TECHNICAL BULLETIN

Technical Assessment and Standards Development Branch March 2021

Methodology for Completing an Odour Assessment for Odour Mixtures

The purpose of this technical bulletin is to provide an overview of the method for conducting an odour assessment for odour mixtures. This technical bulletin will assist facilities with assessing off-property impact at odour receptors using air dispersion modelling. This technical bulletin clarifies the expectations of the Ministry of the Environment, Conservation and Parks (ministry) when preparing odour assessments for mixtures and provides guidance for practitioners.

Table of Contents

1.0 Introduction

The objective of an odour assessment is to better understand the potential odour impacts or adverse effects at locations where human activity occurs. An odour assessment can also provide information to assist in developing an odour control strategy, if needed.

This technical bulletin is intended to complement, and not replace, other ministry guidance materials that are relevant to odour assessments including, but not limited to:

- *Guideline A-10: Procedure for Preparing an Emission Summary Dispersion Modelling Report* ("Guideline A-10");
- *Guideline A-11: Air Dispersion Modelling Guideline for Ontario* (Guideline A-11);
- *Methodology for Modelling Assessments of Contaminants with 10 Minute Average Standards and Guidelines under O.Reg. 419/05 Technical Bulletin* ("Methodology for 10 Minute Average Modelling Assessments"); and,
- *Guideline for Addressing Odour Mixtures in Ontario*.

This technical bulletin provides guidance for any new or existing facility that needs to complete an odour assessment for odour mixtures. An odour assessment may be developed:

- As a voluntary action by the facility, typically in response to odour complaints;
- In support of an Odour Technology Benchmarking Report, or Environmental Compliance Approval (ECA) application;
- As a result of a condition of an ECA;
- As a result of a notice or order issued by a District Manager or Environmental Officer; and,
- In support of land use compatibility studies, etc.

It should be noted that there is inherent uncertainty when estimating emissions and performing dispersion modelling for odour which may impact odour assessment results and therefore odour assessments should only be one of a number of considerations in the decision-making process. Other considerations include the design and implementation of appropriate odour mitigation and/or control measures.

Regardless of the findings of an odour assessment, the obligation to comply with Section 14 of Ontario's *Environmental Protection Act* (EPA) remains and facilities are prohibited from causing an adverse effect. In addition, any contaminant discharged into air must meet the requirements of *Ontario Regulation 419/05: Air Pollution – Local Air Quality* (O. Reg. 419/05) which may include standards or benchmarks based on odour. Contaminants (or benchmarks) with odour-based values in O. Reg. 419/05 must be assessed following the ministry's Methodology for 10 Minute Average Modelling Assessments.

2.0 Requirements of an Odour Assessment

The required elements of an odour assessment include:

- Identification of all odour sources and odorous activities, including fugitive and intermittent sources, and sources resulting from normal start-up and shut-down activities;
- Description of each odour source and odorous activity, including an identification of the worst-case (most odorous) operating scenario, or operating scenarios, including seasonal variations;
- Measurement or estimation of odour emission rates using source testing or another appropriate estimation method (Guideline A-10);
- Identification of odour receptors and determining the times that human activity may be expected at these receptors;
- Air dispersion modelling using site-specific meteorological data; and,
- Interpretation of results, conclusions and recommendations.

The following documents, if previously prepared, can provide information that the facility may choose to incorporate into the odour assessment:

- Best Management Practices Plan (BMPP) for Odour;
- Odour Technology Benchmarking Report (OTBR);
- Odour control / abatement plan, outlining planned mitigation measures and the timelines for implementation;
- Odour Control Report, prepared as a requirement of Ontario Regulation 1/17: *Registrations Under Part II.2 of the Act – Activities Requiring Assessment of Air Emissions* (O. Reg. 1/17); and,
- Details of community liaison efforts and neighbourhood surveys.

Information in an odour assessment may also be referenced when preparing some of the above documents.

3.0 Background

Odours are a major source of public complaints to many regulatory agencies in North American and European communities. Although odours can be from a single contaminant[1], odours from industrial or commercial operations or other activities often result from a mixture of contaminants. Odour mixtures are complex as the chemical interactions are not well understood and there is no general correlation between individual chemical compositions, odour intensity, and adverse effect. In some cases, one odour at a facility may mask odours from other sources. In other cases, the effects may be

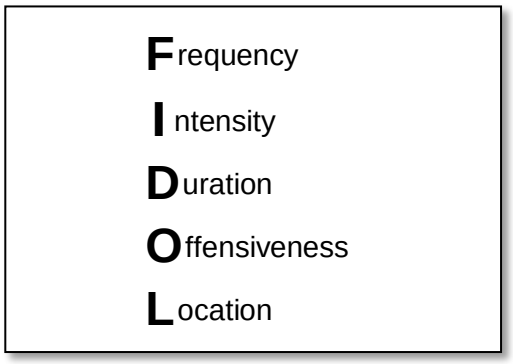
[1] The ministry's ACB list does have benchmarks for some contaminants that are based on odour. Where a contaminant is known to be present, it must still be assessed under O. Reg. 419/05.

synergistic and result in heightened odour strength and/or individual sensitivity to the odours present.

Due to the subjectivity of human perceptions and responses to odour, it is difficult to predict when odours from a facility will result in adverse effects or complaints at specific neighbouring odour receptors.

3.1 Odour Characterization

Although each person's perception of an odour is unique, it is useful to consider and to describe the odour in detail using the FIDOL model.



