AIR DISPERSION MODELLING
GUIDELINE FOR ONTARIO
[GUIDELINE A-11]

Version 3.0

Guidance for Demonstrating Compliance with

the Air Dispersion Modelling Requirements set out in

Ontario Regulation 419/05

Air Pollution – Local Air Quality

made under the *Environmental Protection Act*

PIBs # 5165e03

Ontario

FOREWORD

The “Air Dispersion Modelling Guideline for Ontario”, (the ADMGO Document), July 2016 version 3, provides guidance on complying with the dispersion model requirements of Ontario Regulation 419/05: Air Pollution – Local Air Quality (“the Regulation”).

This guideline is intended to provide guidance to ensure the fair and consistent implementation of the Regulation. This document updates the previous Ontario Ministry of the Environment and Climate Change (the ministry) document PIBs #516502 dated March 2009.

The ADMGO Document is intended to provide guidance to ensure the fair and consistent implementation of the Regulation and to be used in combination with the ministry document, “Procedure for Preparing an Emission Summary and Dispersion Modelling Report, version 4, 2016”.

The ministry may periodically publish a list of questions and answers to assist in the interpretation of the ADMGO Document. The contents of this document may also be updated from time to time based upon public consultation consistent with the Ontario Environmental Bill of Rights legislation. All web site addresses referred to in this document were current at the time of release.

While every effort has been made to ensure the accuracy of the information contained in this ADMGO Document, it should not be construed as legal advice. In the event of conflict with requirements identified in the Regulation, then the regulatory requirements shall determine the appropriate approach.

For further details or to obtain copies of the approved dispersion models, regional meteorological files, or terrain data please contact:

Ministry of the Environment and Climate Change’s Public Information Centre

135 St. Clair Avenue West, 1st floor, Toronto, ON M4V 1P5

Tel. 416-325-4000 or 1-800-565-4923, or

The ministry’s website.

For any addenda or revisions to this guide please visit the ministry website. Information may also be obtained from:

Ontario Ministry of the Environment and Climate Change

Air Monitoring and Transboundary Sciences Section

Environmental Monitoring and Reporting Branch (EMRB)

125 Resources Rd, Toronto, ON M9P 3V6

General Inquiries: 416-235-6171

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1.0 INTRODUCTION

Ontario's local air quality regulation (O. Reg. 419/05: Air Pollution – Local Air Quality or the "Regulation") works within the province's air management framework by regulating air contaminants released into communities by various sources, including local industrial and commercial facilities[1] . The Ontario Ministry of the Environment and Climate Change (the ministry) regulates contaminants in air to protect communities who live close to these sources. The Regulation aims to limit substances released into the air that can affect human health and the environment, and requires industry to operate responsibly under a set of rules that is publicly transparent.

The Regulation includes three compliance approaches for regulated facilities to demonstrate environmental performance, and make improvements when required. These compliance approaches include meeting air standards prescribed in the Regulation, requesting, receiving and meeting a site-specific standard or registering under and meeting the requirements of a technical standard (if available). All three compliance approaches are allowable under the Regulation.

Provincial air standards are used to assess a facility's individual contribution of contaminants to air. They are set based solely on science without taking into account technological or economic factors. As such some regulated facilities and industry sectors may not be able to meet some standards due to unique technical or economic limitations. In these cases, industries or sectors look to technology and best practices to improve their environmental performance and comply with the Regulation by either requesting a site-specific standard or registering under a technical standard (if available).

The Regulation places limits on the concentration of contaminants in the natural environment that are caused by emissions from a facility. The concentrations in the natural environment are calculated at a location referred to as a "point of impingement" which is defined in section 2 of the Regulation, as follows:

[1] This Regulation does not apply to discharges of contaminants from motor vehicles or to discharges of heat, sound or vibration (section 5 of the Regulation).

Points of impingement

"2. (1) A reference in this Regulation to a point of impingement with respect to the discharge of a contaminant does not include any point that is located on the same property as the source of contaminant.

(2) Despite subsection (1), a reference in this Regulation to a point of impingement with respect to the discharge of a contaminant includes a point that is located on the same property as the source of contaminant, if that point is located on,

(a) a child care facility; or

(b) a structure, if the primary purpose of the property on which the structure is located, and of the structure, is to serve as,

(i) a health care facility,

(ii) a senior citizens' residence or long-term care facility, or

(iii) an educational facility."

The Regulation requires that where a facility discharges a contaminant into the air from one or more sources, the concentration at any point of impingement (POI) resulting from that combined discharge must be less than the standard prescribed in the Regulation. The ministry also uses a broader list of point of impingement limits (ministry POI Limits)[2] and other screening tools[4] to assist in preventing adverse effects that may be caused by local sources of air pollution.

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[2] The generic term "limits" in the context of this guideline means any numerical concentration limit set by the ministry including standards in the schedules to the Regulation, guidelines and recommended screening levels for chemicals with no standard or guideline. The ministry Air Contaminants Benchmarks List (ACB List) summarizes standards, guidelines and screening levels used for assessing point of impingement concentrations of air contaminants.

Demonstration of compliance with the air standards compliance approach under the Regulation begins with development of an Emission Summary and Dispersion Modelling (ESDM[5]) report that includes a summary of total property air emissions. These emissions are then converted to POI concentrations using approved mathematical air dispersion models. In addition, a facility may use an approved air dispersion model in combination with monitoring or measurement to determine compliance.

The “Procedure for Preparing an Emission Summary and Dispersion Modelling Report” (Procedure Document) provides guidance on complying with the requirements of the Regulation that govern the content of an ESDM report, that are set out in section 26 of the Regulation. The Procedure Document should be used in conjunction with this “Air Dispersion Modelling Guideline for Ontario” (ADMGO) (as amended from time to time), other ministry documents, and associated technical bulletins. The guidance in these documents is primarily intended for facilities that are operating under the prescribed air standards compliance approach or are required to do an ESDM report because they are applying for an Environmental Compliance Approval (ECA) or requesting a site-specific standard.

1.1 *Application of the Dispersion Models in the Regulation*

The Regulation requires the use of specified approved dispersion models to assess compliance with ministry POI Limits when using the air standards compliance approach. Earlier versions of the regulation (previously known as Regulation 346 – General Air Pollution Regulation) included a set of suggested air dispersion models in the Appendix to Regulation 346. The models in the Appendix to Regulation 346 are being phased out and replaced with new air dispersion models developed by the United States Environmental Protection Agency (US EPA).

The Regulation provides a staggered phase-out (between 2010 and 2020) of the models in the Appendix to Regulation 346[6], according to a schedule that varies by industrial sector (defined by the North American Industry Classification System (NAICS)).

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[4] For contaminants with standards that have an annual averaging period, please refer to the ministry technical bulletin “Methodology For Assessment Of Contaminants With Annual Average Standards under O. Reg. 419/05” (as amended).

[5] A facility which emits only noise as a contaminant is not required to prepare an ESDM report.

[6] The Regulation defines the “Appendix to Regulation 346” as the Appendix to Regulation 346 of the Revised Regulations of Ontario, 1990 (General — Air Pollution) made under the Act, as that regulation read immediately before it was revoked on November 30, 2005. The “Appendix to Regulation 346” is available from the ministry website or the Public Information Centre.

Subsection 6 (1) of the Regulation lists the “approved dispersion models” which include:

(i) the US EPA dispersion models: SCREEN3 and AERMOD;

(ii) the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) method of calculations for Building Air Intake and Exhaust Design (see section 9 of the Regulation, Same Structure Contamination); and

(iii) the models in the Appendix to Regulation 346.

Please note that ISC-Prime was an approved dispersion model until February 1, 2012.

The “approved dispersion models” in the Regulation are required to be used when assessing compliance with the air standards in Schedules 2 and 3[7] (in accordance with sections 19 and 20 of the Regulation). Approved dispersion models are also used to assess conformance with ministry guideline values. Note, however, that the models in the Appendix to Regulation 346 are **only** considered to be an “approved dispersion model" if section 19 applies to discharges from the facility.

The models work in conjunction with the standards as follows:

- To demonstrate compliance with the half-hour average air standards listed in Schedule 2 of the Regulation, any of the approved dispersion models may be used (after appropriate conversion of time averaging periods is made as per section 17 of the Regulation, if necessary).

- To demonstrate compliance with the air standards listed in Schedule 3 of the Regulation, any of the approved dispersion models, **except for** the models in the Appendix to Regulation 346, may be used (after appropriate conversion of time averaging periods is made as per section 17 of the Regulation, if necessary).

Section 6 of the Regulation defines approved dispersion models for the purposes of parts of the Regulation as follows:

[7] Note that under s. 35 (4) of the Regulation, site-specific standard is deemed to be a Schedule 3 standard.

Approved dispersion models

6. (1) For the purposes of this Part, the following are approved dispersion models for discharges of a contaminant, except as otherwise provided:

1. The AERMOD dispersion model made available on the Internet by the United States Environmental Protection Agency, as amended from time to time, or a copy of that model that is available from the ministry.

2. The ASHRAE method of calculation.

3. Revoked: O. Reg. 507/09, s. 4 (1).

4. The SCREEN3 dispersion model made available on the Internet by the United States Environmental Protection Agency, as amended from time to time, or a copy of that model that is available from the ministry.

5. The method of calculation required by the Appendix to Regulation 346, if section 19 applies to the discharges.

(2) The ministry shall make copies of the approved dispersion models referred to in paragraphs 1, 4 and 5 of subsection (1) available through a website maintained by the ministry on the Internet or through the ministry's Public Information Centre.

The US EPA models referred to in section 6 of the Regulation are available on the US EPA website or at the ministry Public Information Center. As noted in the Regulation, these models are updated from time to time. This means that there is a specific version of each of these models that is considered to be an "approved dispersion model". Under subsection 177 (6) of the Environmental Protection Act, the adoption of an amendment to a document that has been incorporated by reference (e.g. AERMOD/AERMET/ASHRAE), comes into effect once the ministry publishes a notice of the amendment in either The Ontario Gazette or the environmental registry under the Environmental Bill of Rights (EBR), 1993. Modellers should refer to the ministry's website for information on air dispersion model versions to be used to demonstrate compliance with O.Reg.419/05.

The ASHRAE method of calculation is copyrighted and a licence to use this method must be purchased from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE Handbook - Building Air Intake and Exhaust Design).

1.2 *Key Phase-In Dates*

The ministry continues to develop and update air standards to regulate contaminants. All facilities operating under the air standards compliance approach are required to comply with any new or revised air standards by the posted phase-in dates or follow one of the other compliance approaches (e.g. site-specific standards or technical standards). Compliance with air standards is primarily assessed using air dispersion models. Newer air dispersion models are being phased in by sector as the models in the Appendix to Regulation 346 are being phased out.

The staged phase-out of the models in the Appendix to Regulation 346 is set out in sections 19 and 20 of the Regulation. In general, the phase-out is as described below:

- Until February 1, 2020, facilities may use any of the models listed in section 6 of the Regulation, including the models in the Appendix to Regulation 346, to assess compliance with the air standards in Schedule 2. However, facilities within the sectors listed in Schedule 4[8] or Schedule 5 may only choose from SCREEN3 or AERMOD to assess compliance with the air standards in Schedule 3 and must assess same structure contamination using the ASHRAE method.

- **On or After February 1, 2020**, all facilities may only choose from SCREEN3 or AERMOD to assess compliance with the air standards in Schedule 3. All facilities must also use the ASHRAE method to assess same structure contamination.

A notice can be issued by a ministry Director prior to the phase-in period to assess compliance with Schedule 3 standards, using a newer US EPA model set out in subsection 6 (1) (please refer to subsection 24 (2) of the Regulation). However, such facilities would not be required to comply with the Schedule 3 standards until their phase-in date.

[8] Newer models [SCREEN3, AERMOD, and ASHRAE] applied to Schedule 4 facilities on February 1, 2010 and to Schedule 5 facilities February 1, 2013.

If a facility is not in a sector listed in Schedule 4 or 5 they can request a “speed up” to Schedule 3 standards in advance of the phase-in dates (as per subsection 20 (4)). This requires them to comply with Schedule 3 standards only for the individual contaminants that are set out in the notice. Alternately, the Director can issue an Order under subsection 20 (5) of the Regulation to require the Schedule 3 standards to apply. That facility would then be governed under similar rules of Schedule 4 or 5 for the contaminants set out in the Order.

Note that the ASHRAE method may be used by any facility in advance of the mandatory phase-in dates of the Schedule 3 standards to assess same structure contamination using Schedule 2 half-hour air standards. Similarly, the SCREEN3 or AERMOD models may be used in advance of the mandatory phase-in dates to assess maximum POI concentrations using Schedule 2 half-hour air standards (see section 17 of the Regulation). If a facility wishes to use the Schedule 3 standards as their compliance point, they may request that the Director issue a notice under subsection 20 (4) of the Regulation, as described earlier.

The models in the Appendix to Regulation 346 are available from the ministry website. Copies of SCREEN3 and AERMOD can be obtained from the US EPA website as well as through the ministry’s website or Public Information Centre. The ASHRAE method of calculation is copyrighted and a licence to use this method must be purchased from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE Handbook).

Key Phase-In Dates for Air Standards

New/updated air standards apply to all sectors regardless of the models used to assess POI concentrations. Air standards are phased in over a period of time so that industry can take actions needed to comply with the regulation. Generally, new or updated air standards are phased in over a three to five-year period.

1.3 **Specified Dispersion Models**

Section 7 of the Regulation generally states that where a model is at least as accurate for that facility as an approved dispersion model, the Director may add it to the list of approved dispersion models for that facility. Conversely, where a model is less accurate than an approved dispersion model (or another model that the facility has been notified to use under section 7), the Director may remove it from the list of approved dispersion models for that facility.

In summary, subsection 7 (1) allows that where the Director feels that a model may predict more accurately than another, the Director may require a person to use:

- a specific approved dispersion model;

- another dispersion model (e.g. alternative model); or
- a combination of models or a combination of models and monitoring.

Specifically, subsections 7 (1) to 7 (3) of the Regulation state:

<u>Specified dispersion models</u>

"7. (1) The Director may give written notice to a person who discharges or causes or permits the discharge of contaminants from a property stating that the Director is of the opinion that, with respect to discharges of a contaminant from that property,

(a) one or more dispersion models specified in the notice would predict concentrations of the contaminant at least as accurately as an approved dispersion model;

(b) a combination specified in the notice of two or more dispersion models would predict concentrations of the contaminant at least as accurately as an approved dispersion model;

(c) a combination specified in the notice of one or more dispersion models and one or more sampling and measuring techniques would predict concentrations of the contaminant at least as accurately as an approved dispersion model; or

(d) one or more approved dispersion models specified in the notice would predict concentrations of the contaminant less accurately than,

(i) a dispersion model or combination specified under clause (a), (b) or (c), or

(ii) another approved dispersion model.

(2) Before the Director gives a person a notice under subsection (1), the Director shall give the person a draft of the notice and an opportunity to make written submissions to the Director during the period that ends 30 days after the draft is given.

(3) If a notice is given under subsection (1) with respect to discharges of a contaminant from a property, a reference in this Part to an approved dispersion model shall be deemed, with respect to those discharges,

(a) to include a dispersion model or combination specified under clause (1) (a), (b) or (c); and

(b) not to include a dispersion model that is specified under clause (1) (d)."

For example, in the appropriate circumstances, the Director may remove SCREEN3 and AERMOD and add CALPUFF to the list of approved dispersion models for a facility. Accordingly, the facility would then be required to assess compliance using only CALPUFF. A ministry Director would implement the above, by written notice. Note, however, that such a notice would not be effective for compliance purposes until section 20 began applying to the facility (see subsections 7 (8) and (9) of the Regulation). As outlined previously, the application of section 20 can be "sped up" if the facility requests a notice under subsection 20 (4) or if the Director orders it under subsection 20 (5).

Subsections 7 (5) to 7 (11) of the Regulation include requirements on how the specified dispersion models will be used in terms of timing; reference to "approved dispersion models", ESDM reports and standards.

Specified dispersion models

"7.

(5) Subsection (3) does not apply to a discharge of a contaminant until,

(a) three months after the notice is given under subsection (1), unless clause (b) applies; or

(b) one year after the notice is given under subsection (1), if the notice includes a notice under clause (1) (c).

(6) Subsection (5) does not apply for the purpose of preparing a report to which subsection 23 (3), 24 (2), 30 (5) or 32 (16) applies.

(7) Subsection (5) does not apply to a discharge of a contaminant if subsection (3) would have the effect of permitting the discharge.

(8) If a notice is given to a person under subsection (1) and section 20 does not apply to the person in respect of a contaminant, subsection (3) applies to the person in respect of the contaminant only after section 20 begins to apply to the person in respect of the contaminant.

(9) Despite subsection (8), if a notice is given to a person under subsection (1) and section 20 does not apply to the person in respect of a contaminant, subsection (3) applies to the person in respect of the contaminant for the purpose of preparing a report to which subsection 23 (3), 24 (2), 30 (5) or 32 (16) applies.

(10) The Director may, by written notice, revoke a notice given under subsection (1).

(11) Subsection (3) ceases to apply to discharges of the contaminant three months after the notice is given under subsection (10).

Subsection 7 (5) of the Regulation states that the specified use of a dispersion model as an approved dispersion model is not applicable until three months (or one year if monitoring is involved) after the issuance of a written notice by the Director. Subsection 7 (7) clarifies that the three month delay, before the required use of the specified model, is only applicable if the facility is not in compliance with ministry POI Limits (i.e. it is not applicable if the specified model would enable the facility to demonstrate compliance with the standard).

2.0 OVERVIEW OF THE APPROVED DISPERSION MODELS

2.1 Modelling Overview

Air dispersion modelling is the mathematical assessment of contaminant impacts from emissions sources on air contaminant concentrations within a study area. Factors that impact the fate and transport of contaminants in the atmosphere include meteorological conditions, site configuration, emission release characteristics and surrounding terrain, amongst others.

2.2 *Overview of the Models in the Appendix to Regulation 346*

The models in the Appendix to Regulation 346 consist of the following three models:

- The Scorer and Barrett model/equation for use in calculating concentrations at points of impingement on the same building or structure and up to 5 metres horizontally from the building or structure on which the point of emission is located.
- The Virtual Source dispersion model for use in calculating point of impingement concentrations from stacks and vents that are generally less than twice the height, above grade, of the building that the stack or vent is on.
- The point source dispersion model for use with stacks that are generally greater than twice the height, above grade, of the building that the stack or vent is on.

The virtual source and the point source models have been translated into a software program known as the Regulation 346 Dispersion Modelling Package available from the ministry's website. This software package has been set up to search through the slightly unstable and neutral meteorological conditions[9] specified in the Appendix to Regulation 346 to identify the meteorological condition which will give the highest half-hour average concentration at a point of impingement. The program is

[9] The models in the Appendix to Regulation 346 use slightly unstable and neutral conditions referred to as C and D atmospheric stability classes but does not include the unstable conditions identified as A and B atmospheric stability classes nor the stable conditions, identified as E and F atmospheric stability classes.

designed to search through all ground-level receptors[10] off the facility's property to find the maximum half-hour average concentration. In addition, the Regulation 346 Dispersion Modelling Package can calculate the concentration at specific points of impingement, such as air intakes on the roofs of nearby buildings or impingement on the sides or roof of an apartment building. See Appendix C for instructions on the use of the models in the Appendix to Regulation 346.

2.3 Overview of SCREEN3, AERMOD and ASHRAE

Ontario's approved dispersion models include SCREEN3 for screening analyses and AERMOD for more sophisticated modelling analyses. In addition, the ASHRAE model must be used as necessary to assess potential for contamination of building air intakes that are located on the same structure as the source of the contaminant (see section 9 of the Regulation). SCREEN3 or AERMOD are used for assessment of POI concentrations at receptors that are not located on the same structure as the source of contaminant. A brief overview of each of these models can be found in the following subsections. For appropriate model selection, please review Chapter 2.3.1 – 2.3.3, as appropriate that outline the details of the following air dispersion models:

- AERMOD
- SCREEN3
- ASHRAE (same structure contamination)

2.3.1 AERMOD

The AERMIC (American Meteorological Society/EPA Regulatory Model Improvement Committee) Regulatory Model, AERMOD[1,2, 3,4] was specially designed to support the US EPA's regulatory modelling programs. AERMOD was developed to replace the Industrial Source Complex Model-Short Term (ISCST3) as US EPA's approved model for most small-scale regulatory applications[5,6]. It incorporates concepts such as planetary boundary layer theory and advanced methods for handling complex terrain. The Plume Rise Model Enhancements (PRIME)[7] building downwash algorithms were incorporated into AERMOD as well.

[10] Air dispersion models compute the concentrations of contaminants emitted from user-specified sources at user-defined spatial points. Modellers commonly refer to these points as receptors. These receptors are used in the modelling exercise to determine concentrations of contaminants at points of impingement as defined in section 2 of the Regulation. See also section 14 of the Regulation.

This provides a more realistic treatment of downwash effects than previous approaches.

The PRIME algorithm was designed to incorporate two fundamental features associated with building downwash:

- Enhanced plume dispersion coefficients due to the turbulent wake.
- Reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake.

BPIP (Building Profile Input Program) must be used to generate the necessary PRIME downwash parameters which then form part of the input file for AERMOD. For more guidance on how buildings are defined, refer to section 4.6.2.

