIRS options.

4.4 Ambient Odor Concentration (D/T)

4.4.1 History of Field Odor Concentration Measurement

In 1958, 1959, and 1960 the U.S. Public Health Service sponsored the development of an instrument and procedure for field olfactometry (ambient odor strength measurement) through Project Grants A-58-541; A-59-541; and A-60-541 (Huey, et. al., 1960). The first field olfactometer, called a Scentometer, was manufactured by the Barnebey-Cheney Company and subsequently manufactured by the Barnebey Sutcliffe Coporation.

A field olfactometer creates a series of dilutions by mixing the odorous ambient air with odor-free (carbon-filtered) air. The U.S. Public Health Service method defined the dilution factor as Dilution to Threshold, D/T. The Dilution-to-Threshold ratio is a measure of the number of dilutions needed to make the odorous ambient air non-detectable.

The method of producing Dilution to Threshold (D/T) ratios with a field olfactometer consists of mixing two volumes of carbon-filtered air (two carbon filters) with specific volumes of odorous ambient air. Figure 4.1 is a block diagram which illustrates the mixing of carbon-filtered air with odorous air in a field olfactometer.

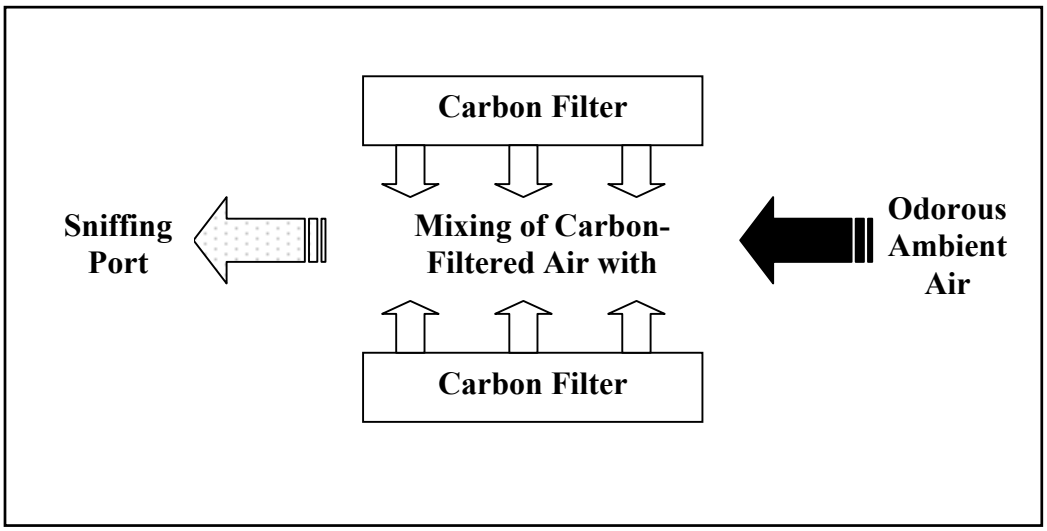

Figure 4.1. Block diagram of field olfactometer air flow.

The method of calculating Dilution to Threshold (D/T) for a field olfactometer is:

$$\text{Dilution Factor} = \frac{\text{Volume of Carbon Filtered Air}}{\text{Volume of Odorous Air}} = \textbf{D/T}$$

Note that the calculation method for field olfactometry is different from the calculation of the dilution factor in laboratory olfactometry (see Section 3.3).

The calculation difference is illustrated in the following example:

A field olfactometer uses 7 volumes of carbon-filtered air to one volume of odorous air:

$$\frac{7}{1} = 7 \quad \text{(D/T Value)}$$

A laboratory olfactometer uses 7 volumes of carbon-filtered air to one volume of odorous air:

$$\frac{7+1}{1} = 8 \quad \text{(Z value)}$$

Two commercially available field olfactometers include the original Scentometer, developed in the late 1950's, and the Nasal Ranger®, introduced to the market in 2002.

4.4.2 Scentometer Field Olfactometer

The Barnebey Sutcliffe Corporation Scentometer is a rectangular, clear plastic box (15.25cm x 12.7cm x 6.2cm) containing two activated carbon beds. The box contains two ½" diameter air inlets to the activated carbon beds (one on top and one on the bottom of the box). There are six odorous air inlet holes on one end of the box for six different D/T values (2, 7, 15, 31, 170, and 350). The opposite end of the box contains two glass nostril tubes for sniffing. The Scentometer is sold for approximately $650. Figure 4.2 shows a photo of a Scentometer.

Figure 4.2. The Scentometer Field Olfactometer (Barnebey Sutcliffe Corp.). Note the two glass nostril ports to the left and the series of orifice holes at the back of the unit to the right in this photo.

4.4.3 Nasal Ranger Field Olfactometer

The St. Croix Sensory - Nasal Ranger Field Olfactometer operates based on the same principles as the original Scentometer Field Olfactometer. Carbon-filtered air is supplied through two replaceable carbon cartridges. An orifice selector dial on the Nasal Ranger contains six odorous air inlet orifices for six different D/T values (2, 4, 7, 15, 30, and 60). The dial contains six "blank" positions (100% carbon-filtered air) alternating with the D/T orifices. The dial is replaceable for other D/T series (e.g. 60, 100, 200, 300, 500). Figure 4.3 is a photo of a Nasal Ranger.

Figure 4.3. The Nasal Ranger® Field Olfactometer (St. Croix Sensory, Inc.). The inset picture shows a close-up of the orifice dial, which is located right side of the Nasal Ranger in this photo.

The diluted odorous air is sniffed through an ergonomically designed nasal mask, which is constructed of a carbon fiber/polyurethane blend with a fluoropolymer (Teflon-like) coating. A check valve is placed in both the inhalation and exhalation outlet of the nasal mask in order to control the direction of airflow while using the Nasal Ranger.

The Nasal Ranger is designed with an airflow sensor that measures the sniffing flow rate through the field olfactometer. The measured flow is continually compared to design specifications and feedback is provided to the user through LED's mounted on the top of the unit. The user must sniff at a rate where the LED's show the total airflow is in the Target range (nominal 16-20 LPM). This feedback loop standardizes the sniffing rate for all users of this field olfactometer and allows for certified traceable calibration of the Nasal Ranger. The Nasal Ranger is sold for approximately $1500.

The field olfactometer instrument, the "Dilution to Threshold" (D/T) terminology, and the method of calculating the D/T are referenced in a number of existing state and local agencies' odor regulations and permits. Therefore, a field olfactometer is a realistic and proven method for quantifying ambient odor strength when used by trained air pollution inspectors or monitors.

Common Dilution-to-Threshold (D/T) ratios used to set ambient odor guidelines are: D/T's of 2, 4, and 7. Field olfactometers typically have additional D/T's (dilution ratios) such as 15, 30, 60 and higher dilution ratios.

4.5 Applicability of Field Olfactometry

Field olfactometry with Odor Intensity Referencing Scales (OIRS) and calibrated field olfactometer are cost effective means to quantify odors. Facility operators, community inspectors, and neighborhood citizens can confidently monitor odor strength at specific locations around a facility's property line and within the community when using OIRS's or calibrated field olfactometers.

The following methods are presented in brief exemplary form as an application guide for field olfactometry. These methods describe types of odor monitoring and when it may be appropriate to monitor odors.

(1) **On-Site Monitoring –** Operators have the unique ability to monitor odors throughout the day with field olfactometry. Operator monitoring can include odor observations of arriving materials, outdoor process activities, and fugitive air emissions. Monitoring odors on-site may include following a logical pathway around the facility to determine where odors exits or making odor observations at predetermined locations, i.e. open doorways, driveways, storage areas, and fence lines.

(2) **Random Off-Site Monitoring –** A frequently used method for ambient odor monitoring is the "random inspection" approach. Random monitoring leads to a compilation of data that can be correlated with meteorological information and on-site activities. Managers and regulators alike find that random odor monitoring using field olfactometry is a cost effective protocol.

(3) **Scheduled Monitoring –** Well-planned scheduled monitoring can be limited to a daily walk-about or drive around, or structured with several visits to predetermined monitoring locations. Data from field olfactometry can be used to correlate the many parameters that influence odor episodes, including meteorological conditions and on-site operating activities.

(4) **Intensive Odor Survey –** An in-depth evaluation of on-site odor generation and off-site odor impact may be needed for permit renewal or facility expansion. Extensive data collection using field olfactometry will identify which sources or operations cause odor and which ones do not cause odor off-site. All potential odor sources and operations could be ranked and their relative contributions determined. Short-term trials or tests of odor mitigation measures, e.g. odor counteractants, would also require an intensive period of data collection using field olfactometry.

(5) **Citizen Monitoring –** The implementation of citizen odor monitoring with field olfactometry can be part of an interactive community outreach program. The primary function of citizen odor monitoring is to collect information, through accurate record keeping, which represents real conditions in the community. Citizens recruited and trained to measure odors using OIRS's or field

olfactometers would also report odor descriptors. Citizen odor monitoring will assist in determining prevalent times and prevalent weather conditions of odor episodes. Citizen odor monitoring with field olfactometry will also help in understanding the odor strength at which an odor first becomes a nuisance.

(6) **Complaint Response –** The use of Odor Compliant Hot Lines is a common method used by facilities and communities to respond to odor episodes. A complaint response plan, with designated on-call responders, creates opportunities for verifying odor episodes, tracking odor sources, and quantifying odor strength with field olfactometry.

(7) **Plume Profiling –** Standard and specialized air dispersion modeling predicts the transport and dilution of odors by the wind. A protocol, known as plume profiling, supplements and calibrates air dispersion modeling. Several inspectors using OIRS's or field olfactometers, spaced cross wind and down wind from an odor source, would measure and record the odor strength as butanol intensity or D/T values. The odor plume profile would then be documented and overlaid on the local terrain map. Therefore, the air dispersion modeling and the local topography would be integrated with actual odor measurements from field olfactometry.