FIDOL refers to five parameters: Frequency, Intensity, Duration, Offensiveness, and Location, which are relevant to robust odour surveys and assessments. Various combinations of these five factors can lead to off-property odour issues; however, any of the five FIDOL factors can be the determining factor.

Four of the five FIDOL factors can be quantitatively assessed at a receptor with air dispersion modelling: frequency, intensity, duration, and location. The fifth FIDOL factor, offensiveness, is subjective and therefore cannot be quantified objectively. Therefore, in Ontario, odour assessments typically focus on the four parameters that can be quantified.

3.1.1 Frequency

The odour frequency, or how often the odour is emitted or detected over time, can be an important factor in assessing the impact of potential odour sources. Increased frequency of odours may result in even weak or pleasant odours being a source of complaints. Recurring odours (and rapid fluctuations in intensity) may also be more noticeable than steady background odours. Another factor associated with frequency is the timing of the odour. For example, does it occur at the same time of day (e.g. only morning, late afternoon) or in a pattern that can be predicted?

3.1.2 Intensity

Odour strength or intensity is the concentration of the odour and is typically measured in 'odour units'. Odour intensity can also be subjectively quantified using simple descriptors

such as strong or weak, or a simplified odour intensity scale that ranks odours from zero (no odour detected) to ten (a maximum or very strong odour). These subjective methods can be useful when tracking odour complaints over time or over a geographic area.

3.1.3 Duration

The duration refers to the length of time an odour can be present or detectible. The duration of an odour episode may be very brief (a few seconds) or may extend for minutes or hours depending upon the local weather conditions and the source of odour. This information may help determine whether it was the result of an abnormal operating condition or event, or whether the odour is constant or intermittent.

3.1.4 Offensiveness

The offensiveness of the odour is also referred to as the “hedonic tone”. This is not a quantitative parameter, but a subjective rating of the odour‘s pleasantness (or unpleasantness), with assigned descriptors (e.g. sewage, chemical, garlic, rotten eggs, bakery, etc.).

This parameter is subjective because an odour that is very offensive to some may be of little concern to others. There are, however, a number of odours which are offensive to most people that may result in odour complaints at a very low odour concentration (e.g. odours from wastewater treatment, rendering, etc.). The offensiveness of a mixture of odorous contaminants is typically dictated by one or a few dominant contaminants.

3.1.5 Location

People in urban, suburban, undeveloped, or established agricultural areas all have varying sensitivities to odours. The nature of human activity is also a factor, as homeowners and residents may have different responses to odours than people attending schools, community centers or events at sports fields or parks (see section 7.3 for list of various odour receptors).

3.2 Units of Measure for Odour

The concentration of an odour, or odour intensity, is measured in odour units (OU or OU/m^3). The odour concentration of a sample is determined in a lab by olfactometry, where the sample is presented to an odour panel of individuals selected and screened to be representative of the general population. One odour unit (1 OU) is the concentration at which 50% of a panel can just detect the odour (odour threshold). It should be noted that the reference value of 1 OU/m^3 is considered equivalent to an n-butanol (CAS 71-36-3) concentration of 123 ug/m^3.

The following are commonly used odour metrics that have specific relevance to odour assessment. It should also be noted that these odour metrics do not take the offensiveness of the odour into account.

The following definitions can be found in Part G - Method ON-6: Determination of Odour Emissions from Stationary Sources of the Ontario Source Testing Code (OSTC), which specifies procedures and methods facilities must follow when collecting air emission testing data:

- Odour Unit (OU) – for an odour sample, it is a dimensionless quantity which is the number of unit volumes of odourless gas required to dilute one unit volume of odorous sample gas (under standard conditions) to reach the odour panel's detection threshold.
- Odour Concentration (OU/m^3) – the number of odour units per volume of gas at wet standard conditions.
- Odour Emission Rate (OU/s) – the quantity of odour units (OU) which crosses a given surface divided by time. It is the product of the odour concentration, and the wet reference volumetric flow rate (at standard temperature and standard atmospheric pressure, 298 K and 101.3 kPa respectively).
- Odour Panel – typically composed of 8 assessors or more who are qualified to judge samples of odorous gas using dynamic olfactometry. Each assessor must be appropriately screened.
- Odour Flux ($OU/s/m^2$) – the odour released from an area source (with or without induced flow).

3.3 Odour Detection and Recognition Thresholds

The following odour mixture concentration thresholds can be useful for odour assessments.

- Odour Detection Threshold (DT) - The dilution factor at which the sample has a 50% probability of being detected by a human assessor. The DT is sometimes referred to as the Odour Threshold Value (OTV). At the DT, the odour concentration in the sample is 1 OU/m^3 by definition.
- Odour Recognition Threshold (RT) - The dilution factor at which 50% of the odour panel can assign appropriate characteristics or descriptors to an odour. Recognition thresholds are typically 3 to 5 times the detection threshold.

The DT and RT are values that may be obtained by an odour laboratory using dynamic olfactometry with an odour panel. In addition to these thresholds, the laboratory may provide a hedonic assessment with descriptors. Some laboratories provide a semi-quantitative indication of the offensiveness of an odour sample (see section 5.1.1) to allow for comparison between samples.

3.4 Ambient Odour Criterion in Ontario

There is no ambient standard or criterion for odour mixtures in Ontario. Some individual facility ECAs have included a condition that odour effects must not exceed a specified odour concentration (in OU/m^3) at odour receptors, in which case the facility is legally required to meet this odour criterion.