AERMOD is a steady state, Gaussian plume model that is currently the US EPA's regulatory air dispersion model. Some of the significant improvements in AERMOD compared to previous US EPA regulatory models, such as the Industrial Source Complex (ISC) model, are:

- incorporates non-Gaussian plume shapes where appropriate;
- dispersion is a function of horizontal and vertical turbulence that varies with height, and uses continuous growth functions rather than discrete stability parameters;
- calculates effective wind speed through the plume;
- allows the use of measured turbulence in meteorological data preparation;
- mixing heights are calculated using hourly meteorological data rather than interpolating from morning and evening estimates;
- more realistic treatment of terrain impacts;
- plumes may partially penetrate the inversion at the mixing height; and
- impact of urban heat islands on turbulence is taken into account.

Some of the AERMOD modelling capabilities are that the model:

- may be used to model contaminant emissions from many sources;

- can handle multiple source types, including point, volume, area and open pit sources. Line sources may also be modelled as a string of volume sources or as elongated area sources;

- enables emission rates to be treated as constant or varied by month, season, hour-of-day, or other optional periods of variation. These variable emission rate factors may be specified for a single source or a group of sources;

- can account for the effects of aerodynamic downwash due to nearby structures on point source emissions;

- contains algorithms for modelling the effects of settling and removal (through dry deposition) of large particles and for modelling the effects of precipitation scavenging (through wet deposition) for gases or particulates;

- has receptor locations that can be specified as gridded or discrete receptors in a Cartesian or polar coordinate system;

- AERMOD requires two types of meteorological data files, a file containing hourly surface parameters and a file containing vertical profiles. These two files are produced by the US EPA AERMET meteorological pre-processor program(8);

- for applications involving elevated terrain, a hill height scale along with receptor elevation is required at each receptor. The US EPA AERMAP terrain pre-processor program(9,10) can be used to generate hill height scales, as well as terrain elevations for all receptor locations;

- an urban option which results in altering dispersion parameters due to the urban heat island effect is included. Factors that affect the selection of the urban option include the population/urban intensity and the location of a facility relative to the urban core. The urban population is an input to this option; and

- yields results that can be output for concentrations, total deposition flux, dry deposition flux, and /or wet deposition flux.

More details on AERMOD model formulations and options can be found in references 1, 2 and 3, as well as the US EPA Guidelines on Air Quality Models (Revised)(11).

2.3.2 SCREEN3

The SCREEN3 model was developed to provide an easy-to-use method of obtaining contaminant concentration estimates. These estimates are based on the US EPA document "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources"[(12)].

The SCREEN3[(13)] model can perform all the single source short-term calculations in the EPA screening procedures document, including:

- estimating a full range of stability classes and wind speeds to find maximum hourly ground-level concentrations and the distance to the maximum. Concentrations can be calculated at a range of downwind distances.
- incorporating the effects of building downwash on the maximum concentrations for both the near wake and far wake regions.
- estimating concentrations in the cavity recirculation zone.
- estimating concentrations due to inversion break-up and shoreline fumigation.
- determining plume rise for flare releases.
- incorporating the effects of simple elevated terrain (i.e., terrain not above stack top) on maximum concentrations.
- modelling simple area sources using a numerical integration approach.
- estimating 24-hour average concentrations due to plume impaction in complex terrain (i.e., terrain above stack top) using the VALLEY model 24-hour screening procedure.

2.3.3 Use of ASHRAE - Same Structure Contamination Model

Improper stack design and configuration can lead to impacts beyond ground level contamination. The influence of buildings on contaminant emissions is examined in Chapter 4.6 - Building Impacts. The interactions between sources and buildings can also lead to situations of emission re-entry into nearby buildings since many buildings have air-handling units located on their rooftops. As a result, it is important to ensure that emissions from rooftop sources do not allow plume impact on air-handling units on their rooftops, or other intakes located on the same building or structure. This is known as same structure contamination.

The ASHRAE Handbook describes a methodology for proper stack design to avoid re-entrainment of contaminants. The Chapter titled “Building Air Intake and Exhaust Design” in the ASHRAE Applications Handbook, as amended or revised from time to time [14, 15], provides analytical approaches for determining impacts on receptors (in this case, typically air intakes) for a series of stack, rooftop and/or sidewall configurations including:

- Strong Jets in Flow Recirculation Cavity
- Strong Jets on Multi-winged Buildings
- Exhausts with Zero Stack Height (flush vents)

Same structure contamination becomes especially important within industrial parks, institutional settings such as hospitals and college/university campuses, or multi-unit commercial complexes where emissions from one unit can impact neighbouring units (where the neighbouring unit is within the same structure as the emission source) through air intakes, open doors, or windows. The ASHRAE model is for use with respect to a point of impingement that is located on the same structure as the source of contaminant. Recall that “point of impingement” is defined in section 2 of the Regulation. In general terms, a point of impingement (POI) includes: (a) any point off-site; and (b) any point on-site that is (i) on a child care facility; or (ii) on a structure that serves primarily as a health care facility, a senior citizens’ residence or long-term care facility, or an educational facility; and (c) any point on the same structure as the source of a contaminant that does not belong to the facility. In situations where there are multiple structures located in close proximity to one another, contact the ministry (EMRB) for additional guidance regarding the modelling approach. In general, structures located within 5 meters of one another would be considered to be the “same structure” for the purposes of air dispersion modelling.

Section 6 of the Regulation lists the ASHRAE method of calculation as an approved dispersion model. ASHRAE is to be used as the approved dispersion model for “same structure contamination” situations. Section 9 of the Regulation states:

Same structure contamination

9. (1) The following approved dispersion models are the only approved dispersion models that may be used for the purposes of this Part with respect to the contaminant and a point of impingement that is located on the same structure as the source of contaminant:

1. ***The ASHRAE method of calculation.***
2. ***A dispersion model or combination of dispersion models that, pursuant to subsection 7 (3), is deemed to be included in references in this Part to approved dispersion models, if the notice given under subsection 7 (1) states that the Director is of the opinion that the dispersion model or combination of dispersion models would predict concentrations of the contaminant at least as accurately as the ASHRAE method of calculation.***
3. ***The method of calculation required by the Appendix to Regulation 346, if section 19 applies to discharges of the contaminant.***

(2) The ASHRAE method of calculation may be used for the purposes of this Part with respect to a contaminant only with respect to a point of impingement that is located on the same structure as the source of contaminant.

Section 9 of the Regulation sets out that, when the points of impingement are located on the same structure as the source of emission of the contaminant, a person may choose to use ASHRAE (with appropriate time averaging under section 17, if necessary), as the approved dispersion model or the Scorer and Barrett calculation in the Appendix to Regulation 346. However, when section 20 begins to apply, a person must use either ASHRAE or an alternative model specified by the Director in a notice issued under section 7 of the Regulation.

The ASHRAE method can determine concentrations for a range of averaging periods. Where ASHRAE cannot accommodate the averaging period of the standard, then the 1-hour concentration should be determined and converted to the appropriate averaging period for that contaminant using the equations set out in section 17 of the Regulation.

The emission rate (contaminant mass release rate) used in the model must correspond to the averaging period of the ministry POI limit in accordance with section 11 of the Regulation.

It should be noted that modellers assessing same structure contamination using one of the approaches described above must also assess against the ministry POI Limits at other off-property POI locations using one of the appropriate approved dispersion models listed in section 6 of the Regulation. Chapter 8.1 contains additional guidance on ASHRAE.

2.4 **Alternative Models**

There are some situations where the Director may specify the use of a model that is not listed in subsection 6 (1) of the Regulation. Such models would be considered to be an "alternative model" under section 7 of the Regulation. Once a notice is issued, these alternative models may be used instead of, or to complement the ministry's list of approved dispersion models. The following list contains alternative models that are currently considered by the ministry on a case-by-case basis. Please see Appendix A for terms of appropriate use and required supporting explanations.

- CALPUFF
- CAL3QHCR
- SDM – Shoreline Dispersion Model
- Physical or Wind Tunnel Modelling
- AERSCREEN

The ministry may consider other models where a modeller can demonstrate that the alternative dispersion model is at least as accurate as an approved dispersion model. In accordance with section 7 of the Regulation (see Chapter 1.3 of this ADMGO document for an excerpt of section 7 of the Regulation) the Director may authorize the use of an alternative model by issuing a notice, if of the opinion that the specified model would be at least as accurate as an approved dispersion model.

3.0 A TIERED APPROACH FOR ASSESSING COMPLIANCE WITH MINISTRY POI LIMITS USING SCREEN3 OR AERMOD

As set out in section 6 of the Regulation, a person may use the models in the Appendix to Regulation 346, SCREEN3 or AERMOD to assess compliance with the standards in Schedule 2 of the Regulation. In some situations, a conversion to the relevant averaging period of a standard will have to be performed (please refer to section 17 of the Regulation for authorized conversion calculations). A facility that is subject to section 19 of the Regulation (i.e. Schedule 2 standards apply) may request that the Director issue a notice under subsection 20 (4) to allow the use of the Schedule 3 standards as its compliance point in advance of the phase-in dates.

Section 6 of the Regulation also sets out that any of the US EPA approved dispersion models (SCREEN3 or AERMOD) can be used to assess compliance with the standards in Schedule 3 (subject to the section 7 of the Regulation – Specified Dispersion Models).

The SCREEN3 dispersion model is simpler and in many situations is generally more “conservative”[11] in assessing point of impingement concentrations than the AERMOD approved dispersion model listed in section 6 of the Regulation. As a result, it is often appropriate to initially calculate a point of impingement concentration using SCREEN3.

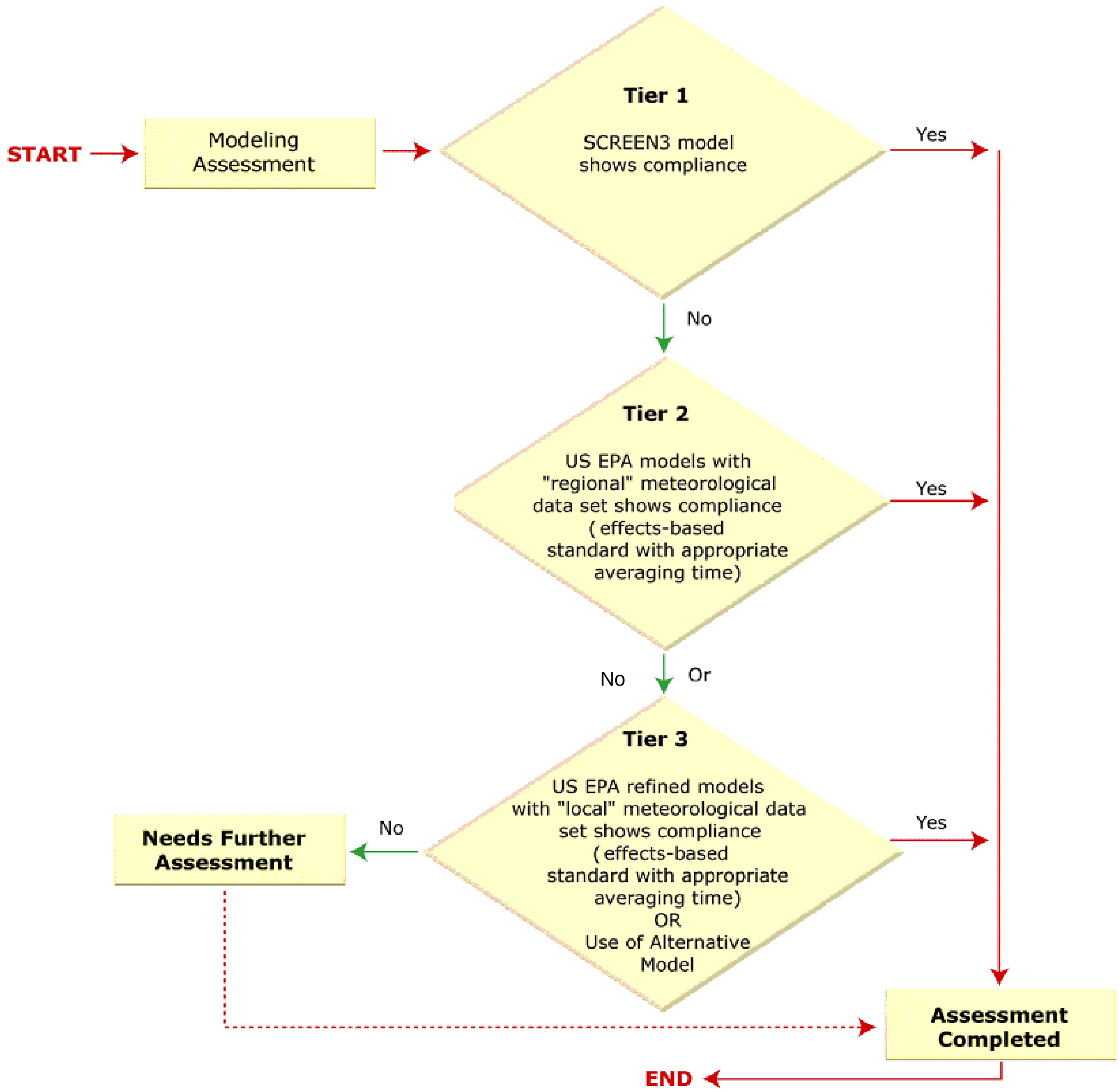
The AERMOD dispersion model uses more refined input data for parameters such as meteorology, local land use and terrain. However, it is reasonable to use simplified data inputs when the selected data results in conservative assessments of point of impingement concentrations. As a result, a modelling assessment may consist of a series of modelling steps. The ministry refers to this step-wise method to modelling as a tiered approach.

A tiered approach to air dispersion modelling is commonly used and is presented in Figure 3.1. This approach focuses the required level of effort according to site requirements. It should be noted that any of the three tiers may be performed and linear progression through each tier is not necessary. More sophisticated modelling techniques would need to be applied each time a successive screen showed an exceedence of ministry POI Limits. Successive screens combined with improved data quality as required by section 12 of the Regulation and in the ESDM Procedure

[11] For the purpose of this ADMGO Document the term “conservative” refers to an assessed POI concentration that is likely to be higher than the actual concentration.

Document, means that the last tier would require the most sophisticated modelling and emission estimating techniques, and would be the most representative of actual on-site conditions and contaminant concentrations.

Figure 3.1: Tiered Modelling Approach Flow Diagram



A Tier 1 assessment represents the most conservative assumptions about meteorological conditions and modelling inputs. To complete a Tier 1 assessment, a modeller shall use the SCREEN3 model.

Tier 2 and 3 modelling assessments represent more sophisticated, precise and accurate modelling inputs and scenarios. The most significant difference between

Tier 2 and 3 assessments is the use of more site-specific or local meteorological data inputs. To complete a Tier 2 assessment, the modeller shall use the pre-processed regional meteorological data made available by the ministry (see Chapter 3.2 Tier 2 Modelling below for data sets). A Tier 3 assessment requires the use of more site-specific meteorological data approved by the Director (e.g. the data required in paragraphs 3 and 4 of subsection 13 (1) of the Regulation). In Tier 3 assessments, the ministry may also require alternative models that may be more representative of local conditions and produce more representative concentrations for specific contaminants.

The Tier 2 and Tier 3 modelling assessments calculate results for each hour of the meteorological data set, which allows for specifying emission rates appropriate to the hour of the day and day of the week for the hourly average, 24-hour average and annual average derivations (i.e., a variable emission rate scenario). For more information on estimating emission rates, refer to the ESDM Procedure Document.

Any modeller may choose to go directly to the more sophisticated modelling techniques (Tier 2 or 3) and skip the initial Tier 1 of the screening methods. In some situations, such as with complex facilities or requests for site-specific standards, the ministry may require a modeller to proceed to Tier 2 or 3 directly.

3.1 **Tier 1 Modelling**

Tier 1 is a screening level analysis and shall be completed a screening model such as the US EPA SCREEN3 model, which requires no input of real meteorological data as it includes all potential worst case meteorological conditions. If a Tier 1 conservative modelling assessment demonstrates compliance with ministry POI Limits, and emission estimates are in accordance with the guidance outlined in the ESDM Procedure Document, there is no need for additional modelling.

3.1.1 Use of Conservative Dispersion Factors

Conservative dispersion factors can be used to conservatively screen out contaminants and/or sources with insignificant (negligible[12]) emissions from further modelling analyses, consistent with section 8 of the Regulation.

Negligible sources of contaminant

"8. (1) It is not necessary, when using an approved dispersion model for the purposes of this Part, to consider a source of contaminant that discharges a negligible amount of the relevant contaminant, having regard to,

(a)the total amount of the contaminant that is discharged by all the sources of contaminant with which the approved dispersion model is used; and

(b)the nature of the contaminant.

(2) Despite subsection (1), the Director may give written notice to a person who discharges or causes or permits discharges of contaminants requiring the person to consider a source of contaminant specified in the notice in accordance with the notice when the person uses an approved dispersion model for the purposes of this Part, if,

(a)the Director has reasonable grounds to believe that, if the source of contaminant is considered, the person may contravene section 19 or 20; or

(b)Sections 19 and 20 do not apply to discharges of the relevant contaminant and the Director has reasonable grounds to believe that, if the source of contaminant is considered, a discharge of the relevant contaminant may cause an adverse effect.

(3) Before the Director gives a person a notice under subsection (2), the Director shall give the person a draft of the notice and an opportunity to make written submissions to the Director during the period that ends 30 days after the draft is given."

A series of conservative dispersion factors (in micrograms per cubic metre per gram per second emission) have been developed using SCREEN3 for a short stack on a 6

[12] Note: The Regulation uses the term 'negligible' in reference to contaminants that are emitted in amounts too small to be relevant and may be excluded from the assessment of compliance with the air standards in the Regulation and ministry POI Limits. The term 'not negligible' is also used in the Regulation (see paragraph 4 of subsection 26 (1)). For the purposes of the guidance information contained in the ESDM Procedure Document and ADMGO, the term 'insignificant' is synonymous with 'negligible' and 'significant' synonymous with the term 'not negligible'.

metre tall building in combination with distances from the stack as shown in Table 3-1. These should be used to assess negligibility in accordance with the approach outlined in the ESDM Procedure Document.

The 1-hour concentrations can be converted for comparison to ministry POI Limits with different averaging periods in accordance with the method outlined section 17 of the Regulation.

Table 3-1: Conservative Dispersion Factors (1-hour averaging period)

Distance (m)	Urban Dispersion Factor ($\mu g/m^3$ per g/s emission)	Rural Dispersion Factor ($\mu g/m^3$ per g/s emission)
Up to 20	8700	10000
40	6300	8100
60	4600	5900
80	3400	5100
100	2600	4500
150	1400	3500
200	900	2800
250	600	2300
300	450	1900
350	350	1700
400	300	1500
450	250	1300
500	200	1150
600	150	950
700	120	800
800	90	650
900	80	575
1000	70	500

3.1.2 Modelling Multiple Sources Using SCREEN3

SCREEN3 performs single source calculations to determine maximum 1-hour average concentrations downwind of the source. SCREEN3 can be applied to multi-source facilities by conservatively summing the maximum concentrations for the individual emission sources.

To simplify the modelling when there are many release points on a facility, a modeller may choose to:

i. combine individual stacks/vents into a single stack where the stack parameters are selected to generate a conservative dispersion factor; or

ii. combine individual sources into area or volume sources where the size and locations of the sources are conservatively selected.

Information on which sources can be grouped and how this can be done conservatively is given in Chapter 4.5.2. Combing Individual Sources into Volume, Area and Single Point Sources. The approach of combining sources may also be used in Tier 2 and Tier 3 modelling as long as the source characteristics selected are reasonably conservative.

3.2 Tier 2 Modelling

Tier 2 assessments involve the use of the more advanced[13] approved dispersion models, such as AERMOD, and the use of regional meteorological data sets made available by the ministry. The ministry has created the regional meteorological data sets to be used in these assessments, which are available on the ministry's website. Alternately, the meteorological data sets may also be obtained through the ministry's Public Information Centre: 1st floor, 135 St. Clair Avenue West, Toronto, ON M4V 1P5, 416-325-4000, 1-800-565-4923.

This is consistent with subsection 13 (1) of the Regulation (for more information on meteorological data, see Chapter 6 of this guideline).

The available files include the pre-processed AERMOD-ready regional data sets in addition to the raw AERMET-ready surface and upper air files. Local land use conditions can be incorporated by using these AERMET-ready surface and upper air files to produce AERMOD-ready files. The dispersion modelling assessment should be completed with the most appropriate regional data set for the location and surrounding land use of the facility and compared to ministry POI Limits for the appropriate averaging period to demonstrate compliance.

Note: As set out in paragraph 2 of subsection 13 (1), it is possible to refine regional meteorological data sets by specifying local land use conditions when using AERMOD. This step would still be considered a part of a Tier 2 assessment, however, the AERMET model inputs must be clearly articulated and documented in the Emission Summary and Dispersion Modelling Report (ESDM Report) (see Chapter 11.1.1 of the ESDM Procedure Document and paragraph 10 of subsection

[13] A reference to an advanced dispersion model in this Guideline is a reference to AERMOD or another air dispersion model capable of using hourly meteorological observations to calculate contaminant dispersion and resulting POI concentrations. Note that this is a different concept than an "approved dispersion model" under the Regulation.

26 (1) of the Regulation). Modellers should consult EMRB to confirm that representative surface parameters have been selected and AERMET is used appropriately.