These methods are presented in brief exemplary form as guide and are not mutually exclusive, often being combined into a comprehensive odor management program.

5.0 ANALYZING SPECIFIC CHEMICAL ODORANTS (CHEMICALS)

Odor perception occurs when one or more chemical substances in the air come in contact with the human olfactory system. The term odorant refers to any chemical substance in the air that is part of the perception of odor. Odorants may also be irritants to the human receptor and irritants may be co-pollutants with odorants. Therefore, analyzing for specific odorants (and irritants) may be necessary as part of an investigation of odors. Further, specific odorants may be identified as surrogates for the perceived odor and may become the chemical markers used in permitting and enforcement of odor.

Measuring odorous air as odor is accomplished using the standard practices presented in previous sections. However, the investigations and studies of odor sometimes require the analysis of the chemical substances in the odorous air. The chemical substances may include odorants, non-odorants, irritants, air toxics, hazardous air pollutants, criteria pollutants, and other pollutants. Analysis of specific odorants may include the use of on-site real-time monitoring instruments (field analysis) and laboratory based analytical equipment (laboratory analysis).

5.1 Field Analysis of Chemical Odorants

Field analysis of chemical odorants and other chemical substances can be accomplished using a variety of portable analysis methods. These field portable methods include low

cost colorimetric detector tubes ($5.00 per tube with a $500 pump) to higher cost portable electronic instruments ($5,000 to $10,000). All of these portable analysis methods have limitations in either sensitivity or specificity, which may affect their value as "portable odor instruments".

Colorimetric detection tubes are low cost ($5.00 per tube) and are available for many specific chemical compounds. However, each tube type has possible interferences with chemical compounds similar to the target analyte. For example, ammonia colorimetric detector tubes have cross sensitivity (interferences) with other basic substances such as organic amines.

The Jerome Hydrogen Sulfide Analyzer, Model 631X, made by Arizona Instruments, has a reported detection limit of 0.001 ppm (1-ppb) hydrogen sulfide, however, almost all of the reduced sulfur gas compounds cause a response which is record as hydrogen sulfide. Therefore, the Jerome analyzer can be considered a hydrogen sulfide analyzer with other sulfur gas interference or considered a survey instrument for all reduced sulfur gas compounds.

Electronic noses are specialized detection instruments with hybrid proprietary sensors that detect many chemical species. Because electronic nose sensors have broad range detection capability, they need to be programmed for specific odorant mixtures. Without programming, an electronic nose instrument cannot report which odorants are being detected. However, with programming, an electronic nose reports the presence of a known (programmed) odorant mixture. Therefore, the application of electronic noses has been successful in manufacturing quality control (i.e. a sample of Product 'A' meets the quality standard for Product 'A'). The use of portable electronic noses in environmental pollution applications is in development.

Table 5.1, Field Analysis of Chemical Odorants, briefly summaries the several portable instrument types and related parameters.

Parameter	Sampling/Analytical Method	Instrument	Instrument Costs $
Mixtures	Electronic Noses	Cyranose	10,000
Reduced Sulfur Gases	Gold Film Analyzer	Jerome by AZI	10,000
Selected Analytes	Colorimetric Detector Tubes	Draiger or MSA	500
VOC's	FID and PID	Various Manufacturers	5,000

Table 5.1 Field Analysis of Chemical Odorants

5.2 Laboratory Analysis of Chemical Odorants

The collection of odorous air samples and the laboratory analysis of chemical odorants can be cost-effective depending on the Data Quality Objectives (DQO's) for investigation, enforcement action, or compliance verification. Data Quality Objectives

(DQO's) are statements that specify the type and detail of the sample collection and analytical method utilized to satisfy the end use or purpose. Following the USEPA's approach to document the planning and quality control aspects of Superfund Cleanup programs, i.e. Quality Assurance Project Plan (QAPP), five Data Quality Objective (DQO) Levels are used:

DQO Level 1 – Screening: includes field analysis with portable instruments/methods and grab samples of odorous air for preliminary laboratory analysis. Even though Level 1 is the lowest data quality it is the most rapid and often is the first necessary step in planning further testing.

DQO Level 2 – Field Analysis: includes slightly more complex sampling procedures (i.e. composite sampling) and can incorporate mobile laboratory instrumentation or fixed point monitors. Level 2 is often needed to develop sufficient information (i.e. base line data) prior to planning odor control mitigation measures.

DQO Level 3 – Engineering: includes planning and sampling to document mass emission rates as well as selection of specific laboratory analysis to identify the specific odorants that may be surrogates for the odorous air. Level 3 is a cost-effective data quality approach when measuring performance or success of odor control mitigation efforts, i.e. process changes, odor control equipment.

DQO Level 4 – Conformational: includes the full use of compliance testing protocols and Contract Laboratory Programs (CLP) in accordance with EPA recognized protocols. Level 4 is needed to document conformance to standards or permit conditions.

DQO Level 5 – Non-Standard: includes all non-standard protocols or experimental protocols that may be needed to detect unusual or unregulated chemical compounds. Level 5 quality control is similar to Level 4 after the method or protocol has been fully adapted or developed.

Table 5.2, Laboratory Analysis of Chemical Odorants, presents the most common chemical odorant parameters: aldehydes, amines, organic acids, sulfur gases, and VOC's and the sampling and analytical methods for each parameter.

The cost of analysis for each analytical method varies from $100 to $400. For example, the analysis of ammonia utilizing the NIOSH S347 method cost approximately $75 compared to the more expensive VOC analysis utilizing EPA Method TO-15 in the full scan mode (75 VOC library of compounds) and reporting Tentatively Identified Compounds (TIC's) costs approximately $375. These cost estimates do not include the costs of sample containers and sample collection. Further, the necessary incorporation of "field duplicates" and "field blanks" add to the cost of sampling and analysis.

Parameter	Sampling Method	Analytical Method	Instrument	IDL	MDL/MRL
Aldehydes/Ketones	Sorbent Tube	EPA TO-11	HPLC	1.0 ug/ml	250 ug/m3
Amines, Aliphatic	Sorbent Tube	NIOSH 2007/2010	IC	1.0 ug/ml	250 ug/m3
Ammonia	Sorbent Tube	NIOSH S347	IC	0.5 ug/tube	50 ug/m3
Organic Acids	Sorbent Impinger	EAS 01.Acid.311	HPLC-UV	1.0 ug/ml	250 ug/m3
Reduced Sulfur Gases	Tedlar Bag	ASTM D5504-98	GC-SCD	N/A	5-ppbv
Volatile Organics	Canister/Tedlar Bag	EPA TO-15	GC-MS	1.0 ug/m3	1.0 ug/m3

Note: Cost of analysis for each analytical method varies from $100 to $400

Key:

IDL - Instrument Detection Limit

MDL - Method Detection Limit

MRL - Method Reporting Limit

Table 5.2 Laboratory Analysis of Chemical Odorants

6.0 COMMUNITY ODOR STUDIES

6.1 The Citizen Complaint Pyramid

A conceptual model for what makes an odor episode lead to a citizen complaint is the "Citizen Complaint Pyramid," shown in Figure 6.1. Four parameters make up the hierarchy in this pyramid: 1) Character, 2) Intensity, 3) Duration, and 4) Frequency. This assumes an odor episode exists when an odorant is present above the detection threshold.

The "Character" of the odor is the actual descriptions of what the odor smells like. This parameter is sometimes called the "quality" or "offensiveness" of the odor. More offense odors will be more annoying.

"Intensity" of the odor refers to the overall strength or power of the odor. The more intense the odor, the more likely a citizen is to be annoyed. Even very pleasant odors such as perfumes can be very annoying at high intensities.

"Duration" is the elapsed time of each individual odor episode. Longer duration odor episodes can lead to more drastic changes in plans around a citizen's home or community. Episodes of very short duration may be over before a citizen even thinks about adjusting his or her plans.

Finally, "frequency" refers to how often the citizen experiences odor episodes. The more frequent the intrusion into the citizen's life, the more annoying each experience becomes.

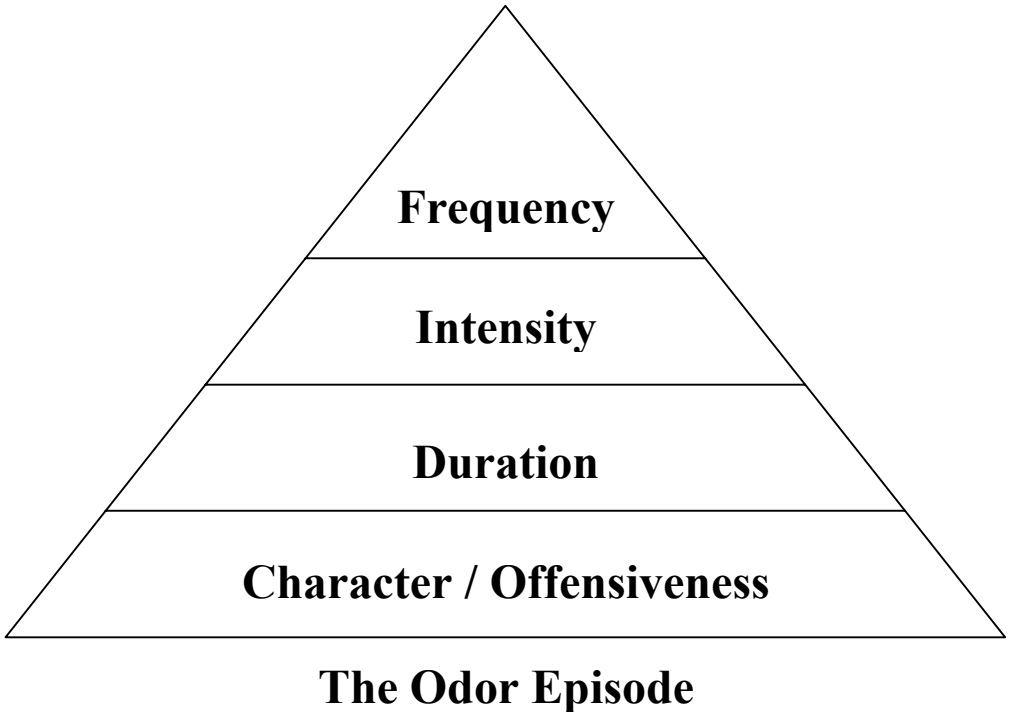

Figure 6.1 The Citizen Complaint Pyramid

This model is sometimes given the acronym "F-I-D-O," frequency, intensity, duration, and offensiveness, with the "offensiveness" term used instead of the "character" term. The cumulative effect of these four parameters creates the nuisance experience and the resulting citizen's complaint.