The value of 1 odour unit (OU) is often considered when assessing the potential for odour effects over a 10-minute period using odour modelling results. A value of less than 1 OU does not necessarily mean there is no adverse effect.

3.5 Relevant Ontario Regulations, Guidelines and Tools

The following Ontario Regulations, guidelines and tools are applicable to odour and odour assessments:

i. The *Environmental Protection Act* (EPA). This is one of the primary pieces of environmental legislation in Ontario; its purpose is to provide for the protection and conservation of the natural environment (EPA s. 3). The EPA provides a regulatory framework to address contaminants, which includes odour.

ii. Guideline for Addressing Odour Mixtures in Ontario. This guideline outlines the approach the ministry is taking to address odour mixtures in Ontario. It provides guidance on addressing odour in applications for Environmental Compliance Approvals and Renewable Energy Approvals as well as in land use planning.

iii. *Ontario Regulation 419/05 – Air Pollution - Local Air Quality* (O.Reg. 419/05). This regulation regulates contaminants discharged into the air by various sources, including local industrial and commercial facilities. Although there are no standards for odour mixtures in O.Reg. 419/05, there are standards (or other benchmarks) for specific contaminants that are odorous.

    O.Reg. 419/05 has specific requirements for the preparation of an Emission Summary and Dispersion Modelling Report which are detailed in the ministry's Guideline A-10 and Guideline A-11. These guidelines do not include specific references to addressing odour mixtures; however, odour assessments should adhere to these guidelines where applicable.

    The ministry has also published a technical bulletin to address modelling odorous contaminants with standards, guidelines or benchmarks (Methodology for Modelling Assessments of Contaminants with 10 Minute Average Standards and Guidelines under O. Reg. 419/05). Although this technical bulletin was developed for the purposes of modelling individual contaminants, the requirements in this technical bulletin should also be followed when modelling odour mixtures

iv. The Ontario Source Testing Code (OSTC), Method 6, outlines three traditional methods of sampling for odours (dynamic pre-dilution, evacuated lung and flux chamber methods) and one modified method specific to sampling open bed

biofilters. It is recommended that any odour source testing program be conducted in accordance with the requirements of the OSTC and discussed with a Source Assessment Specialist of the Technology Standards Section, Technical Assessment and Standards Development Branch (including submission of a pre-test plan for comment and approval to promote good quality data). Submission of a pre-test plan is required for compliance source testing.

3.6 Odour Assessment for New or Greenfield Facilities

Where possible, consideration of potential odour effects and the proximity to receptors that may be affected should occur during the site selection stage. For any facility with potential sources of odour, proper site selection can significantly reduce the potential for future odour issues. The ministry has developed guidance for land use planning in the ministry's Land Use Compatibility Guideline and Guideline for Addressing Odour Mixtures in Ontario. These guidelines should be consulted when considering potential facility locations.

Once a site is selected, strategic site layout, facility design, and operational or air pollution controls should be considered with the objective of minimizing or eliminating odour effects once the facility is operational. An odour assessment can be used to assist the facility to better understand what is needed. In the planning stage, it is understood that assumptions regarding odour emission rates will be required. However, the odour assessment can provide insight into which activities and sources are likely to be odorous, where the most frequent effects occur based upon prevailing winds and meteorological conditions, and what reductions can be achieved by changes in facility design, site layout, the addition of odour control on sources, etc.

4.0 Odour Emissions Inventory

The development of an odour emission inventory is a required element of an odour assessment. The first step is source identification and description, which involves developing a comprehensive list of all potential sources of air emissions at the facility. This inventory may have already been prepared (e.g. as part of the development of a BMPP for Odour or an Emission Summary and Dispersion Modelling (ESDM) report for an ECA application) and requires an understanding of all processes and activities that are considered normal or typical for the facility, as well as sources that may be or become odorous. Foreseeable upset conditions (e.g. decomposition of organic matter) are examples of potential causes of odours that are not a normal operation or activity but may result in odours and should be identified and addressed as a potential odour source.

The inventory should be comprehensive and include all point and fugitive sources associated with normal operating conditions, whether they discharge continuously or intermittently, as well as potential odour emission during normal start-up or shutdown.

It is important to note that there are sources that may not release odours at the time that a survey is conducted for the purpose of an inventory but have the potential for odour emissions under certain conditions. For this reason, the odour emission inventory must be prepared in collaboration with site personnel that have a thorough knowledge of the processes and activities.

An initial screening of these sources may identify which sources would not emit odours under normal operating conditions, or which may be considered to have negligible impact in comparison to other sources known to be the main cause of the odour effect. Examples of scenarios where sources of contaminants may be considered negligible are presented in Section 7 of Guideline A-10; however, with odour, screening out sources as negligible or insignificant is more complex than for individual contaminants. Low emission rate odour sources can still be significant if there is poor dispersion, if they are highly offensive, or if the source is very close to an odour receptor.

Caution must be taken to ensure sources that can be significant in terms of the maximum odour emission scenario and modelled effects are not screened out. A summary of sources considered insignificant, if applicable, must be included in the odour assessment along with a rationale for screening them out. This will allow for a review of these sources if significant changes occur at the facility, or if the facility suspects an odour source deemed insignificant is contributing to off property odours.

4.1 Process Sources

Process sources are typically captured and exhausted as point sources. Once captured, these sources may first be directed to pollution control equipment to reduce the emission rate of odorous contaminants. It should be noted that the efficiency of most capture systems is less than 100%. As a result, odour from process sources can also be exhausted by passive vents, general building ventilation fans or louvres, or other fugitive sources.