3.3 Tier 3 Modelling

For situations where ministry POI limits are not met in a Tier 2 assessment, or the regional meteorological data set is not representative of the conditions at the facility being modelled, more precise analysis with locally representative meteorological data or advanced modelling (Tier 3) shall be used to assess contaminant concentrations. Alternative models may be required under section 7 of the Regulation. A Tier 3 assessment would consider the use of alternative models if a notice is issued by the Director under section 7 of the Regulation. Paragraphs 3 and 4 of subsection 13 (1) also set out the requirements for more site-specific meteorological data and subsections 13 (2) and 13 (3) set out a notice provision where the Director may specify the type of meteorological data to be used. For more information, see Chapter 6 of this guideline.

For geographical locations with unique local meteorology, appropriate local meteorological data sets may be obtained from the ministry. Local meteorological data can be developed by the modeller, but all local or site-specific meteorological data must be approved by the ministry. Site-specific meteorological data can be generated using:

- observations (e.g. Environment Canada, National Oceanic and Atmospheric Administration observations) for a representative location in the vicinity of the facility (appropriately converted and reformatted into a format acceptable to AERMET), and upper air data sets, available from the ministry. This data is processed through AERMET along with local land use characteristics to produce the meteorological input files. Chapter 6.4 describes the information needed for verifying the meteorological data files produced by a modeller.

- Using on-site data for advanced meteorological modelling using Weather Research and Forcasting Model (WRF), CALMET or other models, the ministry or the modeller can prepare more detailed and site-specific data files. In this case, the ministry requests that a plan be submitted for review in advance of the meteorological modelling. Upon acceptance of the plan, the resulting meteorological data set and supporting documentation would be submitted to the ministry for review and approval under subsection 13 (1) of the Regulation.

In either case, it is strongly recommended that any dispersion modelling **should not** commence until ministry approval of the data is granted under section 13 of the Regulation. A form is available on the ministry website to request approval of site-specific meteorological data ["Request for Approval under subsection13 (1) of Regulation 419/05 for use of site-specific meteorological data" (PIBs # 5350e)].

4.0 MODEL INPUT DATA

Emission rate estimates are a key input parameter for an approved dispersion modelling assessment. Section 10 of the Regulation relates to facility operating conditions. Section 11 sets out the requirements for emission rates. Section 12 sets out the requirements to either “refine” emission estimates or mitigate air pollution when the combined effect of sections 10 and 11 indicate exceedences of air standards (or ministry POI Limits). The ESDM Procedure Document provides guidance on estimating emission rates to ensure that assessments of maximum point of impingement concentration are as accurate as possible and do not under-estimate actual concentrations.

Chapters 4 through 7 of the ADMGO document provide guidance on the model input parameter requirements within sections 13 through 17 of the Regulation.

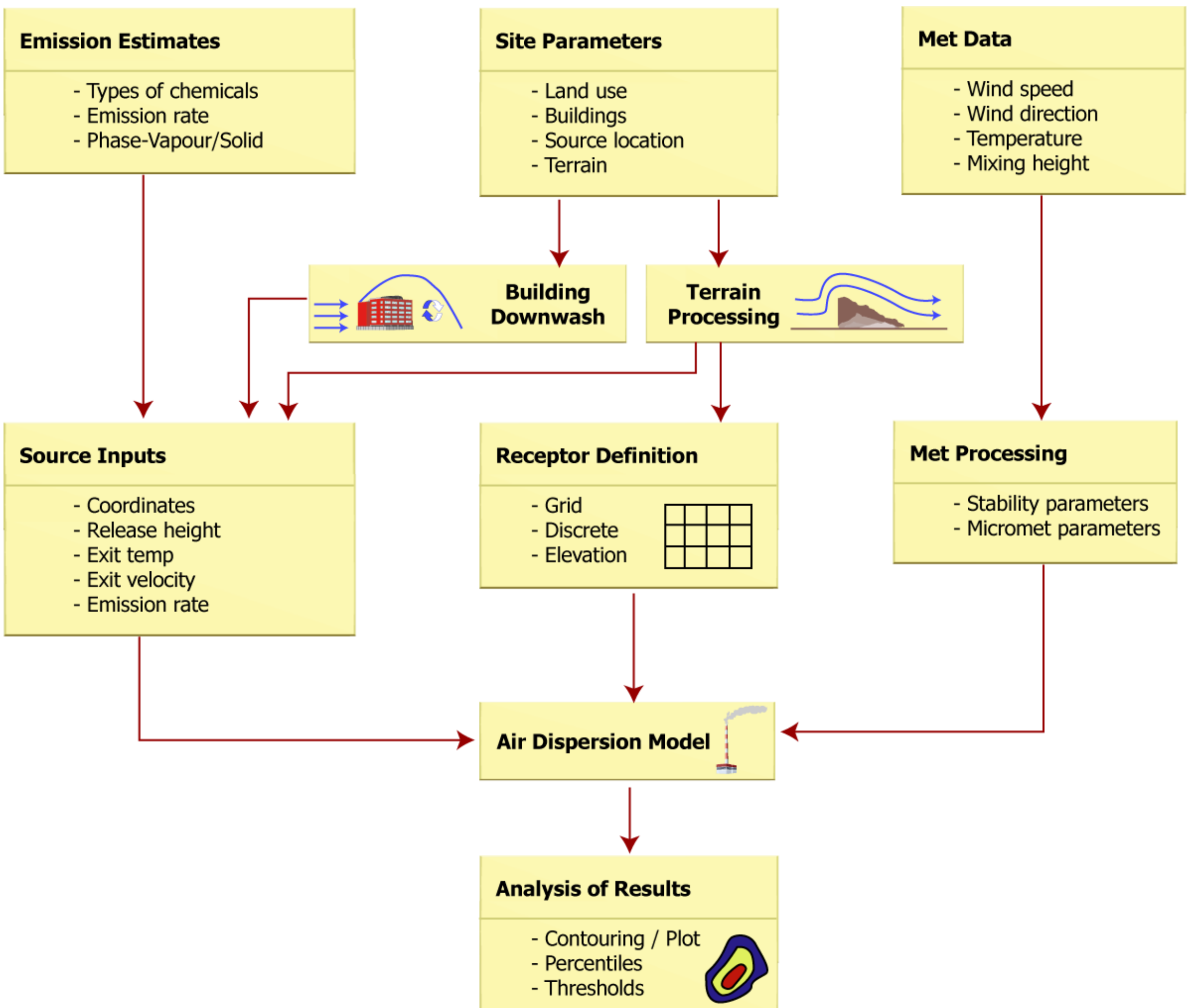
4.1 Comparison of Screening and Other Approved Dispersion Model Requirements

Screening-level modelling assessments require the least amount of effort but should produce the most conservative results in most cases. The SCREEN3 approved dispersion model has straightforward input requirements and is further described in Chapter 4.1.1.

Conversely, air dispersion modelling assessments using a more advanced approved dispersion model such as the US EPA AERMOD model are somewhat more intensive than screening-level modelling. The modelling approach can be broken down into a series of steps. These are described in Chapters 4.1.2 AERMOD Air Dispersion Modelling.

A general overview of the process typically followed for performing an air dispersion modelling assessment is presented in Figure 4.1. The figure is not meant to be exhaustive in all data elements, but rather provides a picture of the major steps involved in an assessment.

Figure 4.1: Generalized Process Flow Diagram for Performing an Air Dispersion Modelling Assessment.



4.1.1 SCREEN3 Air Dispersion Modelling

The SCREEN3 model(13) was developed to provide an easy-to-use method of obtaining contaminant concentration estimates. To perform a modelling study using SCREEN3, data for the following input requirements shall be supplied:

- *Source Type* (Point, Flare, Area or Volume)
- Physical Source and Emissions Characteristics. For example, a point source requires:
    - Emission Rate

- Stack Height
- Stack Inside Diameter
- Stack Gas Exit Velocity
- Stack Gas Exit Temperature
- Ambient Air Temperature
- Receptor Height Above Ground

- *Meteorology*: Although no data input is required, SCREEN3 provides users with the option to consider all wind speeds and stability classes, or a specific stability class and wind speed can be provided. Users should generally use the all wind speeds and stability class option.

- *Building Downwash*: If this option is used then building dimensions (height, length and width) must be specified. Downwash should always be selected for point sources located on or near buildings.

  - Note: To ensure that potential downwash effects for stack heights that equal or exceed the Good Engineering Practice (GEP) height are considered (as they now are in AERMOD), stack heights greater than 2.5x the building height should be conservatively entered into SCREEN3 as 2.4x times the building height (see Chapter 4.6.1 for more information on the GEP).

- *Terrain*: SCREEN3 supports flat, elevated and complex terrain. If elevated or complex terrain is used, distance and terrain heights must be provided.

- *Fumigation*: SCREEN3 supports shoreline fumigation. If used, distance to shoreline must be provided.

As can be seen above, the input requirements are minimal to perform a screening analysis using SCREEN3. This model is normally used as an initial screening tool to assess single sources of emissions. SCREEN3 can be applied to multi-source facilities by conservatively summing the maximum concentrations for the individual emissions sources. The models discussed in the following sections have much more detailed options, allowing for greater characterization and more representative results.

4.1.2 **AERMOD Air Dispersion Modelling**

The more advanced approved dispersion models have many input options, and are described further throughout this document as well as in their own respective technical documents[1,5,6,13]. An overview of the modelling approach and general steps for using models such as AERMOD are provided below. The general process for performing an air dispersion study using AERMOD includes:

- Process meteorological data using AERMET (unless using pre-processed data available from the ministry).
- Obtain digital terrain elevation data (if terrain is being considered – see section 16 of the Regulation).
- Incorporate building downwash using BPIP-PRIME (requires source and building information).
- Characterize the site – complete source and receptor information.
- Perform terrain data pre-processing (if required) for AERMOD dispersion model using AERMAP.
- Run “approved” version of the model.[14]
- Visualize and analyze results.

It should be noted that AERMOD contains several output data processing algorithms that are specifically applicable to compliance with US EPA data processing requirements. For example, when the contaminant IDs for SO_2, NO_2 and $PM_{2.5}$ are specified in the model inputs, the National Ambient Air Quality Standards (NAAQS) processing methodology is employed by default for these contaminants unless it is specifically disabled by the user. This will lead to erroneous predictions of maximum POI concentrations since the NAAQS metric is typically based on a multi-year average of ranked maximum daily values (i.e. for SO_2 the 99th percentile of the maximum daily 1-hr values, averaged over 3 years would be calculated). Users should therefore either disable the output data processing options or specifically avoid choosing these default contaminant IDs within AERMOD (e.g. select “OTHER”), since this would produce results that do not meet requirements of O.Reg.419/05.

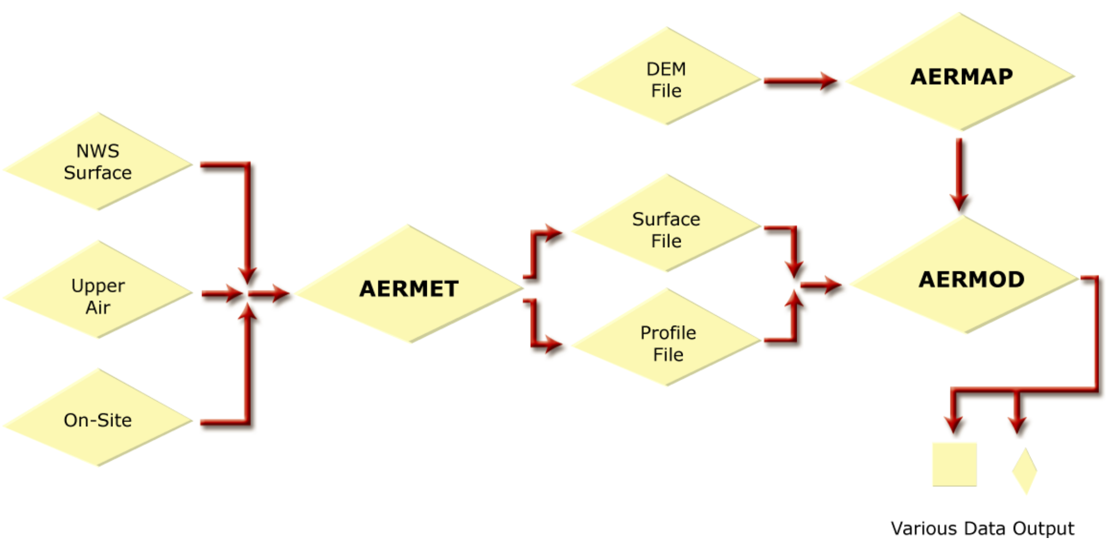
[14] Note that the regulatory version of the AERMOD, AERMET, and ASHRAE models may not necessarily be the most recent version of these models. See Chapter 1.1 Applications of the Dispersion Models in the Regulation for more information on model versions.

It should be noted, that paragraph 12 of subsection 26 (1) specifies that electronic copies of the input files that were used with the model and the output files that were generated by the model for each contaminant must be included in the ESDM report. This includes the output listing files (e.g. *.out, *.lst, which may differ if using a graphical interface program) in addition to any threshold violation files (e.g. *.max) and the contour plot files (e.g. *.plt) generated by the model.

The AERMOD modelling system is comprised of three primary components as outlined below and illustrated in Figure 4.2:

1. AERMET – Meteorological Data Pre-processor
2. AERMAP – Digital Terrain Data Pre-processor
3. AERMOD – Air dispersion model

Figure 4.2: AERMOD Air Dispersion Modelling System



To successfully perform a complex terrain air dispersion modelling analysis using AERMOD, a modeller must complete the processing steps required by AERMET and AERMAP. See Chapter 6.3 for more information on meteorological data.

It should be noted that both the AERMET and AERMOD models are updated by the US EPA from time to time, and the ASHRAE model is periodically updated (historically every 4 years) by the American Society of Heating and Refrigeration and Air-Conditioning Engineers. There is a specific version of each of these models that is considered to be an “approved dispersion model”. In order for a specific version of these models to be considered to be an “approved dispersion model” version, the ministry will give notice that an updated version will be adopted. Such notice would typically be given via a posting on the Environmental Bill of Rights (EBR) Registry.

Once such notice is given, the model versions specified in the notice will be law in Ontario until such time as a new notice is given to adopt another subsequent version.

AERMOD is a steady-state plume model. For the purpose of calculating 1-hour average concentrations, the plume is assumed to travel in a straight line without significant changes in stability as the plume travels from the source to a receptor. At distances on the order of tens of kilometres downwind, changes in stability, wind direction and wind speed are likely to cause this assumption to be invalid. For this reason, AERMOD shall not be used for modelling at receptors beyond 50 kilometres. AERMOD may also be inappropriate for some near-field modelling in cases where the wind field is very complex due to terrain or a nearby shoreline.

4.1.3 **ASHRAE Air Dispersion Modelling**

As an advanced model for same-structure contamination, ASHRAE has many input parameters, which are described briefly in this section with more detailed information in corresponding technical documents [14, 15]. An overview of the modelling approach and general steps for using ASHRAE are provided below. The general process for performing an air dispersion study using ASHRAE includes the following steps:

- Obtain building dimensions.
- Complete source and receptor information including:
    - Emission Rate
    - Stack height above main roof
    - Stack inside diameter
    - Stack gas exit velocity
    - Distance from source to receptor/intake
    - Is the stack capped or not?
    - Wind speed range to be searched (for example, 2 – 12 m/s is a reasonable range over Ontario).
- Perform ASHRAE screening model run assuming a flush vent release.
- If results from the above screening model run failed to show compliance, perform calculations to obtain dimensions of building

recirculation and wake zones; find the maximum roof top recirculation zone height between the source and the receptor.

- Perform advanced ASHRAE model run.

Note that:

- The above steps have to be carried out for each source-receptor combination.
- When defining the largest roof top recirculation zone height, all roof top recirculation zones caused by obstacles between the source and receptor in that specific source-receptor combination have to be included.
- When performing flush vent screening calculations, the stretched string distance should be used for the source to receptor distance (x). For all other cases, the downwind horizontal distance from the centre of the stack should be used.
- In complicated cases, projected building dimensions may have to be used.
- If using a version of ASHRAE that incorporates the surface roughness parameter, in order to prevent inconsistencies the roughness height used must be consistent with those used in other air dispersion modelling meteorological data files (e.g. AERMET).

Modellers are encouraged to contact the ministry's Environmental Monitoring and Reporting Branch (EMRB) for specific guidance in more complex cases.

Information to be provided to the ministry with an assessment of self-contamination using ASHRAE should include a site drawing that shows plan and/or elevation views of the building with the building height, length and width, in addition to source and receptor (intake) locations and distances. Source details and parameters such as the stack height, flow rate and diameter should also be provided. Full calculations (including the wind speed ranges searched and the calculation of any intermediate parameters) must be provided in an Appendix, or electronically via an Excel spreadsheet.

4.2 "Regulatory Default" and "Non-Default" Option Use

The AERMOD model contains several options, which are set by default, that have been identified by the US EPA as "regulatory defaults"[15]. The models also include non-default options. Depending on the model, the non-default options can include, but are not limited to, the following:

- No stack-tip downwash (NOSTD);
- Missing data processing routine (MSGPRO);
- Bypass the calms processing routine (NOCALM);
- Gradual plume rise (GRDRIS);
- No buoyancy-induced dispersion (NOBID);
- Fast Area or Fast All options (FASTAREA, FASTALL);
- By-pass date checking for non-sequential met data file (NOCHKD);
- Deposition (WET, DRY);
- Conversion of NO_x to NO_2 (three methods OLM, PVMRM and ARM);
- Flat terrain (FLAT);
- Plume Depletion (WETDPLT, DRYDPLT);
- Side vents and horizontal caps (BETA); and
- Adjust u* and low wind speed options (LOWWIND).

Modellers shall use all default regulatory options in performing their modelling assessments. Also note that the US NAAQS processing methodology for SO_2, NO_2 and $PM_{2.5}$ must be disabled if AERMOD is run using these contaminant names in the model input file.

15 **Note:** For the purposes of this ADMGO document, the terms "regulatory defaults" and "non-default" options refer to the US EPA nomenclature of defining various aspects of the dispersion models and do not necessarily refer to requirements within the Regulation.

Certain non-regulatory options may be used in a Tier 2 or Tier 3 assessment, but only for side vents and horizontal caps (see Chapter 4.5.3 Special Considerations for Horizontal Sources and Rain Caps), use of flat terrain and use of the FASTAREA/FASTALL options.

The ministry may consider whether it is appropriate to use deposition and plume depletion for Tier 3 modelling assessments, such as those requested for approval under paragraph 3 of subsection 11 (1) of the Regulation for a combined analysis of modelled and monitoring results. Other non-regulatory options may also be considered in a Tier 3 assessment, subject to ministry approval under section 7(1) of the Regulation. In such circumstances, modellers shall provide justification for, and obtain ministry (EMRB) approval for the use of non-regulatory options before submitting their modelling results to the ministry. Modellers are strongly encouraged to consult with the ministry in advance of conducting their model runs.

4.3 Coordinate System

Any modelling assessment will require a coordinate system be defined in order to assess the relative distances from sources and receptors and, where necessary, to consider other geographical features. Employing a standard coordinate system for all projects increases the efficiency of the review process while providing real-world information of the site location. AERMOD's terrain pre-processor, AERMAP, requires digital terrain in Universal Transverse Mercator (UTM) coordinates. The UTM coordinate system uses metres as is its basic unit of measurement and allows for more precise definition of specific locations than latitude/longitude.

For more information on coordinate systems and geographical information inputs, see Chapter 5.0.

4.4 Averaging Periods (Conversion Factor)

Ministry POI Limits are expressed over certain averaging periods. As specified in section 17 of the Regulation, where a dispersion model is designed to determine a concentration for the specified averaging period, it shall be used as it was designed.

When a dispersion model is used that can only calculate concentrations for either a single averaging period or a limited range of averaging periods, conversion factors can be applied to estimate likely maximum concentrations over other averaging periods. The conversion allows model results from screening level assessments to be compared against ministry POI limits with their respective averaging periods. Models such as AERMOD provide the capability of providing 1, 2, 3, 4, 6, 8, 12, and 24-hour averages, as well as monthly and annual averages, therefore eliminating the need for conversion factors within these averaging periods. Conversion factors, however, are still required when modelling for averaging periods less than one hour.

For example, for contaminants where the ministry POI Limit is based on a 30-minute averaging period, only the one-hour averaging period results obtained from the model can be converted to a 30-minute averaging period (see paragraph 3 of subsection 17 (1) of the Regulation).

Section 17 of the Regulation specifies averaging periods to be used, as well as when and how concentration conversions among averaging periods can occur, as follows:

Averaging periods

"17. (1) If a provision of this Part refers to an approved dispersion model being used in connection with a standard that applies to a specified averaging period, the following rules apply for the purposes of this Part:

1. If an approved dispersion model was designed to be used for the specified averaging period, it shall be used as it was designed for that averaging period.

2.If an approved dispersion model was not designed to be used for the specified averaging period but was designed to be used for an averaging period shorter than the specified averaging period, the model may be used as it was designed for the shorter averaging period if the result produced by the model is adjusted in accordance with subsection (2).

3. If the specified averaging period is less than one hour and an approved dispersion model was designed to be used for a one hour period, the model may be used as it was designed for a one hour period if the result produced by the model is adjusted in accordance with subsection (2).