6.2 Odor Study Methods

Community odor studies are a tool used to characterize these four parameters and understand the properties of odor episodes around a facility or several facilities in the same area. Five examples of community odor surveys include:

1. Citizen Odor Hotline
2. Surveys of Recruited Citizens
3. Citizen Odor Log Books
4. Inspectors working for the jurisdiction (county, city, or township)
5. Inspectors working for a third party (e.g. local engineering firm)

6.2.1 Odor Hotlines

Odor hotlines provide an immediate method for citizens to call a telephone number to report an odor episode. There are several forms of odor hotlines:

1. Sponsored by Government Entity
2. Sponsored by Community Group
3. Sponsored by Facility

A government agency may provide an odor hotline similar to a spill response line for chemical spill scenarios. Citizens would call the phone number and provide information about the odor episode taking place or which took place recently. The government agency could document the episode information in a database for future consideration, or a response could be initiated by sending an investigator to the citizen's location.

A citizen group may organize an odor hotline in order to document odors from one or more facilities in a community. This hotline provides one location for citizens to take their complaints and allows the citizen group to organize information about odor episodes for future presentation to a government agency or to the facility management.

A facility may provide an odor hotline for citizens to call and report odor episodes. This allows the facility direct contact with the citizens and provides immediate information about the effects of odors from their facility. The facility may document the episode information in a database for future consideration, or a response could be initiated by sending an investigator to the citizen's location.

6.2.2 Citizen Surveys

Two types of citizen surveys used most often include mail-in questionnaires and telephone questioning. Each of these surveys can be varied in different ways depending on the depth of the study and the availability and involvement level of the community.

6.2.2.1Mail-in Questionnaires. The mail-in questionnaire can be used to investigate the history of community annoyance or to gather data on a series of current odor events. The advantage of this survey is that it allows the citizen to record events more completely and accurately. However, as with the dependence of citizen complaints, this method of data collection is at the mercy of the citizens for they must be annoyed enough to take the time to return the questionnaire.

6.2.2.2 Telephone Surveys. Like mail-in surveys, the telephone survey can be conducted in order to investigate the history of the odors in a community or they can be used to gather data on a series of event episodes. At least one survey has even incorporated calling citizens and obtaining the immediate status of odors by asking the citizen to step outside and describe what they smell. The telemarketing approach gives the citizen the open invitation to praise or condemn the odor conditions in the neighborhood without having to fill out any forms. Unfortunately, one negative of this survey is the intrusion

felt by the citizens when they are interrupted from their daily routine to answer the questions. There are many telemarketing organizations calling citizens on a nightly basis to sell different services, which cause citizens to counteract the telemarketers by screening callers with answering machines, voice mail, and caller I.D. For this reason it is beneficial to recruit a sample of volunteer citizens who will accept the periodic telephone calls to provide information about episodes over a period of time (McGinley, 1995).

6.2.3 Citizen Logbooks

Citizens can be trained to document odor episodes on report forms in a logbook following standard procedures. The citizens are recruited through community organizations or through direct phone calls or home visits. The citizens keep the logbook in an easily accessible location in their home. When they notice objectionable odors at their residence, the citizen completes the report form in the logbook. Generally, one logbook is associated with one location, i.e. citizens may have one log book at home and another at work.

These log books are then returned to a central location where the data would be entered into a database for further analysis and review.

6.2.4 Inspector Working for a Jurisdiction

Odor surveys are often conducted by inspectors who work for a specific jurisdiction (i.e. city, county, state, etc.). For a detailed odor survey, these inspectors will identify observation locations around one or more facilities and out in the potentially effected community. These locations will normally coincide with street intersections or specific receptor locations and will be documented with exact longitude and latitude from a GPS (Global Positioning System) unit. The locations need to be chosen for the inspectors to efficiently visit each observation point in a reasonable amount of time (e.g. one hour).

The observations locations should include permanent ("fixed") locations, which the inspector will visit during each round of observations, and optional locations where the inspector will only stop to make observations if noticeable odors are present.

These inspectors can be trained to observe the odors following standard practices and procedures. The inspectors document their observations on log forms, which are entered into a central database for future review and analysis. See Appendix G for a simple case study involving community odor survey techniques by inspectors.

6.2.5 Third-Party Inspectors

The same inspections can be carried out using third-party observers. Local environmental engineering or industrial hygiene firms usually serve as the third-party inspectors/monitors. These inspectors can be trained to make the same observations

following the same standard practices and procedures. See Appendix G for an example case study involving community odor survey techniques by inspectors.

7.0 CONCLUSIONS

Odor is measurable using standardized scientific methods in odor-testing laboratories with laboratory olfactometry and in the ambient air with field olfactometry. Point, area and volume emission sources can be sampled and tested for odor parameters such as odor concentration, intensity, persistence, and descriptors. Odor can also be measured and quantified directly in the ambient air using one of two standard practices by trained inspectors. One method uses standard odor intensity referencing scales (OIRS) made up of the standard odorant, n-butanol, to quantify odor intensity. The second method utilizes calibrated field olfactometers, which dynamically dilutes ambient air with carbon-filtered air in distinct dilution ratios known as Dilution-to-Threshold dilution factors (D/T's).

Presently, international standards are in place, which dictate the scientific methods and practices of odor measurement. These international standard methods for measuring odor are: objective, quantitative, dependable, and reproducible.

From ASTM International:

- ASTM E679-91: *Standard Practice for Determination of Odor and Taste Threshold by a Forced-Choice Ascending Concentration Series Method of Limits*

- ASTM E544-99: *Standard Practice for Referencing Suprathreshold Odor intensity*

From the Comité Européen de Normalisation (CEN)

- EN13725:2003: *Air Quality – Determination of Odour Concentration by Dynamic Olfactometry*

With these standard odor measurement practice odor limits may be incorporated into odor regulations or into facility permits as compliance determining criteria with confidence:

Ambient Odor Limits
- Odor concentration, D/T
- Odor intensity, ppm butanol

Source Odor Limits
- Odor concentration, odor units per cubic meter
- Odor emission rates, odor units per second

Note: these basic odor limits are <u>not</u> mutually exclusive and are sometimes combined.

The stakeholders for standardized odor measurement are:

- Regulators
- Industries
- Citizens
- Manufacturers of environmental control equipment
- Consultants
- Researchers

With the knowledge of fundamental odor testing methods and practices, an objective approach can be taken to addressing community nuisance odors and problematic odorous emissions. The subjectivity of "nuisance odors" can be replaced with objective, scientific methods of odor measurement with laboratory olfactometry and field olfactometry.

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Appendix I. Odor Terminology

acceptability/unacceptability: Degree to which a stimulus is judged to be favorable or unfavorable. [ASTM E253-97]

acuity: The ability to repeatedly detect or discriminate sensory stimuli. [ASTM E253-97]

accepted reference value: A value that serves as an agreed upon reference for comparison, and which is derived as a consensus value, based on collaborative experimental work under the auspices of a scientific or engineering group. [ISO 5725, part 1]

adaptation (sensory): A decrease in sensitivity to a given stimulus which occurs as a result of exposure to that stimulus. [ASTM E253-97]

anosmia: Lack of sensitivity to olfactory stimuli. [ISO 5492:1992] Absence of the sense of smell.

aroma: Perception resulting from stimulating the olfactory receptors; in a broader sense, the term is sometimes used to refer to the combination of sensations resulting from stimulation of the nasal cavity. See also "odor." [ASTM E253-97]

ascending concentration series: A method of presentation in olfactometry. The assessor (panelist) is presented with a series of dilution ratios (one or two blanks and one odorous presentation) increasing in odor concentration (decreasing dilution ratio). The increase in concentration is usually 2-3 fold. [ASTM E679-91]

assessor: A participant in odor testing (e.g. panelist, panel member, judge, respondent, etc.).

ASTM / ASTM International: An international voluntary standards development organization. The ASTM acronym stands for the original name of the organization, American Society for Testing & Materials. The organization changed their name to ASTM International in 2001.

aversion: A feeling of dislike provoking avoidance of a stimulus. [ASTM E253-97]

best estimate criteria: In olfactometry this is the estimated threshold of an individual assessor (panelist) calculated as the geometric mean of the last dilution ratio where the odor was not detected and the next higher concentration (the first dilution ratio where the odor was detected). [ASTM E679-91]

best estimate threshold (BET): The threshold calculated using the best estimate criteria.

bias: The difference between the expectation of the test results and an accepted reference value. [ISO 5725 part 1] Bias is also known as Systematic error.

binary forced choice: A method of olfactometry testing comprising of two presentations, one blank and one with a diluted odor sample. The assessor is forced to select the one with the odor, even if they must guess.