4.2 Fugitive Sources

Significant fugitive sources of odour must be included in the odour emission inventory. For the purposes of this guidance document, and consistent with Guideline A-10, a fugitive source is a source associated with an area or activity rather than a distinct point of emission or a source whose emissions are not emitted through a confined process stream.

Some examples of potential fugitive odour sources are:

- general ventilation exhausts that are not directly linked to a unit operation or activity;
- building fugitives (open doors, windows, bay doors, louvers);
- pressure relief valves venting odorous gases;

- material transport, handling, and storage (including stockpiles of odorous material and truck track-out);
- leaks of contaminants around process operations; and,
- incomplete capture from ventilation of process operations (such as hooding).

For new facilities, it may be difficult to predict the sources of fugitive emissions and their significance. It is recommended that a new facility adopt appropriate best management practices to reduce fugitive emissions (following the ministry's technical bulletin 'Best Management Practices for Industrial Sources of Odour'), and update the odour assessment once the facility is fully operational.

5.0 Quantification of Odour Emissions

Odour emissions from odour sources can be directly measured by source testing methods or estimated by other means if source testing is not possible. However, estimating emissions from fugitive sources is more difficult. Underestimating emissions rates may lead to odour assessments that may not accurately reflect odour impacts.

The assessment of odour in Ontario is based upon a 10-minute averaging time. Odour emission rates, therefore, must reflect peak or worst-case 10-minute emissions. Section 17 of O.Reg. 419/05 outlines a conversion factor approach to convert 1-hour dispersion model results to 10-minute dispersion model results. This conversion factor approach is based only on meteorological variability and does not consider emissions variability. As such, emission rates must be based on 10-minute peak odour emissions, and the dispersion model results must be converted to 10-minute predictions using the conversion factor approach.

5.1 Source Testing

The use of odour source testing is a common approach to quantifying emissions for an odour assessment. The Ontario Source Testing Code (OSTC) provides guidance intended to facilitate emissions testing of stationary sources to ensure objective and robust data are collected. The OSTC covers Quality Assurance/Quality Control (QA/QC) measures, test methods to determine the sampling locations, number of sampling points, stack gas velocity, flowrate, odour emissions, etc. The OSTC also stipulates that it is essential for the emissions measurement program to be performed by qualified personnel using proper test equipment to ensure the collection of valid test data. The guidance provided in this Technical Bulletin is intended to supplement that of OSTC Method 6 and any requirements stipulated in that Method shall be preferentially followed.

Method 6 of the OSTC outlines four methods of collecting the odour samples for subsequent analysis by olfactometry:

- dynamic pre-dilution (point sources);
- evacuated lung (point and area sources);

- flux chamber (area sources); and,
- static hood sampling method (used for open surfaces with induced air flow such as biofilters, wastewater treatment aeration tanks, clarifiers, etc.).

In addition to these methods, other methods of sampling may be acceptable but should be used with caution and must include consultation with the ministry's Source Assessment Specialists.

Odour sampling methods only provide a snapshot of the odour emissions; therefore, sampling must be strategically scheduled to coincide with the maximum emission scenario for any source.

In order for the ministry to accept source test results, without further analysis, source tests should be validated by the ministry. A ministry validated source test means:

- source testing methods were submitted to the ministry in a pre-test plan;
- the ministry accepted the pre-test plan;
- the ministry had an opportunity to witness the test; and,
- the final report was submitted to the ministry. (Note: if a ministry review of the report indicates that the source test results may not be accurate, the data should not be used)

If the sampling program is carried out voluntarily, it is still recommended that the test program be discussed with a Source Assessment Specialist of the Technology Standards Section and a pre-test plan be submitted for comment and acceptance. If unvalidated test results were to be subsequently used as part of a submission to the ministry (e.g. in support of an ECA application), the ministry may not accept the results.

5.1.1 Odour Sample Evaluation

Following the requirements of the OSTC, the odour concentration is determined by olfactometry with the sample presented to an odour panel of individuals selected and screened to be representative of the general population. There is an inherent amount of uncertainty built into odour measurements as a result of using human noses to quantify odours. The concentration of the odour, in OU or OU/m^3, is determined by the number of equal volumes of odour-free air that are needed to dilute the sample to the detection threshold of 1 OU.

The OSTC requires sample odour evaluations be done by an odour laboratory following a slightly modified version of the European Standard EN13725: 2003 "Air quality – Determination of odour concentration by dynamic olfactometry" (EN13725).

Although not required as part of an odour sampling program in the OSTC, the recognition threshold (RT) can be determined by the panelists, as well as odour characterization using odour descriptors. The degree of pleasantness or unpleasantness for the hedonic

tone, and a common hedonic tone scale uses a range from +10 (most pleasant) to -10 (least pleasant), with 0 as neutral. This information can be useful when comparing source odours to complaints; however, odour characterization is not a mandatory component of an odour assessment.

The reported detection limit for olfactometry is based on the analysis of blank samples, and ranges between laboratories. Most odour evaluation laboratories' detection limit ranges from <6 OU to ~16 OU. Therefore, odour sampling and analysis by odour panel is better suited for analysis of odour samples taken at the source of odours, as opposed to ambient measurements which can be lower than the detection limit. Background odour from the sample bag may also be an issue at the lab, particularly when analyzing samples with low levels of odour only slightly above the DT.