4.If the use of an approved dispersion model is not authorized or required by paragraph 1, 2 or 3, the model shall not be used.

(2) If a provision of this Part refers to an approved dispersion model being used in connection with a standard that applies to a specified averaging period,

(a) the result produced by the approved dispersion model shall be multiplied by the amount determined in accordance with subsection (3), if the model is used under paragraph 2 of subsection (1); and

(b) the result produced by the approved dispersion model shall be divided by the amount determined in accordance with subsection (3), if the model is used under paragraph 3 of subsection (1).

(3) The amount referred to in clauses (2) (a) and (b) is the amount determined in accordance with the following formula:

$$(t_0 \div t_1)^n$$

where,

t_0 = the shorter of,

i. the averaging period that the approved dispersion model was designed to be used for, expressed in hours, and

ii.the specified averaging period, expressed in hours,

t_1 = the longer of,

i. the averaging period that the approved dispersion model was designed to be used for, expressed in hours, and

ii.the specified averaging period, expressed in hours,

n = 0.28 or, if the Director is satisfied that another number would result in an adjustment that produces a more accurate prediction of the concentration of the relevant contaminant, the other number.

(4) If an approved dispersion model is used with respect to a person and contaminant to whom section 20 applies and Schedule 3 sets out more than one standard for the contaminant, using different averaging periods, the model shall be used with respect to each averaging period.

(5) This section does not apply if,

(a) The approved dispersion model that is used is the ASHRAE method of calculation and the model is being used in connection with a standard set out in Schedule 3 that applies to a 10 minute averaging period; or

(b) The approved dispersion model that is used is the method of calculation required by the Appendix to Regulation 346.

A range of averaging period conversion factors have been used in various studies, which are typically a function of the atmospheric stability. The equation given below is consistent with subsections 17 (2) and 17 (3) of the Regulation, and requires modellers to use a value for the exponent n that is based on neutral stability. However, the regulation allows the use of alternate stability dependant values of the exponent n[16] which must be approved by the Director under section 17 (3) of the Regulation.

Equation 1:

$$C_0 = C_1 \times F$$

where,

C_0 = the concentration at the averaging period t_0

C_1 = the concentration at the averaging period t_1

F = factor to convert from the averaging period t_1 to the averaging period t_0

$= (t_1/t_0)^n$

and where, n = 0.28

The formula could be used to calculate shorter averaging period concentrations such as a 10-minute ministry POI Limit starting from a modelled 1-hour average concentration. The equations can also be used to estimate a likely maximum 24-hour average concentration from a model that only produces 1-hour results. For example, output from SCREEN3 could be converted as follows:

$$C_{24\,hr} = C_{1\,hr} \times (1\ hr/24\ hr)^n$$

where: $C_{1\,hr}$ and $C_{24\,hr}$ are the maximum average concentrations respectively.

[16] Considering the modelling limitations and with a goal to reduce the complexity for modellers, the ministry is retaining the historical power exponent of n = 0.28 for conversion. A modeller or the ministry may, in special situations, demonstrate that the use of an alternative conversion approach may be more appropriate or required (see subsection17(3) of the Regulation).

The following table (Table 4-1) lists some of the conversions that may be required by modellers to compare modelled results to ministry POI Limits.

Table 4-1: Common Averaging Period Conversion Factors

Convert From:	Convert To:	Multiply by:
1hr	10 min	1.65
1hr	½ hr	1.2
1hr	24hr	0.4
1hr	Annual	0.08

4.5 Defining Source Types

4.5.1 Selection, Description and Parameters

SCREEN3 and AERMOD support a variety of source types that can be used to characterize most emissions within a study area. Primary source types and their input requirements for both screening and the more advanced models are discussed below. Detailed descriptions on the input fields for these models can be found in the corresponding US EPA model User's Guides, which are referenced in Chapter 10, and are for SCREEN3 [13] and AERMOD[1].

Point Sources

Point sources are typically used to model releases from sources like stacks and isolated vents. Input requirements for point sources include:

SCREEN3

- **Emission Rate:** The emission rate of the contaminant.
- **Stack Height:** The stack height above ground.
- **Stack Inside Diameter:** The inner diameter of the stack.
- **Stack Gas Exit Velocity [m/s] or Stack Gas Exit Flow Rate [m^3/s]:** Either the stack gas exit velocity or the stack gas exit flow rate must be given. The exit velocity can be determined from the following formula:

$$V_s = \frac{4Q}{\pi d_s^2}$$

Where:

V_s = Exit Velocity (m/s)

d_s = Stack Inside Diameter (m)

Q = Flow Rate (m^3/s)

- **Stack Gas Temperature:** The temperature of the released gas in degrees Kelvin (K).

- **Ambient Air Temperature:** The average atmospheric temperature (K) in the vicinity of the source. If no ambient temperature data are available, assume a default value of 293 degrees K. For non-buoyant releases, the user shall input the same value for the stack temperature and ambient temperature.

- **Receptor Height above Ground:** This shall be used to model impacts at "flagpole" receptors. A flagpole receptor is defined as any receptor located above ground level, e.g., to represent the roof or balcony of a building. The default value is assumed to be 0.0 m (i.e., ground-level receptors).

- **Urban/Rural Option:** Specify either Urban or Rural conditions to use the appropriate dispersion coefficient. Chapter 5.4.5 Defining Urban and Rural Conditions provides guidance on determining rural or urban conditions.

AERMOD

- **Source ID:** An identification name for the source being defined, up to 8 characters in length.

- **X Coordinate:** The x (east-west) coordinate for the source location in metres (centre of the point source).

- **Y Coordinate:** Enter here the y (north-south) coordinate for the source location in metres (centre of the point source).

- **Base Elevation:** The elevation of the base of the source. The model only uses the source base elevation if **Elevated** terrain is being used.

- **Release Height above Ground:** The source release height above the ground in metres.

- **Emission Rate:** The emission rate of the contaminant in grams per second.

- **Stack Gas Exit Temperature:** The temperature of the released gas in degrees Kelvin.

- **Stack Gas Exit Velocity:** The stack gas exit velocity in metres per second or the stack gas flow rate (see above Chapter on SCREEN3).

- **Stack Inside Diameter:** The inner diameter of the stack.

Area Sources

Area sources are used to model low level or ground level releases where releases occur from a two-dimensional flat plane with no temperature, velocity or initial mixing or dilution (e.g., landfills, storage piles, slag dumps, lagoons). SCREEN3 allows definition of a rectangular area while AERMOD accepts rectangular areas that may also have a rotation angle specified relative to a north-south orientation. AERMOD can also handle circular and polygon shaped area sources.

SCREEN3

- **Emission Rate:** The emission rate of the contaminant. The emission rate for area sources is entered as an emission rate per unit area (g/(s-m^2).

- **Source Release Height:** The source release height above ground.

- **Larger Side Length of Rectangular Area:** The larger side of the rectangular source in metres.

- **Smaller Side Length of Rectangular Area:** The smaller side of the rectangular source in metres.

- **Receptor Height above Ground [m]:** This shall be used to model impacts at "flagpole" receptors. A flagpole receptor is defined as any receptor that is located above ground level, e.g., to represent the roof or balcony of a building. The default value is assumed to be 0.0 m (i.e., ground-level receptors).

- **Wind Direction Search Option:** Since the concentration at a particular distance downwind from a rectangular area is dependent on the orientation of the area relative to the wind direction, the SCREEN model provides the user with two options for treating wind direction. The modeller shall use the regulatory default option ("YES") which results in a search of a range of wind directions. See US EPA *SCREEN3 Model User's Guide* (13) for more detailed information.

AERMOD

- **Source ID:** An identification name for the source being defined, up to 8 characters in length.

- **X Coordinate:** The x (east-west) coordinate for the vertex (corner) of the area source that occurs in the southwest quadrant of the source. Units are in metres.

- **Y Coordinate:** The y (north-south) coordinate for the vertex (corner) of the area source that occurs in the southwest quadrant of the source. Units are in metres.

- **Base Elevation:** The elevation of the base of the source. The model only uses the source base elevation if elevated terrain is being used. The default unit is metres.

- **Release Height above Ground [m]:** The release height above ground in metres.

- **Emission Rate [g/(s-m^2)]:** Enter the emission rate of the contaminant. The emission rate for area sources is entered as an emission rate per unit area. The same emission rate is used for both concentration and deposition calculations.

- **Options for Defining Area:** AERMOD can have rectangular, circular or polygon areas defined (see US EPA[1] for details).

Note: Receptors may be placed within the area and at the edge of an area. AERMOD will integrate over the portion of the area that is upwind of the receptor. The numerical integration is not performed for portions of the area that are closer than 1 metre upwind of the receptor. Therefore, caution should be used when placing receptors within or adjacent to areas that are less than a few metres wide. In such cases, modellers are encouraged to contact ministry (EMRB) to discuss receptor placement.

Volume Sources

Volume sources are used to model releases from a three-dimensional box that represents the evenly-mixed emissions of a contaminant from the source. A variety of industrial sources can be represented by volume sources, including building roof monitors, fugitive leaks from an industrial facility, multiple vents, and stacker drop points.

<u>SCREEN3</u>

- **Emission Rate:** The emission rate of the contaminant in grams per second (g/s).

- **Source Release Height:** The source release height above ground surface. This is typically the centre of the volume source.
- **Initial Lateral Dimension:** See Table 4-2 for guidance on determining initial dimensions. Units are metres.
- **Initial Vertical Dimension:** See Table 4-3 for guidance on determining initial dimensions. Units are metres.
- **Receptor Height above Ground [m]:** This shall be used to model impacts at "flagpole" receptors. A flagpole receptor is defined as any receptor which is located above ground level, e.g., to represent the roof or balcony of a building. The default value is assumed to be 0.0 m (i.e., ground-level receptors).

Table 4-2: Estimation of Initial Lateral Dimension (S_{yo}) for Volume and Line Sources

Type of Source	Procedure for Obtaining Initial Dimension
Single Volume Source	$S_{y_o} = \frac{side\ length}{4.3}$
Line Source Represented by Adjacent Volume Sources	$S_{y_o} = \frac{side\ length}{2.15}$
Line Source Represented by Separated Volume Sources	$S_{y_o} = \frac{centre\ to\ centre\ distance}{2.15}$

Source: US EPA, 1995 User's Guide for the Industrial Source Complex (ISCST3) Dispersion Models - Volume I, EPA-454/B-95-003a. US EPA. Research Triangle Park, NC 27711.

Table 4-3: Estimation of Initial Vertical Dimension (S_{zo}) for Volume and Line Sources

Type of Source	Procedure for Obtaining Initial Dimension
Surface-Based Source ($h_e \sim 0$)	$S_{z_o} = \frac{vertical\ source\ dimension}{2.15}$
Elevated Source ($h_e > 0$) on or Adjacent to a Building	$S_{z_o} = \frac{building\ height}{2.15}$
Elevated Source ($h_e > 0$) not on or Adjacent to a Building	$S_{z_o} = \frac{vertical\ source\ dimension}{4.3}$

Note: h_e is release height

Source: USEPA, 1995 User's Guide for the Industrial Source Complex (ISCST3) Dispersion Models - Volume I, EPA-454/B-95-003a. US EPA. Research Triangle Park, NC 27711.

AERMOD

- **Source ID:** An identification name for the source being defined, up to 8 characters in length.
- **X Coordinate:** The x (east-west) coordinate for the source location in metres. This location is the centre of the volume source.
- **Y Coordinate:** The y (north-south) coordinate for the source location in metres. This location is the centre of the volume source.
- **Base Elevation:** The elevation of the base of the source. The model only uses the source base elevation if elevated terrain is being used. The default unit is metres.
- **Release Height above Ground:** The release height above ground surface in metres (centre of volume).
- **Emission Rate [g/s]:** The emission rate of the contaminant in grams per second. The same emission rate is used for both concentration and deposition calculations.
- **Length of Side:** The length of the side of the volume source in metres. The volume source cannot be rotated and has the X side equal to the Y side (square).
- **Building Height (If On or Adjacent to a Building):** If the volume source is elevated and is on or adjacent to a building, then the modeller needs to specify the building height. The building height can be used to calculate the Initial Vertical Dimension of the source. Note that if the source is surface-based, then this is not applicable.
- **Initial Lateral Dimension [m]:** This parameter is calculated by choosing the appropriate condition in Table 4-2. This table provides guidance on determining initial dimensions. Units are in metres.
- **Initial Vertical Dimension [m]:** This parameter is calculated by choosing the appropriate condition in Table 4-3. This table provides guidance on determining initial dimensions. Units are in metres.

Line Sources

Examples of line sources are conveyor belts and rail lines. SCREEN3 does not have a default line source type, whereas AERMOD does. There are a number of different approaches that can be used to simulate line sources. These generally include use of a series of area or volume sources to define a line source (e.g. a roadway source), in addition to the release height of the emissions and the initial plume spread. The sources can either be located adjacent to one another, or separated by a specified distance. The AERMOD line source is based on the area source approach, and uses a single area source to represent straight line segments. Additionally, some commercially available software products have built-in a “line sources” generating function for AERMOD, which use either the separated or adjacent volume source approach, or the adjacent area source approach. For additional guidance on modelling roadway type line sources, see Chapter 4.5.3.

Open Flare Sources

Flares are used as control devices for a variety of sources. Enclosed flares are typically modelled as normal point sources when using SCREEN3 or AERMOD. Open flares however, are quite different from traditional “stack type” point sources because they have unique exhaust characteristics. Open flares produce extremely hot (and therefore buoyant) and turbulent exhaust streams. Also, open flares typically have a jet-like flame, and exhaust/combustion contaminants are emitted from a plume that starts at the top of the flame, or the flame tip. Due to these unique characteristics, open flares must be modelled differently than typical stack type point sources. For more information, please refer to the “*Technical Bulletin: Modelling Open Flares under O.Reg.419/05*”, dated July 2016.

In general, they are modelled as point sources with modified exhaust parameters. SCREEN3 supports modelling open flares directly through its flare source type, as this model modifies the exhaust parameters automatically .The AERMOD model does not automatically modify the exhaust parameters, and as such they must be calculated by the user before being input into the model.

SCREEN3

When modelling emissions from flares using the SCREEN3 model, only the flare source type should be employed, with the required input parameters as outlined below.

- **Emission Rate:** The emission rate of the contaminant in grams per second (g/s).
- **Flare Stack Height:** The stack height above ground (m).
- **Total Heat Release Rate:** The heat release rate in calories per second (cal/s) for the flare.

- **Receptor Height above Ground:** This shall be used to model impacts at "flagpole" receptors. A flagpole receptor is defined as any receptor which is located above ground level, e.g., to represent the roof or balcony of a building. The default value is assumed to be 0.0 m (i.e., ground-level receptors).

Note 1: US EPA's SCREEN3 model calculates plume rise for flares based on an effective buoyancy flux parameter. An ambient temperature of 293K is assumed in this calculation and therefore no ambient temperature is entered by the user. It is assumed that 55% of the total heat is lost due to radiation. Plume rise is calculated from the top of the flame, assuming that the flame is bent 45 degrees from the vertical. SCREEN3 calculates and prints out the effective release height for the flare.

Note 2: For Flare releases, EPA's SCREEN3 model assumes a stack gas exit velocity (V_s) of 20 m/s, an effective stack gas exit temperature (T_s) of 1,273K, and calculates an effective stack diameter based on the heat release rate.

AERMOD

AERMOD does not have a specific source type option for open flare sources. Instead, flare emissions are modelled as point sources, with the modified exhaust parameters. These parameters need to be modified to consider buoyancy flux reductions associated with radiative heat losses, in addition to inclusion of the flame length in estimating the effective release height[16,17]. The effective parameters are as follows:

- Modified or "effective" stack height (H_{sl})
- Effective exit velocity (V_{eff})
- Effective stack diameter (D_{eff})

These are known as flare "pseudo-parameters" because they are calculated in a manner to simulate the behaviour of the exhaust plume as if it were a stack type point source, emitted from a height equal to the tip of the flame. The remaining parameters (effective diameter and effective exit velocity) are also calculated at the flame tip, considering the expected expansion and air entrainment into the plume, while conserving buoyancy and momentum flux[18]. The ministry has revised the methodology to be used when modelling open flares in Ontario, and developed the *Technical Bulletin: Modelling Open Flares under O.Reg.419/05, July 2016* to provide specific guidance for modelling these sources. The Technical Bulletin provides background information, the revised methodology and a stepwise procedure for the calculation of the required flare pseudo-parameters. When the AERMOD model or other approved dispersion models are used to model open flare sources, the approach and equations outlined in the Technical Bulletin are to be used to characterize the source parameters. Please refer to the Technical Bulletin for these details when modelling open flares.

Note that all data, assumptions and calculations for the flare pseudo-parameters must be included as part of the supporting documentation for the assessment.

4.5.2 Combining Individual Sources into Volume, Area and Single Point Sources

There are cases where a facility could have a number of release points from vents and short stacks in a confined area at the facility. To simplify the modelling when there are many release points, a modeller may conservatively combine these stacks/vents into a volume source, an area source or a single point source.

The following factors shall be considered when selecting potential sources for combination into a single source:

(a) source characteristics (e.g. exit velocity, temperature, stack/source height) of the individual stacks or vents must be similar,

(b) emission rates from the individual release points must be similar (i.e. there are no sources with significantly larger emission rates),

(c) sources must be located in the same general vicinity, and

(d) the property line must not be too far from the group of stacks/vents.

When employing this approach, the choices of size and location of volume or area sources or the stack parameters for a single stack representing a group must be selected conservatively. For example:

- for combining multiple stacks into a single stack, the parameters for the single stack shall not result in a larger plume rise than would have occurred for the large majority of the stacks being combined (i.e. the exit velocity selected should be conservative), and

- for combining multiple sources into a single volume source, the size of a volume source selected to represent the group of sources shall only consider the volume on which the sources are located and from which the emissions would be released. In most cases, the volume source height would be same as the building/structure height or lower.

Modellers are encouraged to contact EMRB for specific guidance in these situations.

Output of Results for Groups of Sources

When modelling is performed for a number of individual stacks, volume sources or area sources, the use of source groups enable modelling results to be output for specific combinations of sources. The default in AERMOD is the creation of source group "ALL" that considers all the sources at the same time. Analysis of specific groups of sources, such as process vents, site roadways, combustion equipment, etc, can be performed by using the SRCGROUP option. Conversely, individual sources may be assigned to a separate group to determine the concentrations generated by each individual source. It should be noted however that when this is done for individual sources or groups the results reflect the maximum predicted concentrations from each of these, rather than the contribution to the overall maximum from all sources combined.

4.5.3 **Special Considerations**

During some air quality studies, certain source configurations or source types may be encountered that require special attention. Some examples include horizontal sources or emissions from storage tanks. The following sections outline modelling techniques on how to account for the special characteristics of such scenarios.

Shoreline Fumigation

Shoreline fumigation is a phenomenon that may occur along the shore of an ocean or a large lake. When the land is warmer than the water, a breeze forms as the warmer, lighter inland air rises. As the stable, cooler air from over the water moves inland, it is heated from below, resulting in a turbulent boundary layer of air that rises with downwind distance from the shoreline. The plume from a tall stack source located near the shoreline may intersect this turbulent layer and be rapidly mixed to the ground, a process called "fumigation," resulting in high ground level concentrations. AERMOD does not treat the effects of shoreline fumigation. In these and other situations, the use of specific models may be required by the ministry under section 7 of the Regulation.

Shoreline fumigation need only be assessed from tall stacks as it does not occur with respect to emissions from ground level sources modelled as area or volume sources. The SCREEN3 model includes an option to assess whether shoreline fumigation may occur as a result of stack emission sources located near a large lake or water body. Examples of larger lakes or water bodies that could lead to fumigation include the Great Lakes, Georgian Bay, Lake St. Clair, and others.

Generally, facilities located within approximately 1 km of the shoreline of a larger lake or water body, that emit contaminants from taller stack sources greater than 50 metres in height, need assess the potential for shoreline fumigation to occur using the SCREEN3 model. Should the screening assessment show that shoreline fumigation may occur, the use of an alternative model (e.g. CALPUFF, Shoreline Dispersion Model) may be required by a notice issued under section 7 of the Regulation.

Multiple Stacks

When the plumes from multiple closely-spaced stacks or flues merge, the plume rise can be enhanced. Briggs[(19)] has proposed equations to account for this. The reader is referred to that document for further details. Most models do not explicitly account for enhanced plume rise from this cause, and most regulatory agencies do not permit it to be considered in regulatory applications of modelling, with one exception. That exception is the case of a single stack with multiple flues, or multiple stacks located very close together (less than approximately one stack diameter apart). In these cases, the multiple plumes may be treated as a single plume. To do this, a pseudo stack diameter is used in the calculations, such that the total volume flow rate of the stack gases is correctly represented.

Horizontal Sources and Rain Caps

Both horizontal flues and vertical flues with rain caps have little or no initial vertical velocity. Plume rise calculations in most models (including AERMOD and SCREEN3) take into account both rise due to vertical momentum of the plume as it leaves the stack and the buoyancy of the plume. This may result in an over-prediction of the plume rise, and resulting under-prediction of ground-level concentrations, in these models.