CEN: Acronym which stands for the Comité Européen de Normalisation, which is a standardization organization comprised of all countries in the European Union.

character (quality): Word descriptions of what the odor "smells-like."

detection: The assessor (panelist) is certain one presentation (the odor sample presentation) is different from the two blank presentations.

detection threshold (for a reference material): The *odorant concentration* which has a probability of 0.5 of being detected under the conditions of the test. [EN13725:2003]

detection threshold (for an environmental sample): the *dilution ratio* at which the sample has a probability of 0.5 of being detected under the conditions of the test. [EN13725:2003]

determination limit: The odor concentration (or dilution ratio) where 84% of the assessors (panelists) "detect" the odor. [VDI 3881, Part 1]

dilution-to-threshold (D/T): The highest dilution ratio of carbon filtered (odor-free) dilution air to the odor sample air where the ambient odor is just noticeable.

dilution level: A presentation level on the olfactometer which is set at a specific dilution ratio.

dilution ratio: the ratio of total diluted sample flow volume to the odor sample flow volume. (example: 2 cc/min of sample flow and 20L/min of total flow gives a dilution ratio of 10,000)

DT: see "detection threshold"

D/T: see "dilution-to-threshold"

dynamic olfactometer: An olfactometer designed to continuously dilute odorous gases in order to present known dilution ratios to an assessor through a common presentation mask.

dynamic olfactometry: Olfactometry work performed with a dynamic olfactometer.

dysosmia: A dysfunction in the olfactory sense; an impaired sense off smell.

ED50: see "detection threshold (for an environmental sample)"

EN: Acronym which stands for Norme Européenne. These letters precede all European Standards developed through CEN, Comité Européen de Normalisation.

European Odour Unit: That amount of odorant(s) that, when evaporated into one cubic meter of neutral gas at standard conditions, elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one European Reference Odour Mass (EROM), evaporated in one cubic meter of neutral gas at standard conditions. [EN13725:2003]

European Reference Odour Mass (EROM): The accepted reference value for the European odour unit, equal to a defined mass of a certified reference material. One EROM is equivalent to 123µg n-butanol (CAS 71-36-3) evaporated in one cubic meter of neutral gas. This produces a concentration of 0.040 µmol/mol. [EN13725:2003]

field olfactometer: A hand-held dilution device which dynamically mixes carbon-filtered air with odorous ambient air at discrete ratios as a user sniffs through the device and determines the dilution-to-threshold value of the odorous ambient air.

field olfactometry: Term used to describe any evaluation of ambient odors by an individual observer or group of observers including Odor Intensity Referencing Scales (OIRS) and field olfactometer dilution-to-threshold (D/T) measurements.

forced-choice method: A method of olfactometry where the assessor is forced to choose which one of the three presentations, one diluted odor sample presentation and two blank presentations, has the odorous sample, even if no difference is found between the three. [ASTM E679-91]

guess: The assessor (panelist) does not perceive a difference between the odorous and blank presentations and therefore makes a "guess" as to which presentation contained the odor.

group threshold: The average threshold of a group of assessors.

hedonic scale: a scale on which liking or disliking of a stimulus is expressed. [ASTM E253-97]

hyperosmia: An increase in olfactory sense. Having a lower threshold to odors and odorants.

hyposmia: A decrease in olfactory sense. Having an increased threshold (diminished sense of smell).

individual threshold: The detection threshold of one individual assessor.

individual threshold estimate (ITE): The detection threshold of one individual assessor calculated from one dilution series. In olfactometry this value is the best estimate threshold (BET) calculated using the best estimate criteria.

instrument detection limit: The minimum detection limit due to the instrument design.

intensity: The perceived magnitude of a stimulus. [ASTM E253-97]

kakosmia (cacosmia): Dysfunction where there is a presence of unusually unpleasant odors when pleasant odors exist. Usually found in the elderly.

Laboratory olfactometry: the practices, methods, and devices used in a controlled setting (laboratory) to measure the responses of assessors to olfactory stimuli.

odor / odour: Organoleptic attribute perceptible by the olfactory nerves on sniffing certain volatile substances. [ISO 5492] See "aroma."

odorant: A substance that stimulates the olfactory receptors (i.e. a chemical gas). [ASTM E253-97]

odor concentration: The number of European Odour Units in a cubic meter of gas at standard conditions.

odor intensity: The perceived (sensory) intensity of the odor based on a butanol intensity referencing scale (ASTM E544-99).

Odor Intensity Referencing Scale (OIRS): A series of reference odorant samples (e.g. n-butanol), at discrete increasing concentrations, used as a scale to match the odor intensity of environmental odors.

Odor Dilution Units (ODU): see "Odor Unit" and "European Odour Unit"

odor panel: see "panel"

odor threshold: see "detection threshold"

Odor Unit (OU): One odor unit is the amount of odorant(s) present in one cubic meter of odorous gas (under standard conditions) at the panel threshold. see "European Odour Unit"

olfactometer: A dilution apparatus which mixes odorous air in specific ratios with odor free air for the presentation to a panel of observers (assessors).

olfactometry: Measurement of the response of assessors to olfactory stimuli. [ISO 5492]

olfactory: Pertaining to the sense of smell. [ISO 5492]

olfactory receptor: Specific part of the olfactory system which responds to an odorant. [ISO 5492]

olfactory stimulus: That which can excite an olfactory receptor. [ISO 5492, modified]

operator: see "panel leader" or "test administrator"

panel: A group of assessors used to analyze an odorous sample by olfactometry.

panel leader: The operator of the olfactometer and the person who supervises and instructs the assessors (panelists) during sample analysis. See "test administrator"

panel member: An individual assessor who is part of an odor panel.

panel screening: Procedure used to determine if the performance of a panelist (assessor) is in compliance with selected criteria.

parosmia: a perceived change in ones olfactory sense. A distorted sense of smell encountered with certain brain tumors or in mental illness.

perception: Awareness of the effects of a single or multiple sensory stimuli. [ISO 5492]

precision: Closeness of agreement between independent test results obtained under prescribed conditions. [ISO 5725, part 1]

presentation: The presentation of either an odor sample or blank at one dilution level.

presentation face velocity: The velocity of the presentation air at the face of the sampling mask or port.

presentation flow rate: The volumetric flow rate of the presentation air to the assessor.

reaction limit: The odor concentration (or dilution ratio) where 16% of the panelists "detect" the odor. [VDI 3881, Part 1]

recognition: The assessor (panelist) is certain one presentation (the odor sample presentation) is different from the two blank presentations and, further, the assessor can identify or describe the odor.

recognition threshold: The odor concentration which has a probability of 0.5 of being recognized under the conditions of the test. [EN13725:2003]

repeatability (r): Precision under repeatability conditions. [ISO 5725, part 1]

repeatability conditions: Conditions where independent test results are obtained with the same method on identical test material in the same laboratory by the same operator (panel leader) using the same equipment within short intervals of time. [ISO 5725, part 1]

repeatability limit: The value less than or equal to which the absolute difference between two test results obtained under repeatability conditions may be expected to be with a probability of 0.95. [ISO 5725, part 1]

reproducibility (R): Precision under reproducibility conditions. [ISO 5725, part 1]

reproducibility conditions: Conditions where test results are obtained with the same method on identical test material in different laboratories with different operators using different equipment. [ISO 5725, part 1]

reproducibility limit: The value less than or equal to which absolute difference between two test results obtained under reproducibility conditions may be expected to be with a probability of 0.95. [ISO 5725, part 1]

resolution: The dispersion of the distribution of individual threshold estimates (ITE's) for one sample. Calculated from the "determination limit" (84%ile) and the "reaction limit" (16%ile).

retrospective screening: A procedure for reviewing olfactometry results where results of assessors that show a deviation from normal due to health or specific hypersensitivity or hyposensitivity are remove from the group test average. Removal of an assessor's results may be based on the standard deviation or the ratio between their individual threshold estimate (ITE) and the group (panel) average.

RT: see "recognition threshold"

sample: The sample is the odorous gas sample.

Scentometer: A brand of field olfactometer originally manufactured by Barneby–Cheney Company as a result of US Public Health Service Grants in 1958-1960. Also a slang term for a field olfactometer (see "field olfactometer").

screening: A preliminary selection procedure. [ASTM E253-97]

sensory adaptation: a decrease in sensitivity to a given stimulus which occurs as a result of exposure to that stimulus. [ASTM E253-97]

sensory fatigue: Form of adaptation in which a decrease in sensitivity occurs. [ISO 5492]

smell: See "aroma" or "odor."

standard conditions: Room temperature (293K), normal atmospheric pressure (101.3 kPa) on a wet basis [ISO 10780].

step factor: The factor by which each dilution level in a dilution series differs from adjacent dilution levels.

sub-threshold: Pertaining to a stimulus below the specified threshold. [ASTM E253-97]

supra-threshold: Pertaining to a stimulus above the specified threshold. [ASTM E253-97 & E544-99]

test administrator: See "panel leader."

three-alternative forced choice (3-AFC): A test presentation used in odor threshold testing by dynamic olfactometry. The assessors are presented with three samples, one of which contains the diluted odor, while the other two contain odorless "blank" air [ASTM E1432-91].

triangle test: A method of difference testing comprising three coded samples, two of which are the same. The assessor is asked to select the odd sample.

triangular forced choice: A method of olfactometry testing where the assessor is given two blank (odor free) presentations and one dilute odor sample. The assessor is forced to choose which of the three presentations contains the odor.

trueness: The closeness of agreement between the average value obtained from a large series of test results and an accepted reference value [ISO 5725, part 1].

yes / no method: A method of olfactometry in which assessors are asked to judge whether an odor is detected or not at multiple dilution levels.

Z: The variable which stands for a dilution ratio [ASTM E679-91].

Appendix II. Collection of Odorous Air Samples – Case Study

Odorous air samples can be collected from point emission sources (i.e. stack or vent) and from surface (area) emission sources (i.e. liquid surface or solid surface). "Whole-air" samples for laboratory odor testing are typically collected in 10-liter Tedlar gas sample bags for transport to the odor-testing laboratory. Note, also, that Teflon gas sample bags are specified in some sampling protocols.