Some odour sources may be problematic for sampling and analysis by olfactometry, such as oil mists or hot sources with high moisture content as the results may be biased low by condensable materials. The presence of oxidizing agents in the exhaust gas, such as ozone or sodium hypochlorite, may also result in the degradation of the odour sample within the bag prior to analysis.

5.1.2 Requirements for Odour Laboratories

Odour sample results can also be used to design exhaust stacks, select appropriate odour control, determine odour control efficiency, etc. It is therefore critical that they be as accurate as possible.

When analyzing odour samples, odour labs are expected to follow the methodology outlined in EN13725 and the OSTC. In order to assure high quality sample analysis, it is recommended that all odour samples be analyzed by an odour laboratory with some form of accreditation. Currently no Ontario-specific odour lab accreditation is available.

The ministry will work with accreditation organizations to ensure the quality requirements for Ontario's odour laboratories are appropriately developed. Once these quality requirements are developed, it is anticipated that within a reasonable amount of time, all odour laboratories will be required to be accredited in order for the Ministry to validate their laboratory results. Accreditation requirements that will be developed are anticipated to include:

1) demonstrating that the laboratory has an acceptable quality management system in place;
2) demonstrating that the laboratory is adhering to all of Ontario's requirements for proper odour sample analysis;
3) meeting the requirements of EN 13725:2003 (Air quality - Determination of odour concentration by dynamic olfactometry);
4) participating in annual third-party proficiency testing; and,

5) meeting the performance quality requirements of the third-party proficiency testing.

The ministry recognizes that some time would be required for non-accredited laboratories to meet any quality requirements once developed. Therefore, quality accreditation for validated sampling programs is anticipated to start two (2) years after the quality requirements specific to odour labs have been developed. After this date, odour testing results from a laboratory that is not accredited may not be considered as a validated sampling program by the ministry.

5.2 Odour Emission Estimation

There are situations in which only estimated odour emission rates can be used to complete the odour assessment. This is typically the case for new, greenfield facilities that have not yet been constructed. There may also be sources that do not lend themselves to odour source testing due to safety concerns or the nature of the exhaust gases.

The use of engineering calculations to estimate odour emissions from a mixture should be done with caution due to the unpredictable nature of odours. Even in cases where engineering calculations can accurately predict individual contaminant emission rates, there is no accurate method to convert these estimates to an odour mixture emission rate with any accuracy, even if individual odour intensity data is available for the individual constituents. Although there are odour thresholds published for various compounds, these are not additive due to the complex interactions between contaminants and the effects on the odour intensity are not always known.

The quality of the odour assessment output or findings is dependent upon the quality of the odour emission data available. Unfortunately, there is very little published odour data or odour emission factors for industrial sources. There are no factors for odours in the US EPA AP-42 Compilation of Emission Factors, or other references commonly used for developing ESDM reports for air contaminants. Some published odour assessments or guidance documents may have odour data; however, this is very limited and is seldom vetted or peer reviewed.

It is not unreasonable to use published odour concentrations or emission rates for sources that are similar to ones that are the subject of the assessment, as long as the assumptions are clearly identified, and the odour emissions are indeed transferrable. For example, source testing data may be available from:

- another facility that operates a similar process;
- published, representative odour data (e.g. odour emission rates for certain industries or controls may be available); and,
- manufacturer’s guarantee, etc.

However, odour emissions can vary significantly from facility to facility, even when operating the same process or using the same odour controls. Seemingly small changes between facilities such as housekeeping practices, ventilation systems or slight process variations can significantly change the odour emissions. In most cases when using emission factors, the data should be considered marginal or uncertain. Particular caution should be used when applying odour emission factors or emission estimates for new facilities when predicting odour impact on the surrounding area.

5.3 Assessment of Odour Source Potential Using a Field Olfactometer

On-site ambient measurement of odour using a field olfactometer may give an indication of the odour potential of a source. Ambient measurement is not a requirement of an odour assessment; however, this information can be useful by identifying unknown odorous sources, confirming the significance of an odour source, determining whether more accurate quantification of an odour source is required, or confirming whether the source may be deemed insignificant when compared with other sources at the facility. Caution must be used in screening out sources as insignificant, as discussed in Section 4. It should also be noted that ambient measurement is not appropriate for estimating odour emissions at the source.

Any ambient measurements by field olfactometers should be done by trained individuals to obtain a direct measurement of the ambient odour intensity. The field olfactometer must be able to provide accurate and controlled dilution of the ambient air.

5.4 Sampling for Specific Odorous Compounds

Understanding the emission rates of individual contaminants from an odour source does not always provide an accurate understanding of the odour emissions and odour impact. Therefore, sampling for specific odorous compounds is not a requirement of an odour assessment. However, sampling specific compounds can be useful for characterizing the odour source, which can assist with:

- selecting appropriate odour control;
- determining an increase or decrease in odours over different operating scenarios;
- determining the effectiveness of odour controls; or,
- understanding which processes may be causing significant odours.

It should be noted that the requirements of O. Reg. 419/05 must be met in respect of any contaminant discharged into the air, including complying with all contaminant standards. Contaminants with odour-based standards in O. Reg. 419/05 must be assessed following the ministry's Methodology for 10 Minute Average Modelling Assessments.

6.0 Ambient Monitoring for Odour

Ambient odours are present at much lower concentrations than what is found in-stack or at the odour source, typically by orders of magnitude. It is also not uncommon for odour lab detection limits to be in the order of 10 OU or higher. As a result, ambient odour samples in most cases will not be suitable as the detection limit is often too high to produce meaningful results. As mentioned in section 5.3, ambient measurement is not a requirement of an odour assessment; however, odour field surveys and community engagement results, if available, can be useful odour data.