This problem can be alleviated by modifying the source input parameters to minimize the effects of momentum while leaving the buoyant plume rise calculations unchanged. The US EPA outlines such an approach in its Model Clearinghouse Memo 93-II-09[(20)]. The approach is also expressed, in part, in Tikvart[(21)]. This approach is to reduce the stack gas exit velocity to 0.001 m/s, and calculate an equivalent diameter so that the buoyant plume rise is properly calculated. To do this, the stack diameter is specified to the model such that the volume flow rate of the gas remains correct.

In the case of horizontal flues, there will be no stack tip downwash (i.e. reduction of the plume height by an amount up to three times the stack diameter), so that option must be turned off. In the case of vertical flues with rain caps, there will be frequent occurrences of stack tip downwash. The effect of the stack tip downwash however may be underestimated in the model and thus must be corrected. This is done somewhat conservatively by turning off the stack tip downwash and lowering the specification of the stack height by three times the actual stack diameter (i.e. the maximum effect of stack tip downwash). However, the modified stack height must not be reduced to be below the roof level.

With the above references in mind, it should be noted that larger diameters associated with reduced exit velocities can cause issues with the PRIME algorithm. As a result, the ministry's approach is to use an exit velocity of 0.1 m/s, or a velocity based on limiting the exit diameter to 5 times the actual diameter up to a maximum of 5 metres. This exit velocity still effectively eliminates momentum flux and can produce parameters that will not impede model execution.

The current AERMOD model includes a non-default beta option for modelling releases from capped and horizontal discharge stacks. EPA model developers found that the Model Clearinghouse procedure is not appropriate for sources subject to building downwash influences with the PRIME downwash algorithm. The use of an effective diameter adjusted to maintain flow rate could produce unrealistic results with the PRIME algorithm. In the AERMOD capped and horizontal releases options, the vertical momentum is suppressed while the buoyancy of the plume is conserved without modifying the stack parameters.

The two source types are:

- POINTCAP for capped stacks, and
- POINTHOR for horizontal releases.

For each of these source types, the user must specify the actual stack parameters of release height (m), exit temperature (K), exit velocity (m/s), and stack diameter (m) using the SO SRCPARAM card as if the release were a non-capped vertical point source. The AERMOD model performs the necessary adjustments internally to account for plume rise and stack-tip downwash. For horizontal releases, the model assumes that the release is oriented with the wind direction. For PRIME-downwashed sources, the user-specified exit velocity for horizontal releases is treated initially as horizontal momentum in the downwind direction.

The capped and horizontal beta option in AERMOD produces results that are very similar to those using the previously described ministry approach. The beta options for capped and horizontal releases should be used when modelling with AERMOD. When modelling with SCREEN3, the following step-by-step approach should be used . In this discussion,

V =actual stack gas exit velocity

V' =stack gas exit velocity as entered into the model

D =actual stack inside diameter

D' =stack inside diameter as input to the model

H =actual stack height

H' =stack height input to the model

For the source of consideration, modify its parameters as follows:

1. Set *V'=0.1* m/s or a velocity based on limiting the exit diameter to 5 times the actual diameter up to a maximum of 5 metres

2. Set *D'*=*D**SQRT(*V/V'*)

3. If the source is a vertical stack with a rain cap, account for the frequent stack tip downwash by reducing the stack height input to the model by three times the actual stack diameter: *H'=H – 3D*

Roadways

Modelling emissions from roadways and haul roads can be challenging. Historically, none of the advanced dispersion models contained a specific line or roadway source type that could be best used to simulate dispersion of emissions from the surface of a roadway. Instead, roadway sources are typically simulated using a series of volume or area sources. A new line source type was recently added to the AERMOD model, which is based on the area source approach, and uses a single area source for each straight line segment. These types of sources however, do not appropriately simulate the turbulence and added dispersion that occurs in the wake of moving vehicles. Because of this phenomenon, roadway modelling results produced by AERMOD can be overly conservative in some circumstances. This is particularly true of predicted concentrations at receptors located in the area of the perpendicular intersection of road sources and the property boundary. This is likely due to model limitations for receptors at close distances to sources with low release heights and the lack of plume rise.

In order to address these issues, the ministry recommends the following:

- Roadways may be simulated using a series of adjacent or separated volume or area sources. The ministry would prefer that the volume source approach be employed.

- Model receptors should not be placed directly on the roadways, including points where the property line intersects the roadway.

- Model receptors along a property line that intersects a roadway can be offset from the roadway edge by a distance of 1.5 X the road width

The US EPA has also faced similar challenges related to modelling emissions and impacts of haul roads. In 2009 the US EPA formed the Haul Road Workgroup which was comprised of air dispersion modellers from federal, state and local regulatory agencies. The group focussed on challenges related to air dispersion modelling aspects rather than those related to emissions estimation. In particular, the group studied different modelling options and approaches using AERMOD, and produced a memorandum in 2012 that included some specific recommendations regarding the modelling approach[22]. The ministry suggests that the recommendations in this memorandum be followed in modelling emissions from haul roads in Ontario. The memorandum can be found at the following link here.

In certain circumstances, a notice under section 7 of the Regulation may be issued to allow use of a traffic air dispersion model such as CAL3QHCR or CALINE4 instead of the approach described above. Further details on these models can be found in *Appendix A: Alternative Models*.

Pits and Quarries

Emissions from pits and quarries behave differently than ground level sources. Research indicates that a portion of the emissions are retained in the pit, and that they are generally emitted from a smaller area of the pit opening. AERMOD contains an OPENPIT source type that simulates the unique manner in which emissions are emitted from pits and quarries.

Some of the key parameters required by the OPENPIT source are as follows:

- **Source Location:** This is the x and y coordinates of the southwest corner of the source, in metres.

- **Base Elevation:** The elevation of the pit opening (i.e. the top of the pit, which is where the emissions are simulated to occur). The model only uses this if terrain data is being used. The default unit is metres.

- **Release Height:** This is the average release height above the base of the pit in metres (centre of volume). This parameter cannot exceed the effective depth of the pit, which is calculated based on the volume of the pit and specified length and width. Where there are multiple sources within the pit, the specified release height should be based on the average source heights within the pit.

- **Length of Sides:** The length and width of the pit opening in metres. The model uses these values to calculate the effective depth of the pit.

- **Pit Volume:** The total volume of the pit in cubic metres. The model uses this value to calculate the effective depth of the pit.

It should be noted that when using the OPENPIT source type in AERMOD, the model simulates the release of emissions at the top of the pit, from an “effective” area source. As such, modifying the terrain or source base elevation of the pit should only be done based on project development information to account for modifications such as initial topsoil removal. In cases where the elevations in the DEM files reflect an existing pit, use of the existing base elevation (i.e. the pit floor) as the source base elevation in the model will incorrectly result in the model assigning this elevation to the top of the pit (i.e. the top of the pit will be incorrectly placed at the pit floor). It may be more appropriate to model theses sources using different approaches, such as volume or area sources, depending on the situation. Modellers should contact EMRB for further guidance, as necessary.

Liquid Storage Tanks

Storage tanks are generally of two types—fixed roof tanks and floating roof tanks. In the case of fixed roof tanks, most of the contaminant emissions occur from a vent, with some additional contribution from hatches and other fittings. In the case of floating roof tanks, most of the contaminant emissions occur through the seals between the roof and the wall and between the deck and the wall, with some additional emissions from fittings such as ports and hatches.

Approaches for modelling impacts of emissions from various types of storage tanks are described below.

Fixed roof tanks:

Model fixed roof tanks as a point source representing the vent, which is usually in the centre of the tank, and representing the tank itself as a building for downwash calculations.

Floating roof tanks:

Model floating roof tanks as a circle of eight (or more) point sources, representing the tank itself as a building for downwash calculations. Distribute the total emissions equally among the circle of point sources.

All tanks:

There is virtually no plume rise from tanks. Therefore, the stack parameters for the stack gas exit velocity and stack diameter shall be set to near zero for the stacks representing the emissions. In addition, stack temperature shall be set equal to the ambient temperature. This is done in AERMOD by entering a value of 0.0 for the stack gas temperature.

Note that it is very important to either turn off stack tip downwash or to set the diameter to near zero. With low exit velocities and larger diameters, stack tip downwash will be calculated. Since all downwash effects are being calculated as building downwash, the additional stack tip downwash calculations would be inappropriate. Since the maximum stack tip downwash effect is to lower plume height by three stack diameters, a very small stack diameter effectively eliminates the stack tip downwash. Table 4-4 presents values of stack parameters used in modelling tanks.

Table 4-4: Stack Parameter Values for Modelling Tanks

Velocity	Diameter	Temperature
Near zero i.e. 0.001 m/s	Near zero i.e. 0.001m	Ambient – 0.0 sets models to use ambient temperature

4.5.4 Variable Emissions

The AERMOD model supports variable emission rates. This allows for modelling of source emissions that may fluctuate over time. Emission variations can be characterized across many different periods including hourly, daily, monthly and seasonally. For more information on emission estimating, please refer to the ESDM Procedure Document.

Wind Erosion

Modelling of emissions from sources susceptible to wind erosion, such as storage piles, shall be accomplished using variable emissions.

The AERMOD model allows for emission rates to be varied by wind speed. This allows for more representative emissions from sources that are susceptible to wind erosion, particularly waste piles that can contribute to particulate emissions. Once a correlation between emissions and wind speed categories is established, the models will then vary the emissions based on the wind conditions in the meteorological data.

Non-Continuous Emissions

Sources of emissions at some locations may emit only during certain periods of time. Emissions can be varied within the AERMOD model by applying factors to different time periods.

For example, for a source that is non-continuous, a factor of 0 is entered for the periods when the source is not operating or inactive. A factor of 0.5 decreases the mass emission rate for the selected time periods to 50%. Note that only the mass emission rate is affected with the use of these factors. The other source parameters such temperature and exit velocity remain constant. Start-ups and shutdowns are examples of non-continuous emissions which could use the variable emission rate options. Model inputs for variable emissions rates can include the following time periods:

- Hour-of-day;
- Monthly;
- Seasonally;
- Wind speed;
- By Season and hour-of-day; and
- By Season, hour-of-day, and day-of-week.

An external hourly input file can be prepared in which all parameters of specified sources including mass emission rate, exit velocity and temperature may be varied on an hour-by-hour basis over the entire modelling period.

4.6 Building Impacts

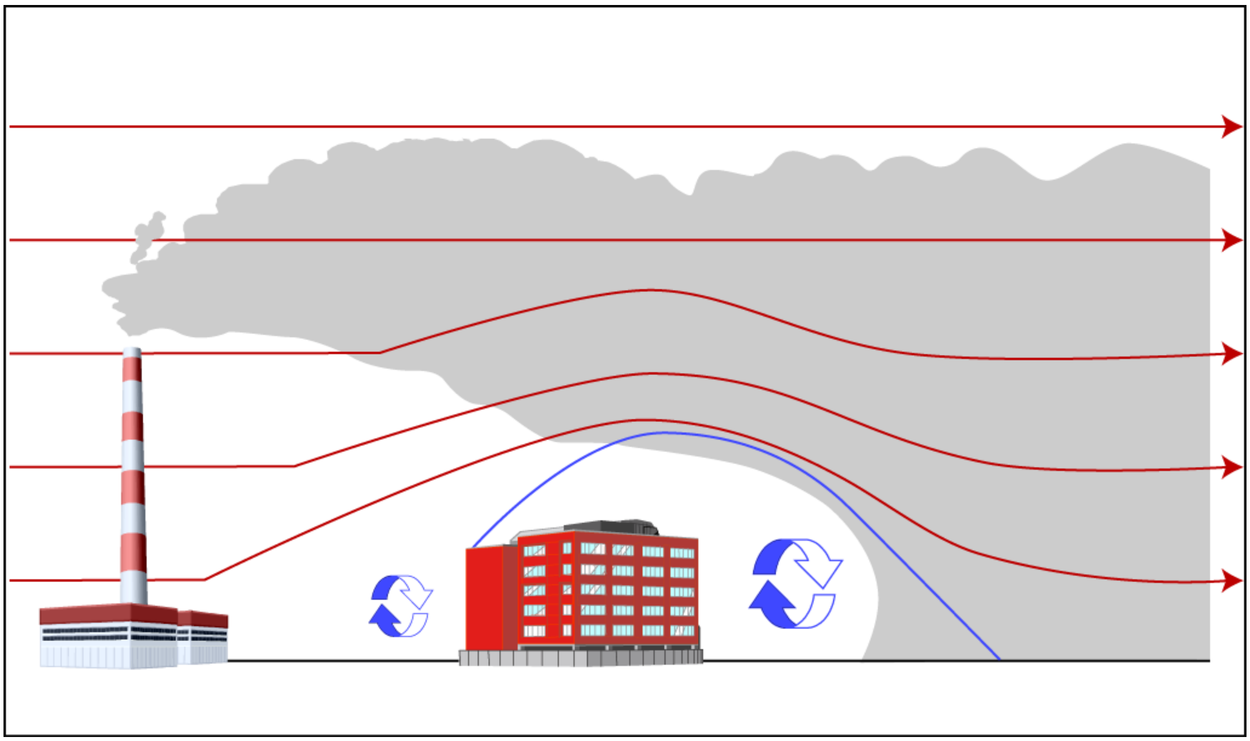
Buildings and other structures near a relatively short stack can have a substantial effect on plume transport and dispersion, and on the resulting ground-level concentrations that are observed. There has long been a generalized approach that a stack should be at least 2.5 times the height of adjacent buildings. Beyond that, much of what is known of the effects of buildings on plume transport and diffusion has been obtained from wind tunnel studies and field studies.

When the airflow meets a building (or other obstruction), it is forced up and over the building. On the lee side of the building, the flow separates, leaving a closed circulation zone containing lower wind speeds. Farther downwind, the air flows downward again. In addition, there is more shear and, as a result, more turbulence. This is the turbulent wake zone (see Figure 4.3).

If a plume gets caught in the cavity, very high concentrations can result. If the plume escapes the cavity, but remains in the turbulent wake, it may be carried downward and dispersed more rapidly by the turbulence. This can result in either higher or lower concentrations than would occur without the building, depending on whether the reduced height or increased turbulent diffusion has the greater effect.

The height to which the turbulent wake has a significant effect on the plume is generally considered to be about the building height plus 1.5 times the lesser of the building height or width. This results in a height of 2.5 times the building heights for cubic or squat buildings, and less for tall, slender buildings. Since it is considered good engineering practice to build stacks taller than adjacent buildings by this amount, this height came to be called "good engineering practice" (GEP) stack height. Figure 4.3 graphically presents the building downwash concept where the presence of buildings form localized turbulent zones that can readily draw contaminants down to ground level.

Figure 4.3: Building Downwash Effect



4.6.1 Stack Height for Certain New Sources of Contaminants: Good Engineering Practice (GEP) Stack Heights And Structure Influence Zones

GEP Stack Heights are the stack heights that the US EPA(26) requires to avoid having to consider building downwash effects in dispersion modelling assessments. The definition of GEP is stack heights equal to the building height plus 1.5 times the smaller of the building height or width.

Section 15 of the Regulation specifies the stack height to be used in modelling for new stacks as follows:

Stack height for certain new sources of contaminant

"15. (1) This section applies to a source of contaminant if all of the following criteria are met:

1.The source of contaminant discharges contaminants directly into the natural environment.

2.Construction of the source of contaminant began after November 30, 2005.

3.No application was made on or before November 30, 2005 for a certificate of approval in respect of the source of contaminant.

4.The source of contaminant is located in an area around a structure that is bounded by a circle that has a radius of five times the lesser of the following:

i.The height above ground level of the structure.

ii.The greatest width presented to the wind by the structure, measured perpendicularly to the direction of the wind.

(2) f an approved dispersion model other than the ASHRAE method of calculation is used for the purposes of this Part with respect to a source of contaminant to which this section applies, the height at which contaminants are discharged into the air from the source of contaminant that is used with the model must be the lower of the following heights:

1.The actual height above ground level at which contaminants are discharged into the air from the source of contaminant.

2.The higher of the following heights:

i.Sixty-five metres.

ii.The height described in subsection (3).

(3) The height referred to in subparagraph 2 ii of subsection (2) is the height determined by the following formula:

$$A + (1.5 \times B)$$

Stack height for certain new sources of contaminant

where,

A =the height above ground level of the structure referred to in paragraph 4 of subsection (1),

B =the lesser of,

i.the height above ground level of the structure referred to in paragraph 4 of subsection (1), and

ii.the greatest width presented to the wind by the structure referred to in paragraph 4 of subsection (1), measured perpendicularly to the direction of the wind.

(4) If paragraph 4 of subsection (1) applies to a source of contaminant in respect of more than one structure, the references in subsection (3) to the structure referred to in paragraph 4 of subsection (1) shall be deemed to be references to the structure for which the height referred to in subparagraph 2 ii of subsection (2) is the greatest.

(5) This section applies only if the approved dispersion model is used with respect to a person and contaminant to which section 20 applies."

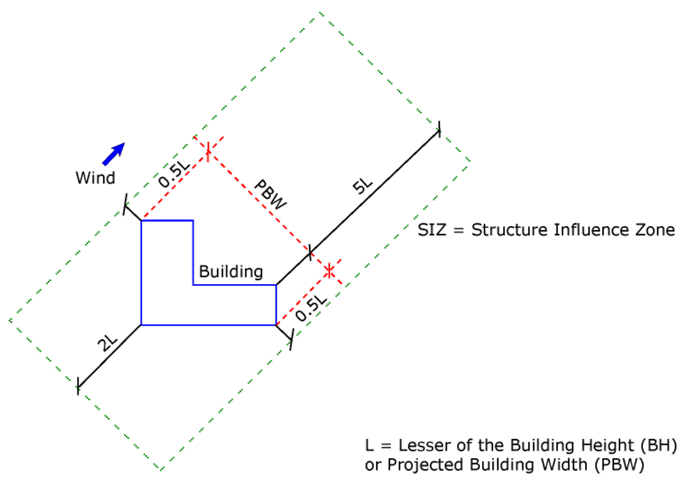
Building downwash shall be considered for point sources that are within the Area of Influence (see Figure 4.4) of a building. For US EPA regulatory applications, a building is considered sufficiently close to a stack to cause wake effects when the distance between the stack and the nearest part of the building is less than or equal to five (5) times the lesser of the building height or the projected width of the building.

$$\text{Distance}_{\text{stack-bldg}} <= 5L$$

For point sources within the Area of Influence, building downwash information (direction-specific building heights and widths) shall be included in the modelling project. Using BPIP-PRIME, a modeller can compute the direction-specific building heights and widths.

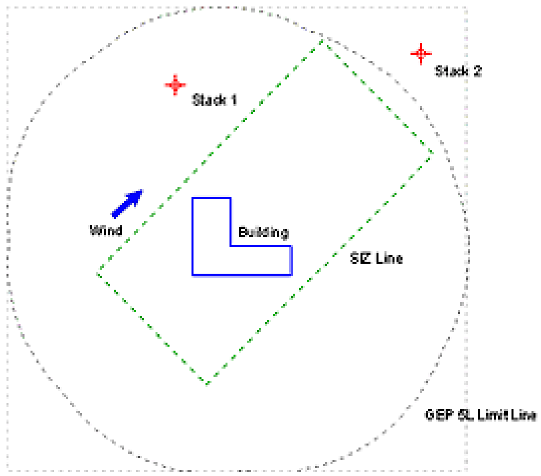
Structure Influence Zone (SIZ): For downwash analyses with direction-specific building dimensions, wake effects are assumed to occur if the stack is within a rectangle composed of two lines perpendicular to the wind direction, one at 5L downwind of the building and the other at 2L upwind of the building, and by two lines parallel to the wind direction, each at 0.5L away from each side of the building, as shown below. L is the lesser of the height or projected width. This rectangular area has been termed a SIZ. Any stack within the SIZ for any wind direction is potentially affected by GEP wake effects for some wind direction or range of wind directions, and shall be included in the modelling project. Figure 4.4 shows the SIZ around a building.

Figure 4.4: GEP 5L and Structure Influence Zone (SIZ) Areas of Influence (after US EPA(23)).



When determining the potential building effects, the BPIP program searches through 360° of wind directions to determine the SIZ for each wind direction, and the point sources that will potentially be affected by downwash, for each wind direction. Figure 4.5 shows the potential SIZ around the entire building, and illustrates how different sources could be affected by downwash, depending on their location relative to the building.

Figure 4.5: GEP 360˚ 5L and Structure Influence Zone (SIZ) Areas of Influence (US EPA[27]).



AERMOD versions prior to version 11059 used the GEP height as a limitation on plume downwash calculations, i.e., downwash was not calculated for stacks greater than the GEP height. This resulted in a discontinuity in model results for stacks that were slightly greater than the GEP height. AERMOD versions 11059 and later have been updated such that building downwash is calculated for **all** stacks in the influence zone/area, including those which are greater than the GEP height. Please note that the Regulation requires the use of the "approved" version of AERMOD, which is the most recent version that has been posted on the EBR.

4.6.2 **Defining Buildings**

All of the US EPA models allow for the consideration of building downwash. SCREEN3 considers the effects of a single building while AERMOD can consider the effects of complicated sites consisting of hundreds of buildings. This results in different approaches to defining buildings which are described below.

SCREEN3 Building Definition

Defining buildings in SCREEN3 is straightforward, as only one building requires definition. The following input data is needed to consider downwash in SCREEN3:

- **Building Height:** The physical height of the building structure in metres.
- **Minimum Horizontal Building Dimension:** The minimum horizontal building dimension in metres.
- **Maximum Horizontal Building Dimension:** The maximum horizontal building dimension in metres.