Odor sampling is often part of an odor study; part of an odor control system performance test; or part of a routine performance test at a facility. The purpose of the odor sampling is often to compare odors from various processes at the facility or to determine if the odor control system is performing according to specifications. Therefore, a case study is used in this Appendix to explain and illustrate sampling from a point source, from an area sources, and from the inlet and outlet of an odor control system. The case study includes collecting four "whole air samples" from a typical wastewater treatment plant (WWTP) facility.

The four samples from the facility are:

#101 Digester Sludge Tank Exhaust
#102 Gravity Belt Thickener Exhaust to the Biofilter
#103 Biofilter Surface from the Gravity Belt Thickener Exhaust
#104 Surface of Influent Channel to Primary Clarifiers

Using the WWTP case study example, the sampling protocol would require the samples to be collected under "normal" operating conditions. The planners of the sampling would determine when "normal" operating conditions existed. The person doing the sampling would document the conditions of the processes and buildings (i.e. doors and windows open or closed) at the time of sampling. The conditions at the time of collecting the samples would be documented so that the results would be in context to the sampling plan's objectives

Prior to the sample taking, the sampler would gather together the sampling equipment that might be needed:

1. Ladder,
2. Pliers or wrench to open sample ports;
3. Pitot tube/inclined manometer to measure velocity and pressure in ducting;
4. Thermometers (wet and dry bulb) to measure temperature of the exhaust air;
5. 10-liter Tedlar gas sample bag with a label;
6. Vacuum case with vacuum pump;
7. Flux chamber for quiescent surface sampling;
8. Tall passive chimney for aerated surface sampling;
9. Teflon sample line (from sample point to vacuum case);
10. Shipping case; and
11. Portable instruments to measure specific chemicals or chemical groups.

In addition to collecting the samples for odor parameter testing, the sampling protocol may require a companion sample (i.e. duplicate) to be collected in a Tedlar gas sample bag or a stainless steel silicate lined or unlined canister for odorant, chemical compound analysis, i.e. reduced sulfur compound gas analysis or volatile organic compound analysis. The protocol may also require testing for specific chemical odorants in the air with portable instruments, i.e. Jerome brand hydrogen sulfide analyzer.

The sampler would also need the following documents ready for use prior to the sampling:

1. Sampling protocol;
2. Air velocity data and calculation sheet;
3. Chain of Custody form(s);
4. Shipping box or case with mailing label;
5. Documents for express shipping; and
6. Phone number of the laboratories and the express shipper.

Sampling Exhaust Stacks and Vents

Sample #101 from the Digester Sludge Tank Exhaust is taken from a "point source" discharging from a short stack above the exhaust fan. Sample #102 from the Gravity Belt Thickener Exhaust is taken from what was a "point source" before it was ducted to the Gravity Belt Thickener Biofilter. The sampler would take air velocity, pressure and temperature measurements on the exhaust air streams from both exhaust fans. The sampler would prepare the sample tubing, sample bag, vacuum case and pump. The 10-liter Tedlar sample bag would be labeled with a number and date. With the bag valve open, the bag would be connected to the tubing inside the vacuum case. The vacuum case would then be sealed. Acting as a sample probe, the Teflon sample tubing would be held in position inside the exhaust stack or exhaust ducting and connected to the bag inside the vacuum case, see Figure II-1. The vacuum pump would then be connected in order to create a vacuum in the case. The vacuum in the case would cause the sample bag to fill with the odorous air from the exhaust stack. Figure II-2, Vacuum Case for Odor Sampling, illustrates the sampling apparatus. Note that an alternative method for sample collection is to use a peristaltic pump.

Figure II-1 Sampling Probe

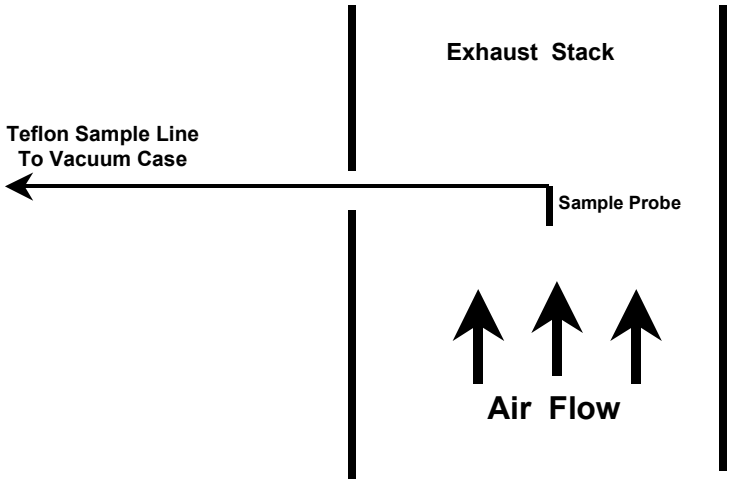
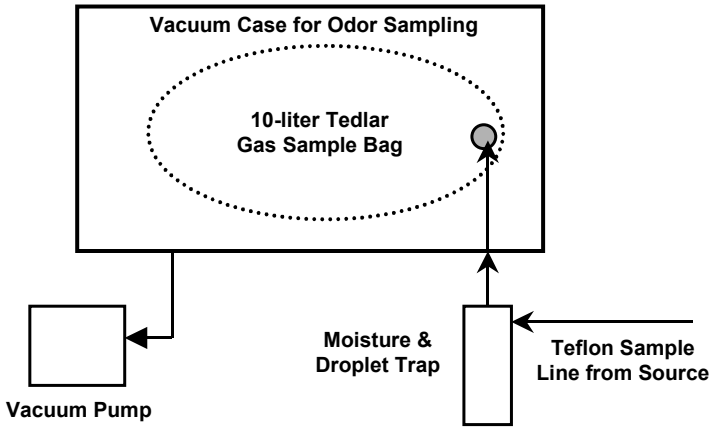


Figure II-2 Vacuum Case Diagram for Odor Sampling



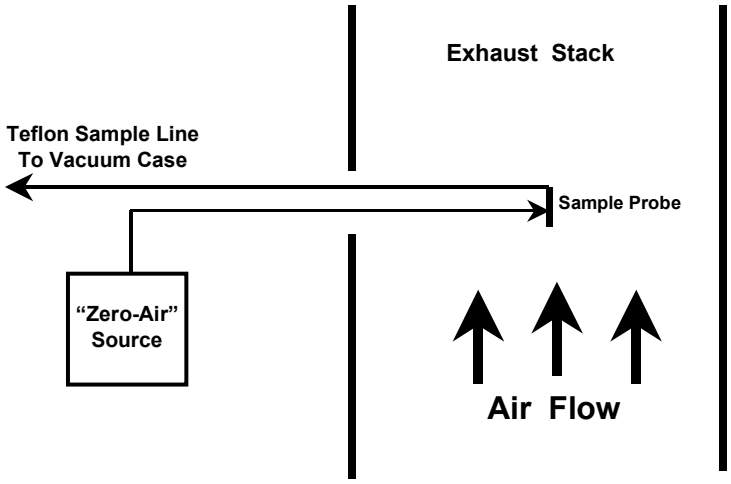
The 10-liter Tedlar sample bag would be first filled with the odorous air for "conditioning" the bag. The bag would be filled to approximately 1/3 full and held for one minute. The bag would then be emptied using the pump to pressurize the vacuum case. The odorous air sample would be discharged back to the exhaust stack through the Teflon sampling line. An alternative method for discharging the odorous air from the sample bag involves removing the bag from the vacuum case and manually “squeezing” the odorous air from the bag. Note that Figure B-2 illustrates the use of a water trap in

the sampling line prior to the vacuum case for the purpose of preventing any water droplets from entering the sample bag.

The "whole-air" sample would then be collected in the sample bag using the vacuum case as described above. The sample bag needs to be only 2/3 full (approximately 7-liters) sufficient room must be available in the sample bag to allow approximately 20% expansion when aircraft shipping is used. When the vacuum is stopped to the case the sample flow stops. The sample line would be disconnected and the sample bag would be removed from the vacuum case after the bag valve is closed.

If the exhaust air is saturated with moisture or if the exhaust air dew point is above ambient air temperatures, additional sampling procedures need to be incorporated. A moisture trap in the sampling line, prior to the vacuum case, would be needed to collect droplets of moisture that may condense in the sampling line. Further, the sample bag may need to be prefilled with dry "zero air" or "high purity nitrogen" in order to prevent warm moist exhaust air from condensing in the sample bag. A "dynamic dilution" sampling probe may be needed for certain sample collection situations. A "dynamic dilution" sampling probe, Figure II-3, Dynamic Dilution Sampling Probe, is a device that simultaneously collects and mixes the sample from the exhaust source with a diluting gas, such as "zero air". Sampling specialists would need to be consulted in these cases for the specialized equipment.

Figure II-3 Dynamic Dilution Sampling Probe



The odor of exhaust air that contains oxidizing chemicals, such as ozone or chlorine, may change with time. Extra sampling precautions or procedures may be needed in these cases and the analytical laboratories would need to be consulted.

The collected sample bag needs to be protected from sunlight and from potential puncture with a durable shipping case or box. The Chain of Custody record would be completed for the sample. The date, time and description of the sample would be recorded as well as the analysis requested.

Each 10-liter Tedlar sample bag needs to be protected by placing the bag inside the shipping box on its end. Sample bags must never be shipped on top of one another. Sufficient room must be available in the shipping box for each bag to expand approximately 20% when aircraft shipping is involved.

The final steps of the sampler, prior to dispatching the sample shipment, would involve completing the shipping documents (air bill number), calling the express shipping company (i.e. UPS or FedEx) for a pickup, and calling the odor laboratory to confirm sample collection and to transmit the air bill tracking number.