For any ambient monitoring, odour intensity can sometimes be measured using a field olfactometer or ranked semi-qualitatively using a defined scale of intensity descriptors (no odour, weak, strong, very strong). Standard odour descriptors can also be used to characterize the offensiveness. This information can be useful when investigating odour complaints and assessing community odour exposure. However, when doing so, special attention should be paid to local environmental factors and there should be an understanding of other facilities capable of producing odours in the area. For ambient monitoring to be useful, it is important to verify that the odour source of interest is the one being quantified. It should also be noted that ambient monitoring using a field olfactometer is only a short-duration sample and should not be used to determine the maximum odour impact or compliance with an odour criterion or objective.

Specific methods for ambient monitoring for odour are not detailed in this technical bulletin. Any ambient measurements by field olfactometers should be done by trained individuals.

7.0 Dispersion Modelling

Air dispersion modelling of odours is a requirement of an odour assessment as it allows for local assessment of the modelled frequency, intensity, duration and location of odours emitted from point, area, and volume sources at a facility. Consideration of the offensiveness may be included as part of the discussion of the odour assessment findings; however, offensiveness is not included in the dispersion modelling.

Modelling may be a useful tool for new and existing facilities to identify which sources are dominant in terms of odour effects to allow odour mitigation measures to be prioritized. Another use of the modelling is to evaluate various control strategies in terms of the actual reduction in odour at a receptor. Dispersion modelling is frequently an iterative process and the results can be used to determine effective control measures to be considered, including altering stack design and location, assessing building ventilation, switching to operating schedules that avoid or restrict odorous activities to certain times of day when weather conditions are favorable for atmospheric dispersion, etc. Dispersion modelling may also be needed as part of a compliance source testing program required by the ministry or as part of an investigation into odour complaints.

Air dispersion modelling for odour assessments should model all significant sources of odour and follow the requirements of Guideline A-11 and the technical bulletin Methodology for 10 Minute Average Modelling Assessments where applicable for odour mixtures. The Methodology for 10 Minute Average Modeling Assessments outlines a tiered approach that starts with the most conservative, worst case scenario and allows for refinements of source emission rates or consideration of when there is human activity at a given odour receptor.

It is recommended that staff from the ministry's Air Modelling and Emissions Unit, Environmental Monitoring and Reporting Branch be consulted for support in cases with complex source or facility layouts, particularly if the odour assessment is completed for regulatory purposes as a condition of an ECA or is completed in response to a ministry notice or order.

The dispersion modelling should consider all odour sources, including those associated with normal operating conditions as well as odours associated with normal start-up and shut-down activities. It should be noted that when performing dispersion modelling for odours from a facility, odour sources with different characteristics and offensiveness should not be modelled separately.

For odour assessments, the desired model output is the 99.5 percentile 10-minute concentration on an annual basis, which discards the 44 highest hours each year (0.5%) at an odour receptor at a time when human activity is expected to occur. However, when emission estimates are used, it is recommended that the maximum 10-minute concentration is used due to the uncertainty. In addition to the percentile, a frequency analysis of the number of 10-minute periods that odour exceeds a threshold established for the study should also be completed. The model must be set up such that the source input in OU/s results in modelled concentrations in OU/m³ (a caution as the default factor of 1,000,000 to convert g/s to µg/m³ in the model would result in odour over-prediction by a factor of one million).

There may be inherent error in dispersion modelling of aerosols or oil mists or contaminants dissolved in vapour droplets that may form fogs and may settle more like particulate matter rather than disperse like a gas. The deposition may also leave an odorous residue at the receptor that cannot be quantified or predicted using dispersion modelling. There are also odours that are associated with particulate matter that may require special consideration in the assessment.

Another limitation to the modelling is the effects of precipitation and UV radiation, the presence of synergistic or attenuating other contaminants in the atmosphere, or the condensation of odorous gases released from warm sources to a cooler atmosphere. These factors, among others, limit the ability of the dispersion models to accurately predict odour nuisance in all situations. However, the modelling is very useful for assessing the effectiveness of control measures on modelled effects, the frequency of

potential odours at odour receptors, and to identify which sources are likely the main contributors of nuisance odours.

7.1 Meteorological Data

The initial tier of dispersion modelling for odours presented in the Methodology for 10 Minute Average Modelling Assessments requires the assessment of maximum odour concentrations along the facility property line and beyond, and may be done using the regional meteorological data sets that are available on the ministry's website. A full grid of receptors must be used for the modelling domain, generated as outlined in Guideline A-11.

The second tier of modelling allows for the assessment of odour effects at specific odour receptors in the vicinity of an industrial facility. For this, it is necessary to use site-specific meteorological data sets as the data better reflect the local area conditions (i.e. local terrain and land use that may significantly affect ground level wind speed and wind direction). As a result, use of Regional meteorological data sets for assessments of frequency is not appropriate; frequency assessments must only be completed using site-specific data. A site-specific meteorological data set can be requested from the ministry Air Modelling and Emissions Unit, Environmental Monitoring and Reporting Branch (MetDataENE@ontario.ca) using the Request for Approval Under s.13(1) of the Local Air Quality Regulation (LAQR) for Use of Site Specific Meteorological Data form.