If using **Automated Distances** or **Discrete Distances** option, wake effects are included in any calculations made. Cavity calculations are made for two building orientations, first with the minimum horizontal building dimension along-wind, and second with the maximum horizontal dimension along-wind. The cavity calculations are summarized at the end of the distance-dependent calculations (see SCREEN3 User's Guide(13) Chapter 3.6 for more details).

AERMOD Building Definition

The inclusion of the PRIME algorithm(24) to compute building downwash has generally produced more accurate results in air dispersion models. Unlike the earlier algorithms used in ISCST3, the PRIME algorithm:

1. accounts for the location of the stack relative to the building;
2. accounts for the deflection of streamlines up over the building and down the other side;
3. accounts for the effects of the wind profile at the plume location for calculating plume rise;
4. accounts for contaminants captured in the recirculation cavity to be transported to the far wake downwind (this was ignored in the earlier algorithms); and
5. avoids discontinuities in the treatment of different stack heights, which were a problem in the earlier algorithms.

Models such as AERMOD allow for the capability to consider downwash effects from multiple buildings. AERMOD requires building downwash analysis to first be performed using BPIP-PRIME(24). The results from BPIP-PRIME can then be incorporated into the modelling studies for consideration of downwash effects.

The BPIP-PRIME was designed to incorporate enhanced downwash analysis data for use with the US EPA [17] ISCPRIME and current AERMOD models. Similar in operation to the US EPA BPIP model, which is used with ISCST3, BPIP-PRIME uses the same input data requiring no modifications of existing BPIP projects. The following information is required to perform building downwash analysis within BPIP/BPIP-PRIME:

- X and Y location for all stacks and building corners.

[17] Note the ISCPRIME model was phased out of the Regulation on February 1, 2012.

- Height for all stacks and buildings (metres). For buildings with more than one height or roofline, identify each height (tier).

- Base elevations for all stacks and buildings.

The BPIP User's Guide[25] provides details on how to input building and stack data to the program.

BPIP-PRIME is divided into two parts.

- **Part One:** Based on the GEP technical support document,[26] this part is designed to determine whether or not a stack is subject to wake effects from a structure or structures. Values are calculated for GEP stack height and GEP related building heights (BH) and projected building widths (PBW). Indication is given to which stacks are being affected by which structure wake effects.

- **Part Two:** This part calculates building downwash BH and PBW values based on references by Tikvart[27,28] and Lee.[29] These can be different from those calculated in Part One.

In addition to the standard variables reported in the output of BPIP, BPIP-PRIME adds the following:

- **BUILDLEN:** Projected length of the building along the flow.

- **XBADJ:** Along-flow distance from the stack to the centre of the upwind face of the projected building.

- **YBADJ:** Across-flow distance from the stack to the centre of the upwind face of the projected building.

For a more detailed technical description of the EPA BPIP-PRIME model and how it relates to the US EPA AERMOD model see the *Addendum to ISC3 User's Guide.*[30]

5.0 GEOGRAPHICAL INFORMATION INPUTS

5.1 Comparison of SCREEN3 with AERMOD Model Requirements

Geographical information requirements range from basic (for screening analyses) to advanced (for more sophisticated modelling). SCREEN3 makes use of geographical information only for complex or elevated terrain; it requires simply the distance from the source and the height in a straight-line. The AERMOD model makes use of complete three-dimensional geographic data with support for digital elevation model files and real-world spatial characterization of all model objects. As explained below, sections 16 and 26 of the Regulation require geographical information to be used.

5.2 Coordinate System

5.2.1 Local

Local coordinates encompass coordinate systems that are not based on a geographic standard. For example, a facility may reference its coordinate system based on a local set datum, such as a predefined benchmark. All site measurements can relate to this benchmark which can be defined as the origin of the local coordinate system with coordinates of 0,0 m. All facility buildings and sources could then be related spatially to this origin. However, local coordinates do not indicate where in the actual world the site is located. For this reason, it is advantageous to consider a geographic coordinate system that can specify the location of any object anywhere in the world with precision.

5.2.2 UTM

The coordinate system most commonly used for air dispersion modelling is the Universal Transverse Mercator (UTM) system which uses metres as its basic unit of measurement and allows for more precise definition of specific locations than latitude/longitude.

It is important to ensure that all model objects (sources, buildings, receptors) are defined in the same horizontal datum, NAD83 (North American datum of 1983) or NAD27 (North American datum of 1927). Defining some objects based on a NAD27 while defining others within a NAD83 can lead to significant errors in relative locations.

5.3 Terrain

5.3.1 Terrain Concerns in Short-Range Modelling

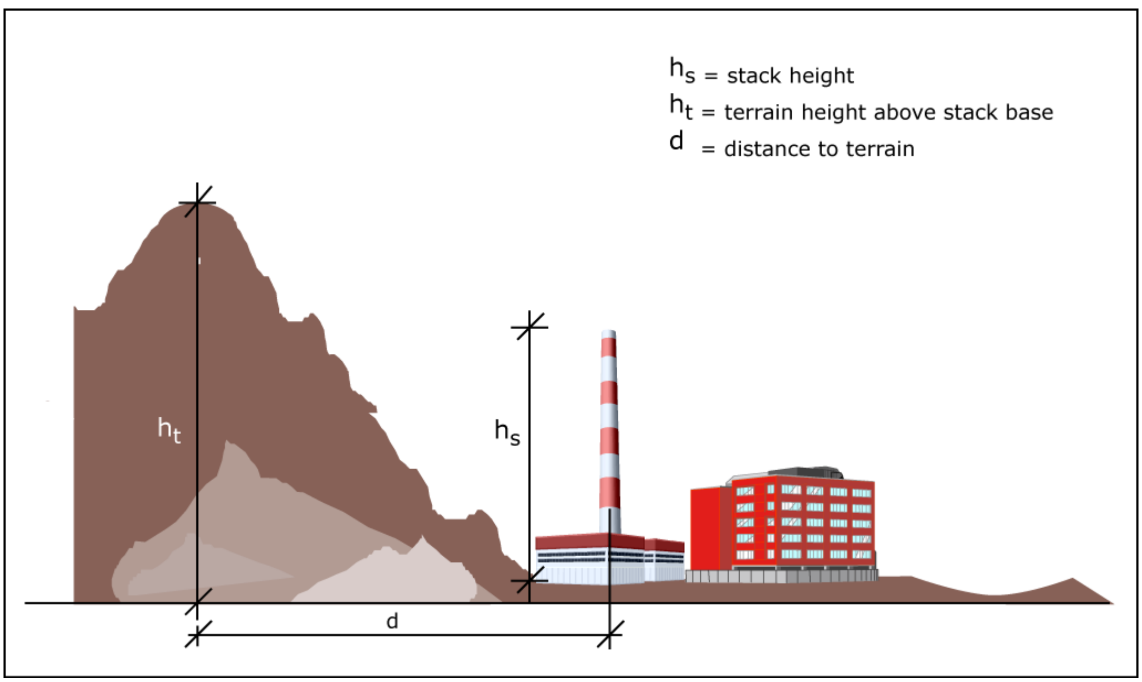
Terrain elevations can have a large impact on the air dispersion and deposition modelling results and therefore on the estimates of potential risk to human health and the environment. Terrain elevation is the elevation relative to the facility base elevation. Chapter 5.3.2 Flat and Complex Terrain describes the primary types of terrain. Although the consideration of a terrain type is dependent on the study area, the definitions below must be considered when determining the characteristics of the terrain for the modelling analysis.

5.3.2 Flat and Complex Terrain

The models consider three different categories of terrain as follows:

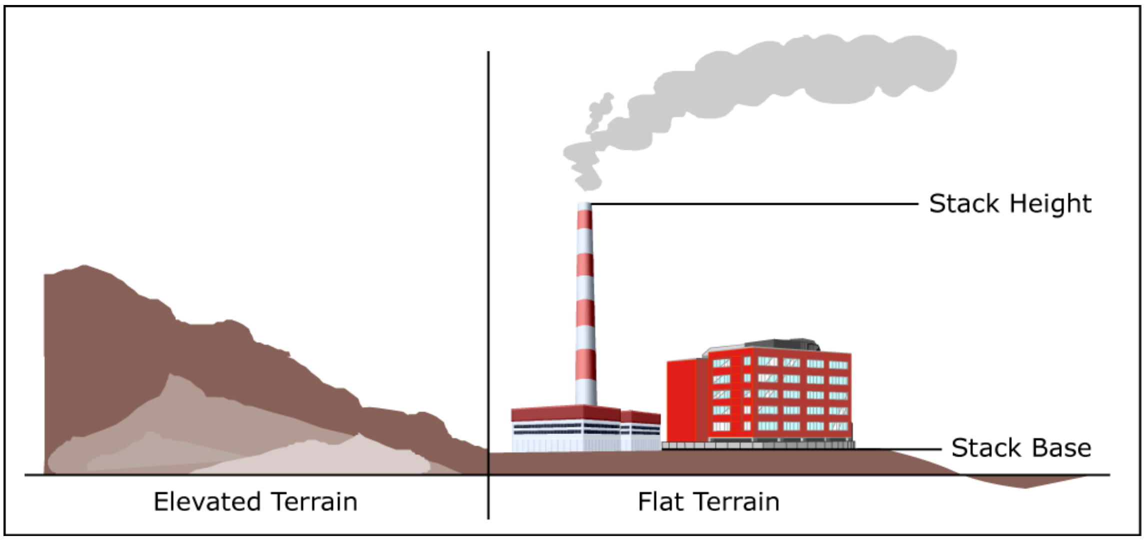
- **Complex Terrain:** as illustrated in Figure 5.1, where terrain elevations for the surrounding area, are above the top of the stack being evaluated in the air modelling analysis.

Figure 5.1 : Complex Terrain Conditions



- **Simple Terrain:** where terrain elevations for the surrounding area are not above the top of the stack being evaluated in the air modelling analysis. The "Simple" terrain can be divided into two categories:
  - **Simple Flat Terrain** is used where terrain elevations are assumed not to exceed stack base elevation. If this option is used, then terrain height is considered to be 0.0 m.
  - **Simple Elevated Terrain**, as illustrated in Figure 5.2 is used where terrain elevations exceed stack base but are below stack height.

Figure 5.2: Simple Elevated and Flat Terrain Conditions



5.3.3 **Criteria for Use of Terrain Data**

Section 16 of the Regulation sets out when terrain must be used. Section 16 of the Regulation states:

Terrain data

"16. (1) If an approved dispersion model is used for the purposes of this Part with respect to any point of impingement that has an elevation higher than the lowest point from which the relevant contaminant is discharged from a source of contaminant, the model shall be used in a manner that employs terrain data.

(2) This section does not apply if the approved dispersion model that is used is,

(a) the ASHRAE method of calculation;

(b) the method of calculation required by the Appendix to Regulation 346; or

(c) a dispersion model or combination of dispersion models that, pursuant to subsection 7 (3), is deemed to be included in references in this Part to approved dispersion models, if the dispersion model or combination of dispersion models is not capable of using terrain data."

Evaluation of terrain within a study area is the responsibility of the modeller. It should be kept in mind that both the terrain elevation relative to the source release heights and the proximity of the terrain features to the facility affect the impact of terrain on the modelled concentration of contaminants at point of impingements. Screening model runs (i.e., SCREEN3) could be used to determine if terrain features could result in higher concentrations.

5.3.4 **Obtaining Terrain Data**

Digital elevation model (DEM) data covering Ontario suitable for use with AERMOD is available at the ministry website. The DEM data is in 7.5 minute format data (resolution 1:25,000) which can be used directly with the AERMOD terrain pre-processor AERMAP.

Terrain data is also available from Natural Resources Canada. It is in a format called CDED (Canadian Digital Elevation Data), and can be obtained at 1-degree or 15-minute spatial resolutions. The ministry prefers the use of the data available on the ministry website.

5.3.5 **Preparing Terrain Data for Model Use**

AERMAP is the digital terrain pre-processor for the AERMOD model. It analyzes and prepares digital terrain data for use within an air dispersion modelling project. Early versions of AERMAP required that the digital terrain data files be in native United States Geological Survey (USGS) 1-degree or 7.5-minute DEM format. The most recent version of AERMAP accepts additional data formats, including the 15-minute USGS DEM format.

The CDEM format is very similar to the USGS DEM format. The CDEM 1-degree or 15-minute data types can be used directly with AERMAP without the need for any conversions. However, 1-degree data does not contain optimal resolution for most air dispersion modelling analyses and thus should not be used given that the above mentioned better resolution DEM data is available. Refer to Chapter 5.2.2 UTM on the UTM coordinate system.

5.4 **Land Use Characterization**

Land use plays an important role in air dispersion modelling from meteorological data processing to defining modelling characteristics such as urban or rural conditions. Land use information is required by paragraph 10 of subsection 26 (1) of the Regulation.

Contents of ESDM report (Section 26 of the Regulation)

"…. 10. A description of the local land use conditions, if meteorological data described in paragraph 2 of subsection 13 (1) was used when using an approved dispersion model for the purpose of this section. …."

Land use data can be obtained from digital land-use maps. These maps will provide an indication into the dominant land use types within an area of study, such as industrial, agricultural, forested and others. This information can then be used to determine dominant dispersion conditions and estimate values for the critical surface characteristics which are surface roughness length, albedo, and the Bowen ratio.

In 2008 the US EPA released the AERSURFACE tool, part of the AERMOD modelling system, to assist users in the appropriate selection of surface characteristics in the vicinity of a facility or site. AERSURFACE was designed to use US Geological Survey (USGS) National Land Cover Data 1992 (NLCD92), which includes 21 land cover categories. These characteristics are then input into AERMET which determines the appropriate dispersion parameters for each area/sector surrounding the site. Consult the AERSURFACE User's Guide[31] for specific guidance on using AERSURFACE.

In cases where the necessary data is not available electronically, users should obtain land use data from appropriate municipal land use maps or from site-specific/area observations, and determine the surface characteristics manually, as described below in Chapters 5.4.1 – 5.4.3. Users should follow the recommendations for determining surface characteristics as presented in Chapter 3.1 Tier 1 Modelling of the AERMOD Implementation Guide, 2008[32] or Chapter 2.3 AERSURFACE Calculation Methods of the AERSURFACE User's Guide. Note that the use of site-specific observations is always preferable to other data sources. The source data (maps) and resulting files should be submitted to EMRB for review prior to use.

It should also be noted that the seasonal characteristics in the AERSURFACE User's Guides[31,32] are based on 5 categories rather than the traditional 4 seasons. However, this approach is more subjective, as it requires user decisions on the land use conditions during specific periods. As a result, the ministry has maintained use of the 4 traditional seasons, in a manner consistent with the seasonal definitions in AERMOD. These are as follows:

- winter (December – February)
- spring (March – May)
- summer (June – August)
- autumn (September – November)

These periods should be used to apply any seasonal variations in surface characteristics.

5.4.1 **Surface Roughness Length [m]**

The surface roughness length, also referred to as surface roughness height, is a measure of the height of obstacles to the wind flow. Surface roughness affects the height above local ground level that a particle moves from the ambient air flow above the ground into a "captured" deposition region near the ground. This height is not equal to the physical dimensions of the obstacles, but is generally proportional to them. For many modelling applications, the surface roughness length can be considered to be on the order of one tenth of the height of the roughness elements.

Figure 5.3: Effect of Surface Roughness

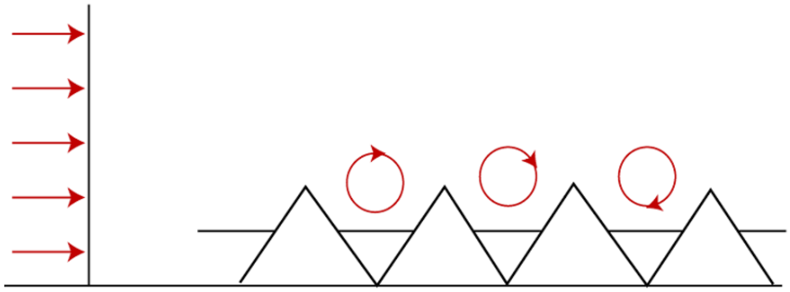


Table 5-1 lists typical surface roughness lengths for a range of land-use types as a function of season.

Table 5-1: Surface Roughness Lengths for Land Use Types and Seasons (meters)[31]

Class Number	Land Use Class Name	Spring	Summer	Autumn	Winter
11	Open Water	0.001	0.001	0.001	0.001
12	Perennial Ice/Snow	0.002	0.002	0.002	0.002
21	Low Intensity Residential	0.4	0.4	0.4	0.3
22	High Intensity Residential	1	1	1	1
23	Commercial/Industrial/Transportation (Airport)	0.07	0.07	0.07	0.07
23	Commercial/Industrial/ Transportation (Other)	0.7	0.7	0.7	0.7
31	Bare Rock/Sand/Clay (Arid Region)	0.05	0.05	0.05	
31	Bare Rock/Sand/Clay (Non-arid Region)	0.05	0.05	0.05	0.05
32	Quarries/Strip Mines/Gravel	0.3	0.3	0.3	0.3
33	Transitional	0.2	0.2	0.2	0.2
41	Deciduous forest	1	1.3	1.3	0.5
42	Coniferous forest	1.3	1.3	1.3	1.3
43	Mixed Forest	1.15	1.3	1.3	0.9
51	Shrubland (Arid Region)	0.15	0.15	0.15	
51	Shrubland (Non-arid Region)	0.3	0.3	0.3	0.15
61	Orchards/Vineyards/Other	0.2	0.3	0.3	0.05
71	Grasslands/Herbaceous	0.05	0.1	0.1	0.005
81	Pasture/Hay	0.03	0.15	0.15	0.01
82	Row Crops	0.03	0.2	0.2	0.01
83	Small Grains	0.03	0.15	0.15	0.01
84	Fallow	0.02	0.05	0.05	0.01
85	Urban/Recreational Grasses	0.015	0.02	0.015	0.005

Class Number	Land Use Class Name	Spring	Summer	Autumn	Winter
	Open Water	0.001	0.001	0.001	0.001
	Woody Wetlands	0.5	0.5	0.5	0.3
	Emergent Herbaceous Wetlands	0.2	02	0.2	0.1

AERMOD allows wind direction dependent surface characteristics to be used in the processing of the meteorological data. The US EPA recommends that the surface roughness in a given wind sector be calculated using the area-weighted average of the differing values for each land use within a specified distance of the site, based on an inverse square distance relationship. The US EPA AERSURFACE User's Guide allows a radius of influence of 0.1 to 5 km to be used for surface roughness calculations, with a recommended distance of 1 km. A radius of influence longer than 1 km would be a reasonable choice for lower roughness lengths. The US EPA 2009 AERMOD Implementation Guide(32) recommends that the assessment be performed at the meteorological tower site. It should be noted that when incorporating local land use conditions into dispersion modelling assessments for the ministry, the conditions surrounding the facility should be specified, rather than the meteorological tower. Also, given the relatively large size of many facilities and the building heights at these locations the ministry will continue to recommend that a 3 km distance from the facility be used when specifying local land use conditions unless the facility is located in an urban environment. For more information on locating a meteorological tower, please refer to "Operations Manual for Air Quality Monitoring in Ontario", as amended.

The selection of wind direction and seasonally dependent land use is described in Chapter 5.4.4 Wind Direction and Seasonably Dependent Land Use. Alternative methods of determining surface roughness lengths may be used, but modellers that undertake the meteorological processing themselves should consult with the ministry (EMRB) prior to data processing (Tier 3 Modelling).

5.4.2 **Noon-Time Albedo**

Noon-time albedo is the fraction of the incoming solar radiation that is reflected from the ground when the sun is directly overhead (see Figure 5.4). Table 5-2 lists typical albedo values as a function of several land use types and season.