Odor laboratories recognize the variable and uncontrolled nature of field conditions (i.e. weather and equipment) and typically have flexible policies for cancellation.

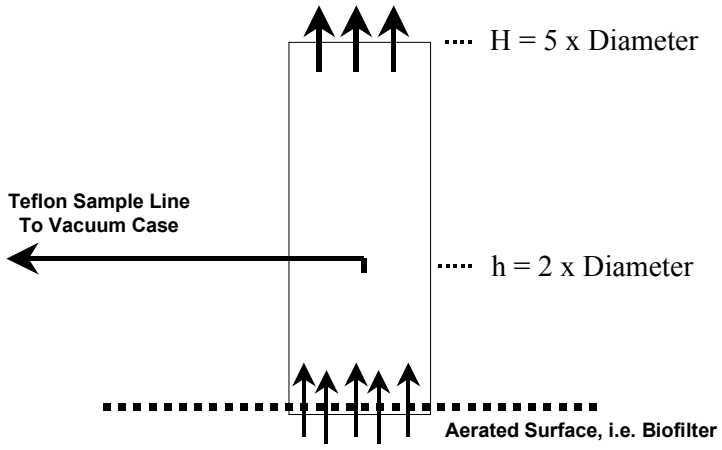
Most odor sampling protocols require the odor evaluations to be conducted within a nominal 30 hour time period after sample taking. When the sample arrives at the odor laboratory, the shipping box and the samples would be inspected with any discrepancies noted, i.e. damage to the sample bags. Review of the sampler's analytical orders on the Chain of Custody Record and comparison of the orders to the original work order would minimize errors and misunderstandings.

Sampling Surfaces

An odorous air sample can be collected from surfaces, sometimes called area sources. Wind speed and direction, air temperature and relative humidity, and solar radiation all affect the odorous emission rate from a quiescent surface, i.e. influent channel of primary clarifier. Aerated surfaces are also affected by the aeration blower flow rate in a diffused air process or the surface of a biofilter. Note that the emission rates for aerated area sources (i.e. aeration basins or biofilters) would be calculated by multiplying the "odor concentration" (i.e. pseudo-dimension of “odor units/cubic meter”) by the blower or exhaust fan flow rate (cubic meters/second).

A “tall passive chimney” or “simulated stack” is an apparatus used to collect aerated surface emission samples. Figure II-4, Tall Passive Chimney Sampler, illustrates the sampling method to isolate an aerated surface. Sample # 103 from the Gravity Belt Thickener Filter Biofilter is taken from the surface of the biofilter that has an upward flow of exhaust air. The tall passive chimney sampler minimizes the effects of cross flow winds at the time of sample collection. A vacuum case would be used to collect the whole-air sample of exhaust air from the biofilter surface using the same bag filling procedure described for the point source sample collection.

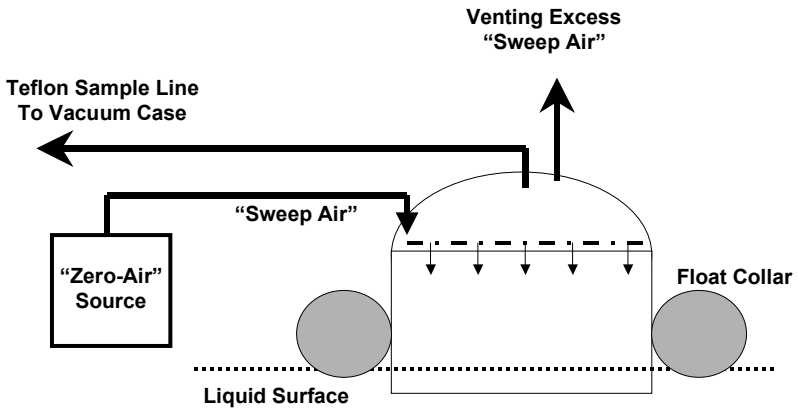
Figure II-4 Tall Passive Chimney Sampler



Sample #104 from the Influent Channel to the Primary Clarifiers was taken using a “flux chamber” floating on the surface of the influent channel. The "flux chamber" or the “surface emission isolation chamber” was originally developed in the 1970's to quantify emissions of inorganic gases from soils. In the 1980's, the U.S. EPA studied flux chambers for measuring the emission of volatile organic compounds from contaminated soil and water surfaces at hazardous waste sites. Figure II-5, Flux Chamber Sampler, illustrates the method to collect whole-air samples from quiescent liquid or solid surfaces. The flux chamber uses a flotation collar to float the chamber on a liquid surface. A clean, odor-free carrier gas (i.e. dry “zero air” or high purity nitrogen) is metered into the flux chamber at a known flow rate (i.e. 5 liters/minute). This flow is known as the “sweep air” for the flux chamber. After an equilibration period of three to four residence times, a sample is withdrawn from the flux chamber at a flow rate less than the sweep airflow rate (i.e. 2 liters/minute). Similar to sampling a point source, a vacuum case and Tedlar sample bag are used to collect the sample from a flux chamber.

The odorous emission rate for an area source would be calculated by multiplying the "odor concentration" (odor units/cubic meter) by a “sweep air” flow rate (cubic meters/second/square meter) of the “flux chamber” used to collect surface emission odor samples.

Figure II-5 Flux Chamber Sampler



Appendix III. Determination of Odor Concentration using Dynamic Olfactometry

This example outlines the calculations from a laboratory test used to determine the odor concentration by dynamic olfactometry. All odorous air samples described in Appendix II were shipped overnight to an odor evaluation laboratory. The laboratory received the samples the next morning and prepared the samples for processing following olfactometry standard ASTM E679-91 EN13725. Following these standard, five assessors were randomly selected from a larger pool of assessors. Each assessor met the butanol threshold and repeatability criteria set forth in EN13725.

All five assessors completed the threshold test (series of dilutions) twice (two rounds). Figure C-1 is an example of an Odor Evaluation Data Sheet for Sample 101 from an odor laboratory. Note the response key at the bottom of this figure [1=incorrect guess, 2=correct guess, 5=incorrect detect, 6=correct detect, 7=incorrect recognition, and 8=correct recognition] (CEN, 2003).

As an example, follow the results of Assessor 1 in Figure III-1. This assessor did not indicate "detection" of the odor at Dilution Level 5, which is a dilution ratio of 4000, but did correctly indicate "a detection" at the next highest odor concentration (lower dilution ratio) of 2000 (two times more odor than 4000). The assessor's individual estimated detection threshold is the geometric mean between 4000 and 2000, or 2820. The result of this statistical method is called the "best-estimate" threshold.

$$\frac{(\log 4000 + \log 2000)}{2} = \frac{(3.60 + 3.30)}{2} = 3.45$$

$$10^{3.45} = 2820$$

The geometric mean is used when calculating the "best estimate" threshold due to the lack of "equal variance" along the dilution ratio scale [Stevens 1962].

The example shown above alludes to a very important concept in analyzing odor-testing data. The ascending concentration series followed during testing of odors is a geometric progression (each dilution level twice the previous level). Since each dilution ratio is half of the previous presentation (twice the amount of odor), the scale does not have an equal spread between values. Applying a logarithm base 10 transformation forces the presentation scale to have an equal spread between dilution levels or, in other words, equal variance along the logarithm scale [Dravnieks, 1986].

Sample No.: 101 Digester Sludge Tank Exhaust

Dilution Level	4	5	6	7	8	9	10	11
Dilution Ratio	8000	4000	2000	1000	500	250	125	63
Log Dilution Ratio	3.90	3.60	3.30	3.00	2.70	2.40	2.10	1.80
Geometric Mean		5657	2829	1414	707	354	177	88
Log (Geo. Mean)		**3.75**	**3.45**	**3.15**	**2.85**	**2.55**	**2.25**	**1.95**

Assessor No.	Responses								Log D	Log R
1	2	1	6	8					3.45	3.15
2	1	1	6	8					3.45	3.15
3	2	2	1	6	8				3.15	2.85
4	1	1	6	8					3.45	3.15
5	1	2	2	8	8				3.15	3.15
1	2	1	6	8					3.45	3.15
2	1	1	6	8					3.45	3.15
3	1	1	1	6	8				3.15	2.85
4	1	2	1	8	8				3.15	3.15
5	2	1	6	8					3.45	3.15

Average Log Value	3.33	3.09
Std. Dev.	0.15	0.13
Detection Threshold	**2140**	
Recognition Threshold		**1230**

Key:
1= Incorrect Guess
2= Correct Guess
5= Incorrect Detection
6= Correct Detection
7= Incorrect Recognize
8= Correct Recognize

Figure III-1 Example Odor Concentration Data Sheet

The individual estimated thresholds of the five assessors over two rounds are averaged to determine the detection threshold. In the example in Figure III-1, this average transformed detection threshold estimate of the 10 tests is 3.33 or 2140 Odor Units (antilog of 3.33 = 2140 O.U.). The recognition threshold is 1230 Odor Units (antilog of 3.09). The "detection threshold" and "recognition threshold" values that are obtained from odor testing are actually derived from dilution ratios, and are therefore dimensionless. However, the pseudo-dimensions of "Odor Units" (O.U.) or "Odor Units per Unit Volume" are commonly applied. For example: "Odor Units per cubic meter."

APPENDIX IV. Statistical Review of Odor Concentration Data

Confidence Interval of Odor Results

It is important to highlight the necessity of the logarithm base 10 transformations that are used in odor testing calculations. These transformations are used to make the non-linear dilution ratio scale a linear scale in logarithm base 10. More specifically, the transformations are performed in order to stabilize (make uniform) the variance. With the uniform variance, the linear transformed data will show symmetry around the group average (panel average result in log base 10). However, this data will be asymmetrical around the reported "dilution factor" (dilution ratio) values of detection threshold and recognition threshold. All statistical calculations, which are based on a normal distribution, must, therefore, be conducted with the transformed values, in this case, the logarithm base 10 values (Mac Berthouex, 1994).