In the case where a facility operates a weather station or has access to local data, it is possible to use this data to develop a meteorological data set for use in AERMOD; the use of such a data set should be discussed with the ministry and, in some cases, the ministry may process the site-specific data set or QA/QC the data for use in the model. In order for the data to be considered acceptable for use, on-site or local meteorological stations must meet ministry siting criteria in addition to calibration and maintenance requirements (as outlined in the ministry document Operations Manual for Air Quality Monitoring in Ontario). Alternately, modelling may be done using both the facility's data set as well as the site-specific data set provided by the ministry to allow for comparisons as the facility's data may better represent localized weather patterns.

The odour dispersion modelling assessment could also involve removing meteorological anomalies from determination of the 99.5th percentile odour concentration when a full receptor grid is used; these anomalies are generally included in the meteorological data set to determine the odour frequency. If meteorology anomalies are removed, they must be removed following the procedures specified in Guideline A-11.

7.2 Source Input Data

For existing facilities, the source input data for odour dispersion modelling must include the actual flow rate measured in the stack and if possible, the odour emission rate based upon the wet flow measurement and the average detection threshold reported for each

odour source. This data may be provided in a source testing report, require measurements at the sources, or be determined from manufacturer's specifications. In the absence of source input data, assumptions or estimates can be made for the purposes of modelling. However, the estimates should be sufficiently conservative such that they are not likely to result in an underestimation of odour effects.

7.3 Odour Receptors

The term 'odour receptor' is commonly used by practitioners as locations where human activities regularly occur. The ministry currently has several definitions of an odour receptor, including in the following:

- Terms & Conditions of certain ECAs (referred to as 'sensitive receptor');
- Methodology for 10 Minute Average Modelling Assessments (places 'where human activities regularly occur');
- Ontario Regulation 359/09 (odour receptor);
- Guideline for Addressing Odours Mixtures in Ontario (point of odour reception); and,
- O. Reg. 1/17 (point of odour reception).

For the purposes of an odour assessment, both the time and place where all nearby human activities regularly occur must be considered. The odour receptors that should be considered for odour assessments should include, but not be limited to:

- residences, or buildings or structures that contain one or more dwellings;
- vacant lots that have been zoned residential;
- hotels or motels;
- public facilities where people sleep (e.g. trailer parks, camping grounds, etc.);
- health care facilities;
- senior citizen's residences or long-term care facilities;
- child care facilities;
- camping grounds;
- schools;
- community centres;
- day care centres;
- recreational centres and sports facilities;
- outdoor public recreational areas (e.g. play grounds/parks, picnic areas, places where food/drink are served, etc.); and,
- commercial facilities where there are continuous public activities (e.g. commercial plazas or office buildings).

For some odour assessments, the ministry may also require facilities to consider other locations as odour receptors for the purpose of the assessment (e.g. neighboring industrial facilities if there is a history of complaints from those locations).

The time when human activities regularly occur may also be taken into consideration when determining the frequency of odour at the odour receptor, as outlined in the technical bulletin Methodology for 10 Minute Average Modelling Assessments. Residences need to be considered as odour receptors at all times; however, the periods when institutional (e.g. schools, child care facilities), commercial (e.g. plazas, office buildings) or seasonal (e.g. golf courses) locations are shut down do not need to be considered as odour receptors during those times.

7.4 Frequency of Occurrence

In order to assist in assessing whether emissions from a facility have the potential to cause an adverse effect, and the potential extent of such effects, it is useful to determine the frequency of exceedance of various thresholds. These should be based on a 10-minute averaging period and should be specific to sensitive receptor locations. The following thresholds are examples that could be considered, if applicable:

Odour Intensity (OU/m3)	Annual Frequency of Occurrence (# of periods/yr)	Total Frequency of Occurrence (# of periods in 5 yr met)
1		
3		
5		
7		
10		

The distribution of these occurrences can provide a better indication of potential areas of concern and may be helpful when developing mitigation plans.

7.5 Source Contributions to Odour

Air dispersion modelling can provide useful insight into which odour sources contribute most to off-site effects and should be prioritized for further abatement, if needed.

Once the physical characteristics and odour emission rates for the individual odour sources are included in the model, source groups can be defined to allow for comparison of different operating conditions or mitigation approaches. AERMOD also has the option to run a Short Term EVENT Model that provides a summary report of the basic source contribution information as well as hourly average concentration values for each source for every hour in the averaging period, and a summary of the hourly meteorological data for the event period. This is not required in an odour assessment; however, the EVENT output file is useful in interpreting the results of the odour modelling with consideration of the times that human activities are expected to occur.

8.0 Interpreting Odour Assessment Results

Due to the complexity and subjective nature of odour as well as potential errors in emissions estimation, dispersion modelling, etc., an odour assessment cannot necessarily determine if adverse effect will occur. However, an odour assessment can be helpful and can be used as one of a number of considerations when making decisions regarding potential adverse effects. An odour assessment can also provide a baseline for the facility, helping determine what level of odour control is needed and which sources of odour should be prioritized for abatement, if needed.

To better understand the results of an odour assessment, an odour objective that reflects the likelihood of an odour issue caused by odour emissions from the facility should be used.

In some jurisdictions, including Ontario, a value of 1 OU for the 10-minutes averaging time has been used for reference purposes based upon a lower potential for odour perception and complaints at this concentration. At this level, theoretically 50% of the population are not expected to detect an odour, assign characteristics or attribute the odour to a specific source. However, an odour assessment showing less than 1 OU at a receptor cannot guarantee that no adverse effects will occur. Conversely, in some cases the use of this criterion alone could lead to unwarranted mitigation, particularly if there is no history of odour complaints.