Figure 5.4: Variations in Albedo Ratios Depending on Ground Cover

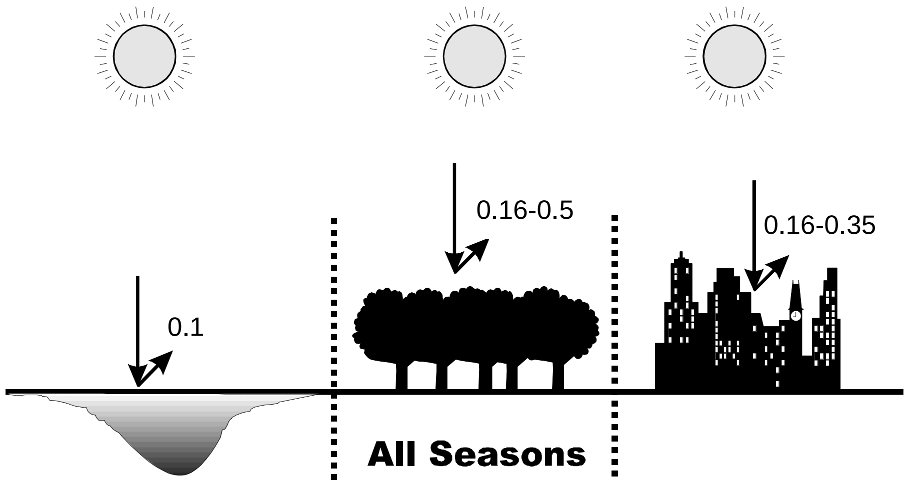


Table 5-2: Albedo of Natural Ground Covers for Land Use Types and Seasons(33)

Class Number	Land use Type	Spring	Summer	Autumn	Winter
11	Open Water	0.1	0.1	0.1	0.1
12	Perennial Ice/Snow	0.6	0.6	0.6	0.7
21	Low Intensity Residential	0.16	0.16	0.16	0.45
22	High Intensity Residential	0.18	0.18	0.18	0.35
23	Commercial/Industrial/ Transportation (at Airport)	0.18	0.18	0.18	0.35
	Commercial/Industrial/ Transportation (Not at Airport)	0.18	0.18	0.18	0.35
31	Bare Rock/Sand/Clay (Arid Region)	0.2	0.2	0.2	
	Bare Rock/Sand/Clay (Non-arid Region)	0.2	0.2	0.2	0.6
32	Quarries/Strip Mines/Gravel	0.2	0.2	0.2	0.6
33	Transitional	0.18	0.18	0.18	0.45
41	Deciduous forest	0.16	0.16	0.16	0.5
42	Coniferous forest	0.12	0.12	0.12	0.35

Class Number	Land use Type	Spring	Summer	Autumn	Winter
43	Mixed Forest	0.14	0.14	0.14	0.42
51	Shrubland (Arid Region)	0.25	0.25	0.25	
	Shrubland (Non-arid Region)	0.18	0.18	0.18	0.5
61	Orchards/Vineyards/Other	0.14	0.18	0.18	0.5
71	Grasslands/Herbaceous	0.18	0.18	0.18	0.6
81	Pasture/Hay	0.14	0.2	0.2	0.6
82	Row Crops	0.14	0.2	0.2	0.6
83	Small Grains	0.14	0.2	0.2	0.6
84	Fallow	0.18	0.18	0.18	0.6
85	Urban/Recreational Grasses	0.15	0.15	0.15	0.6
91	Woody Wetlands	0.14	0.14	0.14	0.3
92	Emergent Herbaceous Wetlands	0.14	0.14	0.14	0.3

5.4.3 Bowen Ratio

The Bowen ratio is a measure of the amount of moisture at the surface. The presence of moisture at the earth's surface alters the energy balance, which in turn alters the sensible heat flux and Monin-Obukhov length, which are both key dispersion parameters used by the AERMOD model. Table 5-3 lists Bowen ratio values as a function of land-use types, seasons and moisture conditions. Bowen ratio values vary depending on the surface wetness. **Modellers shall use the average precipitation (moisture) conditions for selecting the Bowen ratio when processing meteorological data.** If a modeller wishes to use other conditions, they should consult ministry (EMRB) prior to data processing (Tier 3).

Table 5-3: Daytime Bowen Ratios by Land Use and Season for Different Moisture Conditions[31]

Class Number	Land Use Class Name	Seasonal Bowen Ratio - Average				Seasonal Bowen Ratio - Wet				Seasonal Bowen Ratio - Dry			
		Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
11	Open Water	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
12	Perennial Ice/Snow	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
21	Low Intensity Residential	0.8	0.8	1	0.5	0.6	0.6	0.6	0.5	2	2	2.5	0.5
22	High Intensity Residential	1.5	1.5	1.5	0.5	1	1	1	0.5	3	3	3	0.5
23	Commercial/Industrial/ Transportation (at Airport)	1.5	1.5	1.5	0.5	1	1	1	0.5	3	3	3	0.5
	Commercial/Industrial/ Transportation (Not at Airport)	1.5	1.5	1.5	0.5	1	1	1	0.5	3	3	3	0.5
31	Bare Rock/Sand/Clay (Arid Region)	3	4	6		1	1.5	2		5	6	10	
	Bare Rock/Sand/Clay (Non-arid Region)	1.5	1.5	1.5	0.5	1	1	1	0.5	3	3	3	0.5
32	Quarries/Strip Mines/Gravel	1.5	1.5	1.5	0.5	1	1	1	0.5	3	3	3	0.5
33	Transitional	1	1	1	0.5	0.7	0.7	0.7	0.5	2	2	2	0.5
41	Deciduous forest	0.7	0.3	1	0.5	0.3	0.2	0.4	0.5	1.5	0.6	2	0.5
42	Coniferous forest	0.7	0.3	0.8	0.5	0.3	0.2	0.3	0.5	1.5	0.6	1.5	0.5
43	Mixed Forest	0.7	0.3	0.9	0.5	0.3	0.2	0.35	0.5	1.5	0.6	1.75	0.5
51	Shrubland (Arid Region)	3	4	6		1	1.5	2		5	6	10	
	Shrubland (Non-arid Region)	1	1	1.5	0.5	0.8	0.8	1	0.5	2.5	2.5	3	0.5
61	Orchards/Vineyards/Other	0.3	0.5	0.7	0.5	0.2	0.3	0.4	0.5	1	1.5	2	0.5
71	Grasslands/Herbaceous	0.4	0.8	1	0.5	0.3	0.4	0.5	0.5	1	2	2	0.5
81	Pasture/Hay	0.3	0.5	0.7	0.5	0.2	0.3	0.4	0.5	1	1.5	2	0.5
82	Row Crops	0.3	0.5	0.7	0.5	0.2	0.3	0.4	0.5	1	1.5	2	0.5
83	Small Grains	0.3	0.5	0.7	0.5	0.2	0.3	0.4	0.5	1	1.5	2	0.5
84	Fallow	0.3	0.5	0.7	0.5	0.2	0.3	0.4	0.5	1	1.5	2	0.5
85	Urban/Recreational Grasses	0.3	0.5	0.7	0.5	0.2	0.3	0.4	0.5	1	1.5	2	0.5
91	Woody Wetlands	0.2	0.2	0.3	0.5	0.1	0.1	0.1	0.5	0.2	0.2	0.2	0.5
92	Emergent Herbaceous	0.1	0.1	0.1	0.5	0.1	0.1	0.1	0.5	0.2	0.2	0.2	0.5

5.4.4 **Wind Direction and Seasonally Dependent Land Use**

AERMET provides the ability to specify land use characteristics for up to 12 different contiguous, non-overlapping wind direction sectors that define unique upwind surface characteristics. Properties of wind sectors include:

- The sectors must be defined clockwise as the direction from which the wind is blowing, with north at 0°. (i.e. it is the **upwind** conditions that affect downwind dispersion)
- The sectors must cover the full circle so that the end value of one sector matches the beginning of the next sector.
- The beginning direction is considered part of the sector, while the ending direction is not.

Each wind sector can have a unique surface roughness length based on the weighted average of the land use categories within 3 km of the site for that sector. AERMET allows these surface characteristics to be specified annually, seasonally, or monthly to better reflect site conditions. For example, winter conditions can bring increased albedo values due to snow accumulation. Modellers should consult the AERSURFACE User's Guide or contact EMRB for detailed guidance.

5.4.5 **Defining Urban and Rural Conditions**

SCREEN3:

SCREEN3: Requires a designation of the site as being in a predominantly urban or rural setting. The US EPA document *Guideline on Air Quality Models (40 CFR Part 51, Appendix W*[(11)] describes procedures for classifying sites as urban or rural, and requires that either a land use classification procedure or a population based procedure be used in this determination. The land use procedure is considered a more definitive criterion, and should be used by modellers for the purposes of the Regulation unless the ministry has indicated in writing that another procedure (e.g. the population density procedure) is acceptable.

Land Use Procedure: The land use within a 3 km radius around the facility sources is examined. If more than 50% of the area is accounted for by land use categories ranging from multi-family dwelling to commercial and industrial use it is classified as urban. Otherwise the site is classified as rural.

Population Density Procedure: Compute the average population density within a 3 km radius around the facility sources. The designation of urban or rural is the given by:

(a) If $p > 750$ people/km^2, select the Urban option,

If $p <= 750$ people/km^2, select the Rural option.

Note that the population density approach can lead to erroneous classification of urban and rural conditions, if applied incorrectly. For example, in highly industrialized areas, the population density may be low which would indicate a rural classification but the area is sufficiently built-up such that it would be more appropriately classified as urban using the land use approach. Modellers that want to use this approach should contact EMRB for additional guidance.

AERMOD:

The urban option in AERMOD is used to account for the urban heat island effect. Impacts of surface roughness, albedo and the Bowen ratio on turbulent mixing are taken into account in developing the meteorological data sets. In urban areas the direct input of heat and the trapping of long wave radiation between buildings can increase convective turbulence above the levels calculated in the AERMET pre-processor. Factors that affect the selection of the urban option in AERMOD include the population/urban intensity and the location of a facility relative to the urban core. If a facility is located close to the edge of an urban area, the urban heat island option would generally not be selected. Modellers are encouraged to contact ministry (EMRB) to discuss the selection of the urban option for more complex cases.

6.0 METEOROLOGICAL DATA

Section 13 of the Regulation specifies the types of meteorological information that can be used with an approved dispersion model as follows:

Meteorological data

"13. (1) An approved dispersion model that is used for the purposes of this Part shall be used with one of the following types of meteorological information:

1. Regional surface and upper air meteorological data for the part of Ontario in which the source of contaminant is located that was available on May 14, 2007, and continues to be available, through a website maintained by the Ministry on the internet or through the Ministry's Public Information Centre.

1.1 Data described in paragraph 1 that has been processed by the AERMET computer program, as that program is amended from time to time, and that is available through a website maintained by the Ministry on the Internet or through the Ministry's Public Information Centre, if the approved dispersion model that is used is the AERMOD dispersion model described in paragraph 1 of subsection 6 (1).

2. Data described in paragraph 1.1 that has been refined to reflect local land use conditions, if the approved dispersion model that is used is the AERMOD dispersion model described in paragraph 1 of subsection 6 (1).

3. Local or site-specific meteorological data approved by the Director as an accurate reflection of meteorological conditions.

4. Data obtained from a computational method, if the Director is of the opinion that the data is at least as accurate as data that would be obtained by local or site-specific meteorological monitoring.

(2) Despite subsection (1), the Director may give written notice to a person who discharges or causes or permits the discharge of a contaminant requiring that an approved dispersion model that is used for the purposes of this Part be used with a type of meteorological information specified in the notice that, in the opinion of the Director, accurately reflects meteorological conditions.

(3) Before the Director gives a person a notice under subsection (2), the

Meteorological data

Director shall give the person a draft of the notice and an opportunity to make written submissions to the Director during the period that ends 30 days after the draft is given.

(4) This section does not apply if the approved dispersion model that is used is,

(a) the ASHRAE method of calculation;

(b) the SCREEN3 dispersion model described in paragraph 4 of subsection 6 (1);

(c) the method of calculation required by the Appendix to Regulation 346; or

(d) a dispersion model or combination of dispersion models that, pursuant to subsection 7 (3), is deemed to be included in references in this Part to approved dispersion models, if the dispersion model or combination of dispersion models is not capable of using meteorological data.

6.1 Comparison of SCREEN3 with AERMOD Model Requirements

Meteorological data is essential for air dispersion modelling as it describes the primary environment through which the contaminants being studied migrate. Similar to other data requirements, screening model requirements are less demanding than the more advanced models.

SCREEN3 provides three methods of defining meteorological conditions without using actual meteorological data or measurements. These are as follows:

1. Full Meteorology: SCREEN3 will examine all six stability classes (five for urban sources) and their associated wind speeds. SCREEN3 examines a range of stability classes and wind speeds to identify the "worst case" meteorological conditions, i.e., the combination of wind speed and stability that results in the maximum concentrations.

2. Single Stability Class: The modeller can select the stability class to be used (A through F). SCREEN3 will then examine a range of wind speeds for that stability class only.

3. Single Stability Class and Wind Speed: The modeller can select the stability class and input the 10-metre wind speed to be used. SCREEN3 will examine only that particular stability class and wind speed.

Note that modellers should select the "full meteorology" option when using SCREEN 3 to assess POI concentrations under the Regulation.

6.2 Preparing Meteorological Data for use with AERMOD Dispersion Modelling

AERMOD requires actual hourly meteorological conditions as inputs. This model requires pre-processed meteorological data that contains information on surface characteristics and upper air definition. This data is typically provided in a raw or partially processed format that requires processing through a meteorological pre-processor. AERMOD uses a pre-processor known as AERMET which is described further below.

6.2.1 Hourly Surface Data

Hourly surface data is supported in several formats including the CD-144 file format, the SCRAM surface data file format, the ISHD format (TD-3505), and SAMSON surface data as shown below.

(a) CD-144 – NCDC Surface Data: This file is composed of one record per hour, with all weather elements reported in an 80-column card image. Table 6-1 lists the data contained in the CD-144 file format that is needed to pre-process your meteorological data.

Table 6-1: CD-144 Surface Data Record (80 Byte Record)

Element	Columns
Surface Station Number	1-5
Year	6-7
Month	8-9
Day	10-11
Hour	12-13
Ceiling Height (Hundreds of Feet)	14-16
Wind Direction (Tens of Degrees)	39-40
Wind Speed (Knots)	41-42
Dry Bulb Temperature (°Fahrenheit)	47-49
Opaque Cloud Cover	79

(b) MET-144 – SCRAM Surface Data: The SCRAM surface data format is a reduced version of the CD-144 data with fewer weather variables (28-character record). Table 6-2 lists the data contained in the SCRAM file format.

Table 6-2: SCRAM Surface Data Record (28 Byte Record)

Element	Columns
Surface Station Number	1-5
Year	6-7
Month	8-9
Day	10-11
Hour	12-13
Ceiling Height (Hundreds of Feet)	14-16
Wind Direction (Tens of Degrees)	17-18
Wind Speed (Knots)	19-21
Dry Bulb Temperature (° Fahrenheit)	22-24
Total Cloud Cover (Tens of Percent)	25-26
Opaque Cloud Cover (Tens of Percent)	27-28

SCRAM is an older format developed by the US EPA specifically for use by air dispersion models. It does not contain several weather variables, which are necessary for dry and wet particle deposition analysis, including:

i. Surface pressure: for dry and wet particle deposition;

ii. Precipitation type: for wet particle deposition only; or

iii. Precipitation amount: for wet particle deposition only.

(c) SAMSON Surface Data: The SAMSON data format contains all of the required meteorological variables for concentration, dry and wet particle deposition, and wet vapour deposition. The SAMSON data elements used by AERMET and the corresponding Element IDs are shown below in

Table 6-3.

Table 6-3: SAMSON Surface Data Elements

Element	Element ID
Total cloud cover	6
Opaque cloud cover	7
Dry bulb temperature	8
Relative humidity	10
Station pressure	11
Wind direction	12
Wind speed	13
Ceiling height	15
Hourly precipitation amount and flag	21

(d) Integrated Surface Hourly Data (ISHD): Data in this format, which is supported by the USEPA, is available for download from the US National Oceanic and Atmospheric Administration (NOAA), and is in the TD-3505 format. It contains a large number of data elements, many of which are not used by AERMET. Note that ISHD data is reported in Greenwich Mean Time (GMT).

If the processing of raw data is necessary, the surface data must be in one of the above formats in order to successfully pre-process the data using AERMET. Canadian hourly surface data can be obtained from Environment Canada, or US NOAA. Regional pre-processed meteorological data sets can be obtained from the Public Information Centre [Ontario Regional Meteorological Data (PIBs # 5081e01)] or the ministry website here.

6.2.2 **Upper Air Data**

AERMET requires the full upper air sounding data. These data for the Ontario regions are available from the Public Information Centre [Ontario Regional Meteorological Data (PIBs # 5081e01)] or the ministry website here.

Subject to ministry approval under section 13, other upper air data can be used; for example:

- observations (i.e. upper air soundings) from other stations, or
- data generated from mesoscale meteorological models, such as the North America Model (NAM) or North America Regional Reanalysis (NARR)

6.2.3 AERMET and the AERMOD Model

The AERMET program is a meteorological pre-processor which prepares hourly surface data and upper air data for use in the US EPA air quality dispersion model AERMOD. AERMET was designed to allow for future enhancements to process other types of data and to compute boundary layer parameters with different algorithms.

AERMET processes meteorological data in three stages:

1. The first stage (Stage1) extracts meteorological data from archive data files and processes the data through various quality assessment checks.
2. The second stage (Stage2) merges all data available (surface data, upper air data, and on-site data) and stores these data from all hours together in a single file.
3. The third stage (Stage3) reads the merged meteorological data along with the land use surface characteristics (Chapter 5.4) to estimate the necessary boundary layer parameters for use by AERMOD.

Out of this process two files are written for AERMOD:

1. A Surface File of hourly boundary layer parameters estimates; and
2. A Profile File of multiple-level observations of wind speed, wind direction, temperature, and standard deviation of the fluctuating wind components.

6.3 Regional Meteorological Data

The ministry has prepared regional meteorological data sets for use in Tier 2 modelling using AERMOD. These are standard data sets that can be used for air quality studies using AERMOD.

For AERMOD, the meteorological data sets are available in two formats:

- Regional model ready data for AERMOD, with land characteristics for CROP, RURAL and URBAN conditions.

- Regional pre-processed hourly surface data and upper air data files ready for AERMET (stages 1, 2 and 3), which allows consideration of site-specific local land use conditions.

The above data sets are available from the ministry website here, and provide a unique, easily accessible resource for air dispersion modellers in the province of Ontario (see section 13 of the Regulation). The availability of standard meteorological data reduces inconsistencies in data quality and requests to the ministry for meteorological data sets. The regional data sets shall not be modified when used for the purpose of paragraph 1 of subsection 13 (1) of the Regulation. If the pre-processed data sets are used with site-specific land use conditions as per paragraph 2 of subsection 13 (1), this must be documented in the submission as per paragraph 10 of subsection 26 (1) of the Regulation and it is strongly recommended that modellers consult EMRB for guidance or review prior to the completion of model runs.

Each regional data set was developed using surface and upper air data from the nearest representative meteorological station. The surface meteorological sites used were Toronto (Pearson Airport), London, Sudbury and Ottawa along with International Falls, MN and Massena, NY. Note in Table 6-4 there exist two ID numbers for Massena and International Falls. The ID within brackets represents the United States System while the other is the ID for the International System. The following meteorological elements were used in AERMET processing for the 5 year period:

- ceiling height;
- wind speed;
- wind direction;
- air temperature;
- total cloud opacity; and
- total cloud amount.

The upper air stations used were Maniwaki, QC, White Lake, MI, Buffalo, NY, Albany, NY and International Falls, MN. Table 6-4 gives the locations of the surface meteorological sites and lists the upper air station to be used for each site. The locations of the upper air sites are given in

Table 6-5.

Table 6-4: Location of Surface Meteorological Sites

Surface station	ID	Latitude	Longitude	Height above sea level, m	Province/ State	UA to use
Sudbury	6068150	46.62	-80.8	348	ON	White Lake
Ottawa	6106000	45.32	-75.67	114	ON	Maniwaki
London	6144475	43.03	-81.15	278	ON	White Lake
Toronto	6158733	43.67	-79.6	173	ON	Buffalo
Massena	72622 (94725)	44.9	-74.9	65	NY	Albany
International Falls	72747 (14918)	48.57	-93.37	359	MN	International. Falls

Note: All surface stations have an anemometer height of 10 m)

Table 6-5: Location of Upper Air Stations

UA station	ID	Latitude	Longitude
Buffalo	725280	42.93	-78.73
Maniwaki	7034480	46.23	-77.58
Albany	725180	42.75	-73.8
White Lake	726320	42.7	-83.47
Int. Falls	727470	48.57	-93.37

6.3.1 Regional Meteorological Data Processing Methodology

The original surface meteorological data was pre-processed by the ministry to reduce the amount of missing data and to use a minimum wind speed of about 1 m/s. Use of a 1 m/s minimum wind speed essentially eliminates missing hours due to calm conditions. A calm hour is defined as a period where the wind speed is below the measurement threshold of the anemometer. During these periods, the data is often reported as missing, since both the wind speed and direction are either non-existent or highly uncertain. Atmospheric dispersion is typically quite poor during calm conditions, which can lead to elevated pollutant concentrations in the vicinity of a facility. As a result, the ministry regional data sets were processed using a specific methodology to remove the calms and set the minimum wind speed to 1 m/s. Also, the wind directions were randomized to account for the variability in wind directions during these periods. This allows the model to calculate concentrations during these periods. The pre-processing steps were as follows:

1) Treatment of Wind Speed and Direction for Calm/Missing Conditions - Data sets that had approximately 5% or more missing or calm hours, were pre-processed by first filling these missing/calm hours with data from a nearby station with similar climatology. For example, missing/calm hours in the original International Falls and Massena data sets were filled by Kenora and Dorval data, respectively. Any remaining missing/calms hours (if less than 6 consecutive hours in a row) were then interpolated as described below, and the interpolated wind directions were randomized using a random number file. Hours with calm or very low wind speeds were set to minimum speeds of 4 km/h (~1 m/s).

2) Interpolation of Missing Values As indicated above, if missing hours remained after backfilling with data from another station, linear interpolation was applied to a maximum of six missing hours in a row. Note that missing data that occurred at the very beginning and at the very end of the data set (i.e., the first few hours in January of the first year of meteorological data, and the last few hours in December of the last year of meteorological data) were left as "missing", and no extrapolation was applied. Also, if the number of consecutive hours with missing values for the element was more than six, the entire block of values were left as "missing".

3) Unit Conversion - All data from Canadian sites were converted to the United States standard format required for input into AERMET, as previously set out in Table 6-1 and Table 6-2.