When odor testing is conducted on a number of odor samples, with replicates, the data will produce odor results with a standard deviation. The standard deviation from replicate sampling will represent the odor testing reproducibility. From the reported standard deviation, confidence limits can be calculated for odor testing (CEN, 2003).

An olfactometry laboratory may develop a repeatability record with a standard deviation for replicates of 0.05. This is the standard deviation on the transformed scale of logarithms based on n = infinity. A confidence interval can be calculated for a typical odor concentration value (detection threshold) of 2140 (See Appendix C example for Sample No. 101) using the standard deviation of 0.05. The logarithm base 10 value for 2140 is 3.33.

The 95% confidence interval for the value 3.33 is then defined as:

$$95\%\ \text{C.I.} = 3.33 \pm 2.0 \times 0.05 / \sqrt{1}$$

where: t = 2.0 the Student's t-factor for n = infinity (t = 2.0 for 95% C.I.)

This yields a symmetrical confidence interval for the transformed scale:

$$3.33 \pm 0.10 \text{ or } 3.23 \text{ to } 3.43$$

Transforming back to the original scale of odor concentration (detection threshold) gives an estimate of the asymmetrical 95% confidence interval:

$$\text{Antilog}_{10}(3.23) = 1{,}700 \quad \text{and} \quad \text{Antilog}_{10}(3.43) = 2{,}690$$

Therefore, for the odor value of 2140:

the 95% Lower Confidence Limit (LCL) is 1,700 (approx. 20% less than 2140)
the 95% Upper Confidence Limit (UCL) is 2,690 (approx. 25% greater than 2140)

Note that narrower confidence limits can be achieved with replicate sampling for each sample location, i.e. three samples for each location.

Annex I of the European Olfactometry Standard, EN13725, contains a discussion on how to compute confidence intervals and to determine the number of replicates needed for a defined precision (CEN, 2003). Figure IV-1 plots the upper and lower confidence intervals calculated for increasing number of replicates of the sample analysis. The graph is plotted from data presented in Annex I of EN13725. The data shows the most improvement in precision occurs from increasing from one to three replicates.

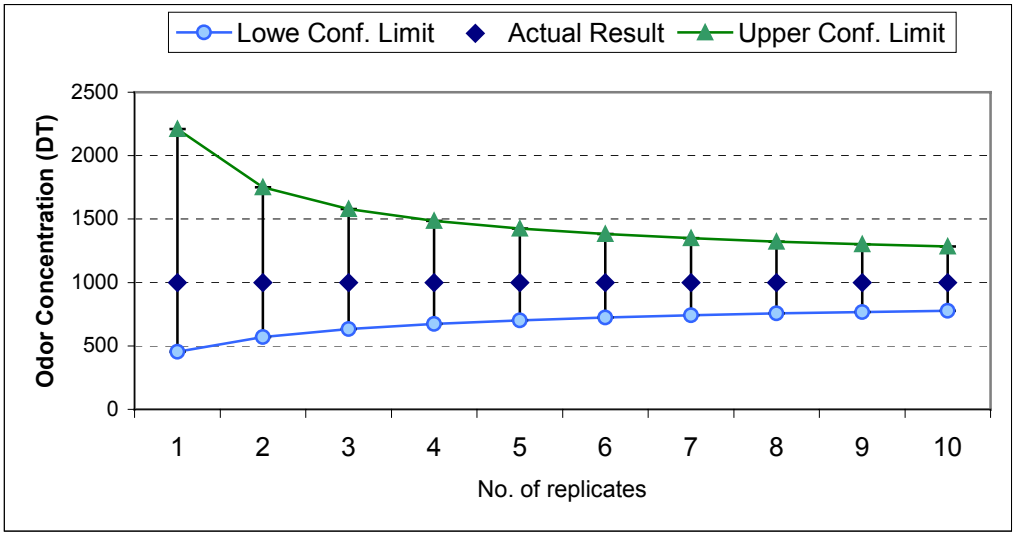


Figure IV-1 95% Confidence Intervals for different numbers of odor concentration measurements (replicates).

Odor Reduction Efficiency

Testing of an odor control system may be used to determine the odor reduction efficiency (η_D). If the inlet or "before" to the odor control system was 1560 (Sample 102, Biofilter Inlet) and the treated or "after" from odor control system was 100 (Sample 103, Biofilter Outlet), then the odor reduction efficiency is determined by:

$$E = \frac{1560 - 100}{1560} \times 100\% = 94\ \%$$

Note that the efficiency calculations can be conducted using the odor "dilution factor" values and need not use the logarithm transformation (CEN, 2003).

Appendix V. Determination of Odor Intensity and Persistency

This example outlines the calculations from a laboratory test used to determine the odor intensity and persistency using a trained panel of assessors. All odorous air samples described in Appendix B were shipped overnight to an odor evaluation laboratory. The laboratory received the samples the next morning and prepared the samples for processing of odor intensity and persistency following olfactometry standard ASTM International E544-99.

ASTM E544-99, "Standard Practice for Referencing Suprathreshold Odor Intensity," presents two methods for referencing the intensity of ambient odors to a standard scale: This example illustrates the Dynamic-Scale Method, which utilizes an olfactometer device with a continuous flow of a standard odorant (n-butanol) for presentation to the assessors.

The odorous air sample is presented to the assessor at full strength. The assessor compares the observed intensity of the odorous air sample to a specific concentration level of the standard odorant from the olfactometer device. Therefore, the assessor will report which level on the butanol scale matches the intensity of the odorous air sample, e.g. "Level 3."

Figure V-1 is a data sheet containing the results of five assessors determining the odor intensity of sample 104, "Surface of Influent Channel to Primary Clarifiers," described in Appendix II.

Sample 104: Surface of Influent Channel to Primary Clarifiers

Assessor No.	Intensity (Assessor Response)	butanol conc. (ppm)	Log Value
1	3	48	1.68
2	2.5	34	1.53
3	3.5	68	1.83
4	2	24	1.38
5	3	48	1.68

Ave. Log Value : 1.62

Odor Intensity (ppm n-butanol) : 42

Figure V-1 Example Odor Intensity Evaluation in a Laboratory.

This referencing method of quantifying odor intensity is the most commonly used method in evaluating environmental odors. For this method, the odor intensity result is expressed in parts per million (PPM) of n-butanol. For Sample 104, the odor intensity is reported as 42-ppm n-butanol equivalent.

Assessors also determine the persistency of the odorous air sample by evaluating the odor intensity at three dilution ratios above the threshold of the odor (suprathreshold). The result of this evaluation is four intensity values over four different "concentrations" of the odorous air sample, full strength and three dilution ratios.

Odor Persistency is a term used to describe the rate at which an odor's perceived intensity decreases as the odor is diluted (i.e. in the atmosphere downwind from the odor source). Odor intensity is related to the odor concentration (dilution ratio) by the "power law" (Steven's Law):

$$I = k\, C^n$$

Where:

I is the odor intensity,
C is the "dilution ratio" and
k and **n** are constants for each odor sample.

Through logarithmic transformation this function can be plotted as a straight line:

$$\log I = n \log C + \log k$$

Therefore, the persistency of an odor can be represented as a "Dose-Response" function. Plotted as a straight line on a log-log scale, the result is a linear equation specific for each odor sample. The slope of the line represents the relative persistency. The logarithm of the constant k is related to the intensity of the odor sample at full strength (Dravnieks, 1986), i.e. the y-axis intercept.

Sample 104 was also evaluated for odor intensity at dilution ratios of 50, 12.5, and 5.0. Figure V-2 is a "Dose-Response" function for sample 104, "Surface of Influent Channel to Primary Clarifiers." This graph shows the log Odor Intensity versus the log of the dilution ratio.

This "Dose Response" graph can be converted to a Power Law graph showing how the intensity changes with odor concentration in "Odor Units." This conversion is completed by taking the recognition threshold of the odorous air sample into consideration. First, the full strength sample presentation, 0.0 log value on the "Dose –Response" graph, has an x-axis value equal to the log of the recognition threshold (Log RT). For sample 104, the RT value was 1000, therefore, on the Power Law graph, this point will be plotted at x=3.0.

The other three points are also converted by subtracting the dilution ratio of the presentation from the recognition threshold (RT) dilution ratio:

$$\log I = n (\log RT - \log C) + \log k$$

Where C is the dilution ratio of the odorous air sample presentation. Figure V-3 is the converted "Dose Response" as the Power Law function.