New Facilities or New Sources of Odour

For new facilities, or facilities introducing a new odour source, the facility-wide target for modelled odour at any odour receptor is recommended to be 1 OU or lower for a 10-minute averaging time during times when human activity regularly occur, regardless of the offensiveness. In these cases, it would also be prudent to include appropriately-zoned vacant lands or lands that may be redeveloped as sensitive receptors for the purposes of evaluating potential odour effects. For assessment purposes only, it is considered acceptable if the modelling shows that, at a location of a human receptor, the target is exceeded less than 0.5% of the time, which corresponds to approximately 44 hours per year. However, for design purposes it is recommended that the maximum 10-minute concentration be considered due to the uncertainty.

Again, it should be kept in mind that due to the complexity of odour mixtures, an odour assessment showing less than 1 OU at a receptor cannot guarantee that no adverse effects will occur. This is especially true for new facilities or sources where only emissions estimation is possible (compared to source testing). New facilities or facilities with new sources of odour should consider proper odour control regardless of odour assessment results and should also consider preparing an odour abatement plan in case of future odour complaints. An odour abatement plan could include source testing, identifying any

fugitive sources of odour missed in the initial odour assessment, technology benchmarking, adopting additional best practices, abatement for dominant sources, etc.

When interpreting odour results from facilities or processes that are not yet operational, it would be beneficial to compare the proposed odour controls and best practices to those from similar facilities or facilities with similar processes. Demonstrating that the proposed works are controlled at a level similar or greater compared to other facilities operating with no odour issues can provide justification that the facility is appropriately designed, and the estimated odour impact is reasonable. Conversely, if similar facilities typically require more odour control than the proposed works, the facility should provide justification as to why additional controls are not required.

Existing Facilities

For existing facilities, the odour assessment should include a description of the facility's current odour reduction efforts as well as complaint history. Complaint history for existing facilities can be a good indication of the facility's current odour impact and should be considered as part of any conclusions or recommendations from the odour assessment. For example, a significant history of complaints can be an indication of odour issues regardless of the odour assessment results.

The odour assessment should also compare the modelled odour concentrations to an odour objective of 1 OU (and if applicable, any specified odour concentration which the facility is required to meet); however, for some existing facilities, 1 OU may be too stringent (see section 8.1).

All Facilities

For all facilities, the odour assessment results should include a discussion of the odour source emission rates used for the dispersion modelling. The discussion should focus on the data quality and the maximum worst-case scenario chosen. The following should be discussed for any significant odour source:

- Data quality of emission rate, and if/how the emission rate used is conservative;
- Description and justification for the maximum emission scenario used; and
- Discussion of the maximum emission scenario used compared to the typical day-to-day operations at the facility, if applicable.

All five of the FIDOL factors should also be discussed in the odour assessment results, and should include at a minimum:

- The number of hours per year that an odour may be detected at an odour receptor (i.e. concentration exceeds 1 OU), and the number of hours the modelled odour concentration exceeds the odour objective at an odour receptor (Frequency);

- The maximum and 99.5 percentile concentrations at all relevant odour receptors on the basis of a 10-minute averaging time, determined using an approved air dispersion model, which can include the removal of meteorological anomalies using the method detailed in Guideline A-11 (Intensity);
- For any modelled exceedances of the odour objective and greater than 1 OU, a discussion of the time of day when these exceedances are predicted, whether off-property odour impacts are predicted over individual high hours (short term peaks), under very specific meteorological conditions, or whether odours are predicted to linger over several hours on the same day (Duration);
- The characteristics or offensiveness of the odour. For odour assessments only, infrequent exceedances of the assessment criteria may be considered acceptable for moderately or less offensive odours (Offensiveness); and,
- The land use of the adjacent area of the facility, and any odour receptor, which may influence the sensitivity to the odour (Location).

8.1 Existing Facilities Operating Over 1 OU

There may be instances where existing facilities have been operating long-term with minimal or no complaints, yet the odour assessment for the existing operations results in a predicted odour value greater than 1 OU at a nearby receptor. This could be due to the uncertainty of the emission rates / dispersion modelling (e.g. emission rates used were overly conservative). However, there are other factors that can contribute to a potentially odorous facility operating without causing an adverse effect, such as:

- odours are less offensive;
- frequency/duration of odours are low; or,
- number of odour receptors are minimal or in areas where occasional odours may be tolerated (e.g. farm land).

In these situations, comparing the modelled odour concentrations to the detection threshold of 1 OU may be too stringent. For example, an odour concentration greater than 1 OU (e.g. using the recognition threshold of 3-5 OU) may be appropriate in rural areas, or at sensitive land uses that are only used seasonally or infrequently compared to a residential property where people continuously occupy the premises. However, justification for an odour concentration greater than 1 OU must be provided.

For existing facilities, when assessing odour impacts at new or proposed receptors that are located closer than existing receptors, an odour objective of 1 OU is still recommended.

9.0 Conclusions and Follow-Up Actions

The conclusion of the odour assessment must discuss the likelihood of adverse effects resulting from the facility's odour emissions based upon the results of the emission

estimation, source testing if applicable, dispersion modelling and using the information listed in section 8 – Interpreting Odour Assessment Results.

When determining the likelihood of adverse effects, the facility should also take into consideration all controls and best practices in place. Where the potential for adverse effects has been identified, the facility should consider developing an odour abatement plan including the addition of other best practices and odour controls, as appropriate. In the event that additional odour controls are required, it is recommended that the facility prepare an odour technology benchmarking report following any applicable ministry guidance.