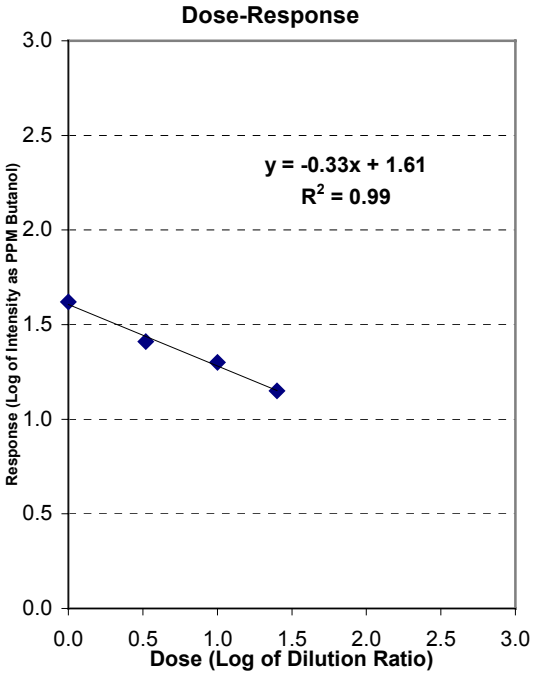


Figure V-2 "Dose-Response" (persistency) graph of odor sample 104

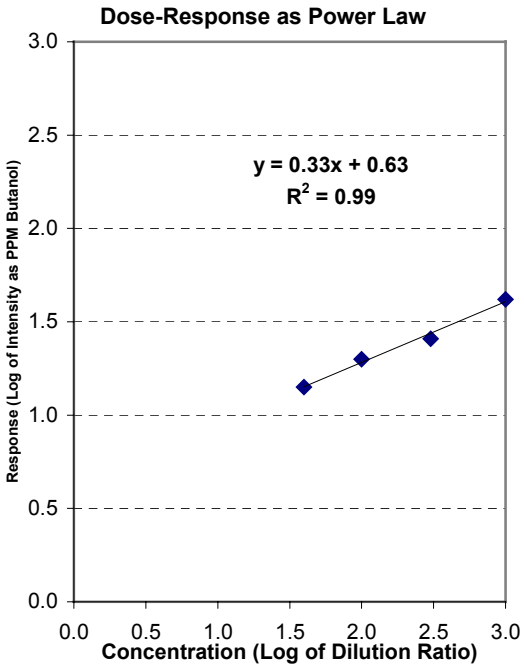


Figure V-3 "Dose-Response" (persistency) converted to "Power Law" graph of odor sample 104

The upward slope of the graph illustrates that the odor intensity of the single odorant increases as the mass concentration increases. The slope of the power law is less than one for odors since it takes a larger and larger increase in concentration to maintain a constant increase in perceived intensity.

Appendix VI. Odor Characterization

Following procedures described in the section titled "Odor Characterization," sample 102 and 103 described in the case study outlined in Appendix B, were evaluated for odor characterization.

Figure VI-1, Odor Characterization – Inlet, represents the results of evaluating Sample 102, Exhaust to the Biofilter. The figure is a spider plot of the eight main odor descriptor categories with the average reported relative strength (0-5 scale) plotted along the lengths of each axis. The further out on the axis the point lies, the stronger the odor character was observed by the assessors. Sample 102, Exhaust to the Biofilter, is highest in "offensive" characters with "Fishy," "Chemical," and "Vegetable" also significantly represented.

Figure VI-1 Odor Characterization: Inlet

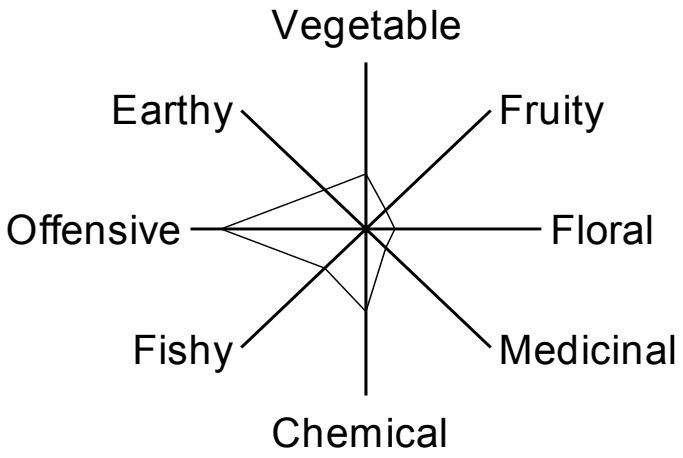
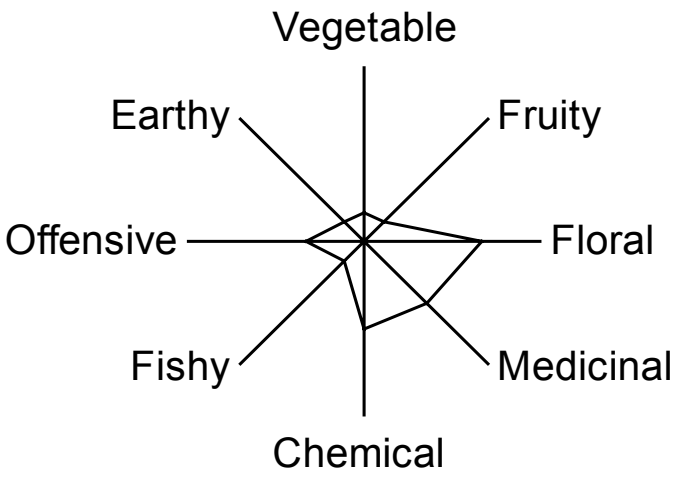


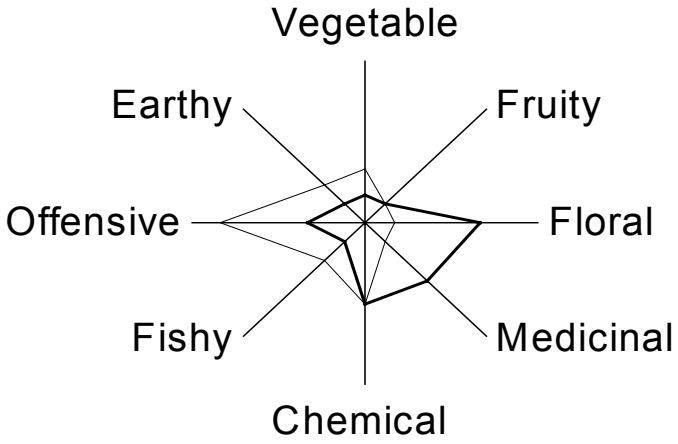
Figure VI-2, Odor Characterization – Outlet, represents the results of evaluating Sample 103, Biofilter Outlet. This sample is highest in relative strength for the "Floral," "Medicinal," and "Chemical" odors with "Offensive," "Earthy," "Vegetable," and "Fishy" also present at lower levels.

Figure VI-2 Odor Characterization: Outlet



Finally, Figure VI-3, Odor Characters – Inlet & Outlet, presents the Biofilter Inlet and Outlet odor descriptors with 2 spider graphs overlapping. This figure shows the reduction in strengths of the "Offensive," "Vegetable," "Earthy," and "Fishy" odors, as well as the increase in "Medicinal" and "Floral" odors.

Figure VI-3 Odor Characters: Inlet & Outlet



In addition to spider graph plots, the odor descriptors reported by an odor panel can be listed or plotted in other formats, i.e. histogram.

Appendix VII. Example Case Study Involving Community Survey Techniques

This case study is intended to provide an example of an odor survey conducted by city personnel investigating ambient odors around several industries in one area of the community.

Five city inspection and enforcement personnel were trained in the topics of odors and odor observation techniques. The personnel learn how to observe the odors following standard practices and procedures. The training also involves field exercises for the personnel to practice these techniques.

A map of the study area is used to plot the observation locations. The inspectors will drive the observation route and stop and make observations at all permanent ("fixed") locations and any predetermined optional locations where they notice an odor.

A data sheet is used to collect the data at each observation point. The data sheet includes weather condition information as well as information specific to each observation point (time of observation, location, D/T value identified, odor intensity based on an odor intensity referencing scale (OIRS), odor character descriptors, identified potential sources of the odor, and any other comments regarding the observation.

Attached to this appendix are an example of a completed data sheet and a map of observation locations around a facility.

The information from the inspection data sheets are entered into a data base for future review and analysis.

EXAMPLE

NASAL RANGER

COUNTY ENVIRONMENTAL DEPT. Date: 1/4/05

Time	Location	D/T 60	30	15	7	4	2	<2	Descriptors	Comments
7:05 AM	1 - INDUSTRIAL PARK							X		
7:10 AM	2 - " "						X		718	FACTORY 'A'
7:15 AM	3 - " "							X		
7:20 AM	4 - " "				X				718, 723	FACTORY 'A'
7:25 AM	5 - INTERSECTION					X			705	FACTORY 'A'
7:30 AM	6 - INTERSECTION							X		
7:35 AM	7 - CO. RD. 20		X						718, 723, 515	'A' & WWTP
7:40 AM	8 - INTERSECTION			X					718, 723	FACTORY 'A'
7:45 AM	9 - JUNCTION RD.				X				718, 723, 515	'A' & WWTP
7:50 AM	10 - CO. RD. 28			X					718, 515, 601	'A' & WWTP
7:55 AM	11 - DIVISION AVE.					X			718, 601	'A' & WWTP
8:00 AM	12 - INTERSECTION							X		
8:05 AM	13 - PARKING LOT					X			104, 304	VEGETATION
8:10 AM	14 - INTERSECTION						X		707	HIGHWAY
8:15 AM	15 - INTERSECTION							X		
8:20 AM	16 - INTERSECTION							X		
8:25 AM	17 - HOUSING DEVEL.						X		201	APPLE TREES
8:30 AM	18 - 3RD & OAK					X			706, 404	COFFEE SHOP

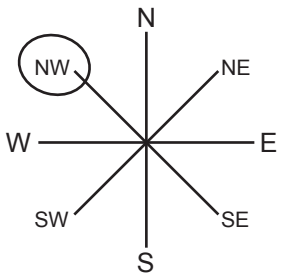
Weather Conditions

- [ ] Sunny
- [ ] Partly Cloudy
- [ ] Mostly Cloudy
- [X] Overcast
- [ ] Hazy

Precipitation:

- [ ] None
- [X] Fog
- [ ] Rain
- [ ] Sleet
- [ ] Snow

Wind Direction Blowing From: (circel one)



Wind Speed:

- [ ] Calm
- [X] Light Breeze (1-5 mph)
- [ ] Moderate Wind (5-15 mph)
- [ ] Strong Winds (15 or higher mph)

Temperature: 55 °F/°C Relative Humidity: 60 % Barometric Pressure: 30.1

Comments: _____

008	NIGEL MACKENZIE	Nigel MacKenzie
Code	Name	Signature

EXAMPLE