The AERMOD ready regional meteorological data sets were generated by the 3 stage AERMET process for three different wind independent surface categories, called “URBAN”, “FOREST” and “CROPS”. These three categories/files allow users to choose the file that most accurately reflects the land use conditions in the vicinity of their site. For each of these three surface types, the ministry used a weighted-average of surface parameters for the typical mix of land uses seen in Ontario for each land use class considered in the category. For example, the surface characteristics in the FOREST regional data sets were calculated assuming that typical forests in Ontario are comprised of a mix of 50% deciduous and 50% coniferous trees.

As indicated previously, the surface characteristics that are adjusted to reflect land use conditions are the albedo (A), the Bowen ratio (Bo) and the surface roughness (Zo). The parameter values used in each of the AERMOD ready regional files were derived from data in Tables 4.1, 4.2b (albedo for average conditions) and 4.3 of the AERMET User's Guide[(8)] and the weightings of different land uses considered in each file. These are shown in Table 6-6, Table 6-7 and Table 6-8 below for each category/file.

"URBAN" – all surface parameters were set to urban values, as in Table 6-6.

Table 6-6: Parameters for URBAN Surface Characteristics

SEASON	A	Bo	Zo
Winter	0.35	1.5	1
Spring	0.14	1	1
Summer	0.16	2	1
Fall	0.18	2	1

"FOREST" – all surface parameters were set to the mixture of coniferous and deciduous forests in the ratio 50%/50% as in Table 6-7.

Table 6-7: Parameters for FOREST Surface Characteristics

SEASON	A	Bo	Zo
Winter	0.42	1.5	0.9
Spring	0.12	0.7	1.15
Summer	0.12	0.3	1.3
Fall	0.2	0.9	1.05

"CROPS" – all surface parameters were set to the mixture of Grassland, Cultivated Land, and Coniferous and Deciduous forest in the ratio: 45%/45%/5%/5% as in Table 6-8.

Table 6-8: Parameters for CROPS Surface Characteristics

SEASON	A	Bo	Zo
Winter	0.6	1.5	0.095
Spring	0.16	0.35	0.15
Summer	0.19	0.65	0.265
Fall	0.19	0.85	0.13

These AERMOD-ready files may be used if the surface characteristics for a radius of 3 km around the facility are reasonably represented by the surface characteristics of one of the prepared files. Note that the values in the above tables are somewhat different than those presented earlier in Table 5-1 to Table 5-3, which were derived from information presented in the AERSURFACE User's Guide. The values in AERSURFACE represent a refinement over those in AERMET as there are 21 land use categories in comparison to the 8 in AERMET. The AERSURFACE data can be used in the development of local meteorological data sets where more detail may be necessary to accurately specify the land use patterns in the area. However, the regional meteorological data sets are intended to be somewhat generic, for use at a variety of locations in each region. As a result, ministry considers the use of the AERMET values in the regional data sets to be valid and representative.

In cases where the surface characteristics at a site do not reasonably match those defined in any of the AERMOD-ready regional meteorological data sets, for example when there are significant areas of water coverage within a 3 km radius, paragraph 2 of subsection 13 (1) of the Regulation allows a modeller to use site-specific surface conditions (i.e. local land use) in combination with the ministry's pre-processed surface and upper air data files in a Tier 2 assessment. In the Stage 3 processing of the meteorological data with AERMET, different surface characteristics may be entered on a variable sector size basis. The surface characteristics for each sector must be the weighted average for a radius of 3 km from the facility. The choice of surface characteristics (surrounding land use) must be well documented and provided as part of a modeller's submission (paragraph 10 of subsection 26 (1) of the Regulation). It is strongly recommended that modellers pre-consult ministry (EMRB) if values for the surface characteristics other than those set out previously in Table 5-1 – Table 5-3 are proposed for use.

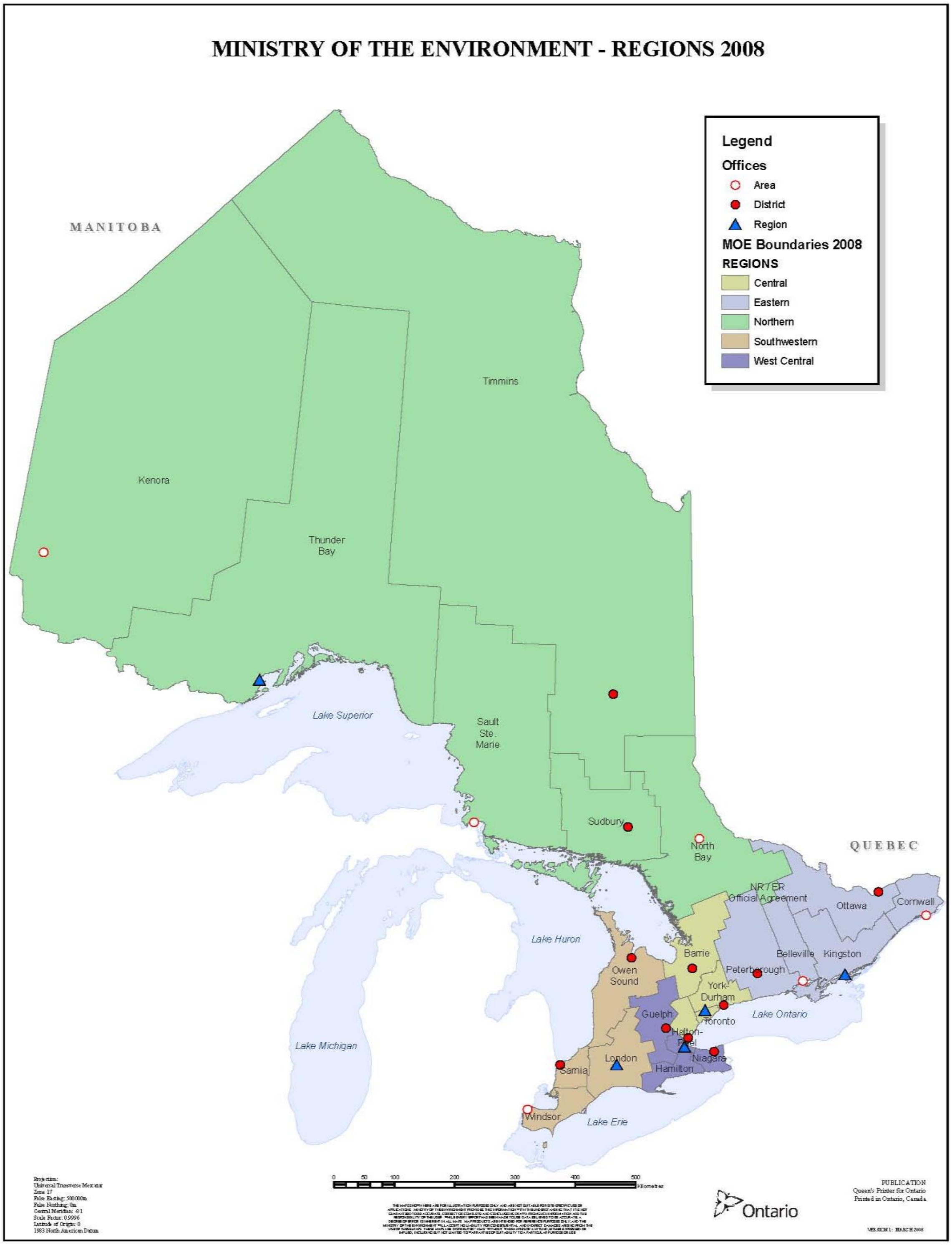
6.3.2 **Use of Ministry Regional Meteorological Data**

The application of the regional meteorological data sets across Ontario is described in Table 6-9. This table lists the ministry region and districts for which each of the meteorological data sets is most applicable. A map of the districts can be found in Figure 6.1.

Table 6-9: Application of Regional Meteorological Data Sets for ministry Regions and Districts

Meteorological Data Set	Ministry Region	Ministry District/Area
Toronto	Central	Toronto, York-Durham, Halton-Peel, Barrie, Owen Sound
London	Southwestern	London, Windsor, Sarnia
London	West Central	Hamilton, Niagara, Guelph
Ottawa	Eastern	Ottawa, Peterborough, Belleville
Sudbury	Northern	Sudbury, North Bay, Sault Ste. Marie, Timmins
Int. Falls	Northern	Thunder Bay, Kenora
Massena	Eastern	Kingston, Cornwall

Figure 6.1: Ontario Ministry of Environment and Climate Change Regions and Their Offices



6.4 Local and Site-Specific Meteorological Data

Meteorological data quality is of critical importance, particularly for reliable air dispersion modelling using models such as AERMOD. If data other than the ministry's Regional Meteorological data sets are used in air dispersion modelling assessments, careful quality control must be used throughout the entire processing phase to ensure that the data set is complete and representative of the site being modelled.

There are four factors that affect the representativeness of the meteorological data. These are: 1) the proximity of the meteorological site to the area being modelled; 2) the complexity of the terrain; 3) the exposure of the meteorological measurement site; and 4) the time period of the data collection. It should be emphasized that *representativeness* (both spatial and temporal) of the data is the key requirement. One factor alone should not be the basis for deciding on the representativeness of the data.

The meteorological data that is input to a model must be selected based on its appropriateness for the modelling project. More specifically, local meteorological data must be representative of the wind flow in the specific area being modelled, so that it properly represents the transport and diffusion of the contaminants being modelled.

As indicated earlier, no approval is required to use the appropriate regional meteorological data set. However, during the assessment it may be determined that the regional meteorological data sets are not representative of the meteorology at the location of the facility. This may be the case where there are differing dominant land uses or terrain in the vicinity that are not captured in the regional met data sets, such as those located next to significant terrain features or large water bodies. In these situations, use of a local data set would be more representative.

Note that ministry approval must be obtained to use any local or site-specific meteorological data set (see paragraphs 3 and 4 of subsection 13 (1) of the Regulation). In some cases, a modeller may be required[18] to use local meteorological data. It should be noted that a notice to use a specific type of meteorological data may be issued where the Director is of the opinion that it accurately reflects meteorological conditions (see subsection 13 (2) of the Regulation). A form to request this approval is available on the ministry website

[18] A modeller is required to use site-specific meteorological data for an Emission Summary and Dispersion Modelling report prepared under section 30 of the Regulation (Upper Risk Thresholds) or section 32 of the Regulation (Site-Specific standard requests) or as required when issues a notice under section 13(2) of the Regulation.

here. Completed forms should be submitted electronically to MetDataENE@ontario.ca or in hard copy to the mailing addresses shown on the form.

6.4.1 Expectations for Local Meteorological Data Use

Pre-processed, AERMOD-ready local surface and upper air data files may be obtained from the ministry upon request. Alternately, raw meteorological data may be obtained from Environment Canada, on-site meteorological stations[19], or data generated computationally by advanced meteorological models such as the US Weather Research and Forecasting (WRF) model. Use of all local meteorological data sets require approval under subsection 13 (1) of the Regulation, regardless of whether it is processed by the ministry or a facility.

When using any data sets that are not processed by the ministry, the quality of the data, origin of the data and any processing applied to the raw data must be outlined for review by the ministry. Missing meteorological data and calm wind conditions can be handled in an approach similar to that used for the generation of the regional meteorological data sets (described in Chapter 6.3.1). Modellers who wish to or who are required to use local or site-specific meteorological data must obtain pre-approval by the ministry by completing a subsection 13 (1) request form, prior to the submission of an ESDM report.

When Environment Canada sites are used as the source of local met data, the ministry requires a description of why the Environment Canada site is representative for the facility and an assessment of the completeness of the data set. This information must be reviewed by the ministry before the modeller develops and processes the local meteorological data set, otherwise approval may not be granted.

When on-site meteorological data is used, the sources of all of the data used to produce the meteorological file, including cloud data and upper air data must be documented. The modeller also needs to:

- describe why the site chosen is representative for the modelling assessment;
- describe the Quality Assurance and Quality Control (QA/QC) program for the station, and the date of last calibration;

[19] Facilities wishing to use on-site meteorological observations for the purposes of dispersion modelling under the Regulation must ensure that the station meets all requirements set out in the *Operations Manual for Air Quality Monitoring in Ontario* (as amended) in terms of siting, calibration, operation and maintenance.

- include a description of any topographic impacts or impacts from obstructions (trees, buildings etc.) on the wind monitor;
- supply information on the monitoring equipment, and the height(s) that the wind is measured;
- supply the time period of the measurements (measurement interval, recording interval, averaging period and method (vector or scalar)); and
- supply the data completeness and the percentage of calm winds.

In preparing regional meteorological data sets, the ministry treated calms winds and missing data as described in Chapter 6.3.1. A similar discussion of the data QA/QC methodology must be presented when modellers process local meteorological data for approval, along with the treatment of calm wind and missing data.

Wind roses showing the wind speed and directions shall be provided with the modelling assessment. If wind direction dependent land use was used in deriving the final meteorological file, the selection of the land use shall be documented as per paragraph 10 of subsection 26 (1) of the Regulation.

Use of computationally generated local meteorological data with WRF or another meteorological model is an extremely complex process, with many data inputs and QA/QC requirements. Modellers who choose to use this approach are strongly encouraged to preconsult with EMRB for guidance in advance of running the meteorological model, otherwise approval under subsection 13 (1) may not be granted.

6.5 **Elimination of Meteorological Anomalies**

In modelling applications using regional or local meteorological data sets, certain extreme, rare and transient metrological conditions may be present in the data sets that may be considered outliers. As such, for assessments of 24-hour average concentrations, the highest 24-hour average predicted concentration in each single meteorological year may be discarded, and the ministry will consider for compliance assessment the highest concentration after elimination of these five 24-hour average concentrations over the 5-year period from the modelling results. In assessments of annual concentrations, the highest annual concentration in the 5-year period will be considered, without removal of any meteorological anomalies.

For shorter averaging periods, such as 1-hour concentrations, the eight hours with the highest 1-hour average predicted concentrations in each single meteorological year may be discarded. The ministry will consider for compliance assessment the highest concentration after elimination of these forty hours over the five-year period from the modelling results. This approach is for modelling results only (i.e. models with meteorological data inputs) and does not apply to measured or monitored concentrations. Note that the elimination of these anomalies is optional. Results will always be conservative if the meteorological anomalies are not eliminated.

Although some commercially available modelling software packages will select these values automatically, it can be done manually. If modelling using AERMOD, this approach can be applied by selecting the Maximum Values Table (MAXTABLE) option in the Output Pathway. A description of how the MAXTABLE could be used to eliminate meteorological anomalies is given in Appendix B.

7.0 RECEPTOR LOCATIONS

The AERMOD air dispersion model computes the concentrations of contaminants emitted from user-specified sources at user-defined spatial points. Modellers commonly refer to these points as receptors. These receptors are used in the modelling exercise to determine concentrations of contaminants at points of impingement as defined in section 2 of the Regulation. Proper placement of receptors is important to ensure that the location of the maximum POI concentration is determined. This can be achieved through several approaches. The types of receptors and receptor grids are described in Chapter 7.1, followed by a discussion in Chapter 7.2 on the grid extents and receptor densities required to capture maximum point of impingement concentrations as required by section 14 of the Regulation.

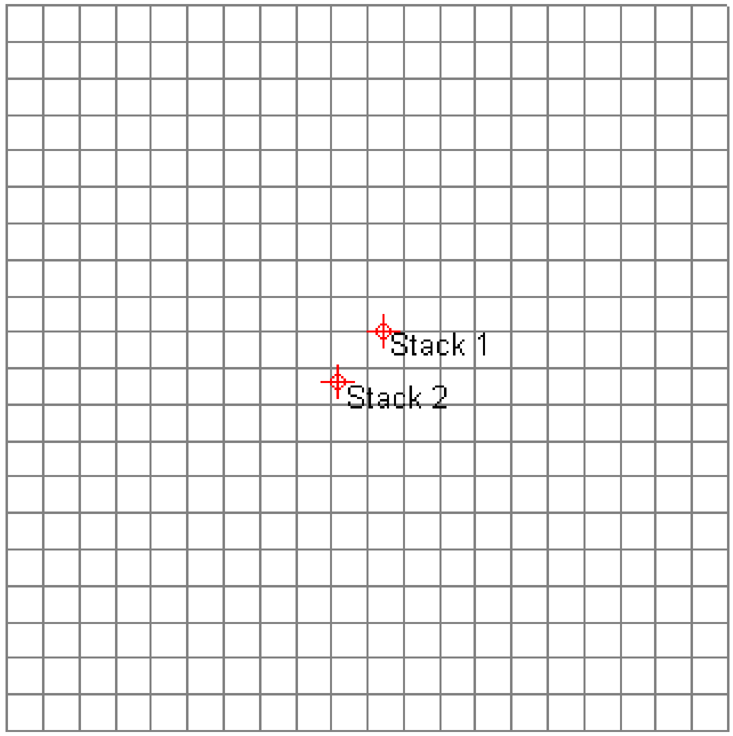
7.1 Receptor Types

Models such as AERMOD support a variety of receptor types that allow for considerable user control over calculating contaminant concentrations. The major receptor types and grid systems are described in the following subchapters. Further details on additional receptor types can be found in the appropriate documentation for each model.

7.1.1 Cartesian Receptor Grids

Cartesian receptor grids are receptor networks that are defined by an origin with evenly (uniform) or unevenly (non-uniform) spaced receptor points in x and y directions. Figure 7.1 illustrates a sample uniform Cartesian receptor grid.

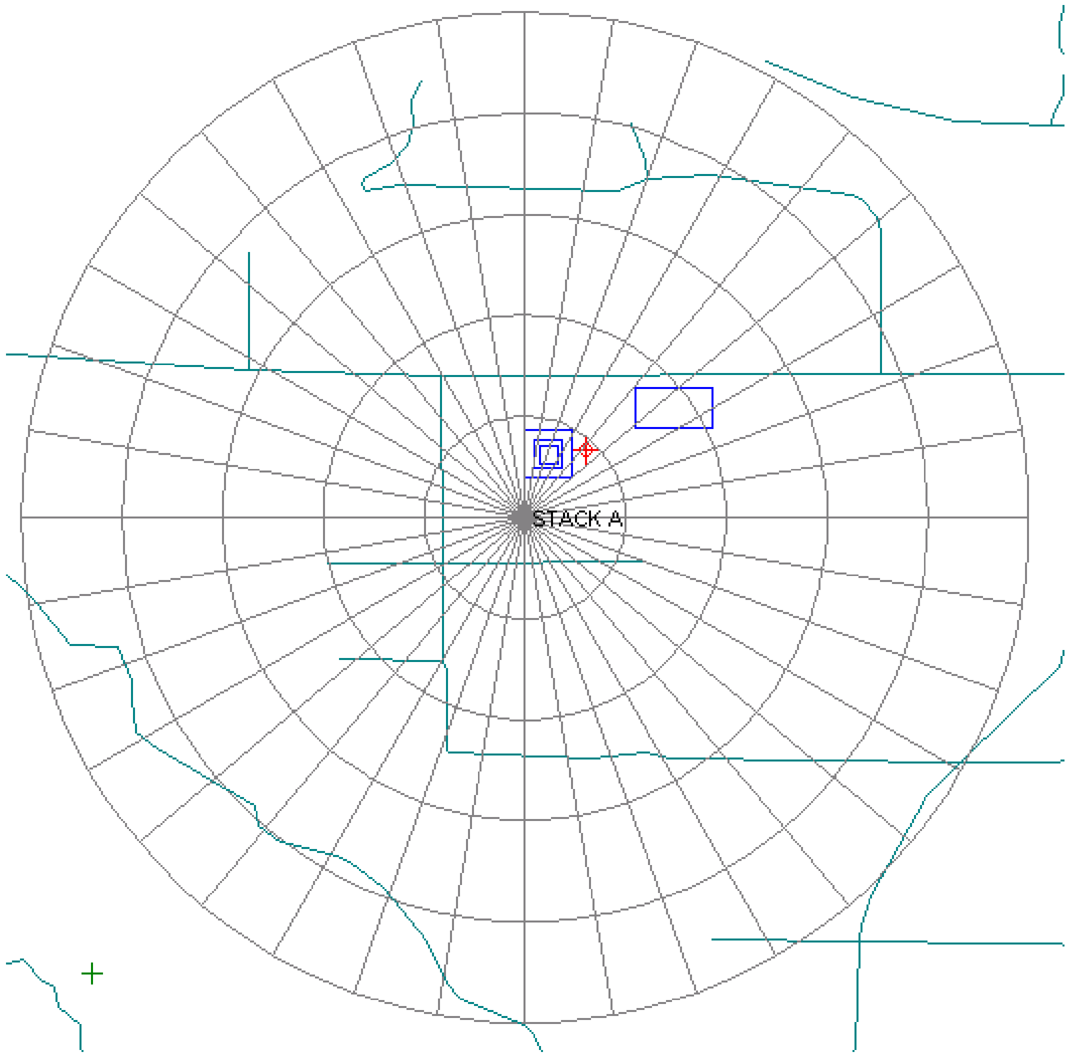
Figure 7.1: Example of a Cartesian Grid



7.1.2 **Polar Receptor Grids**

Polar receptor grids are receptor networks that are characterized by an origin with receptor points defined by the intersection of concentric rings, which have defined distances in metres from the origin, with direction radials that are separated by a specified degree spacing. Figure 7.2 illustrates a sample uniform polar receptor grid.

Figure 7.2: Example of a polar grid.

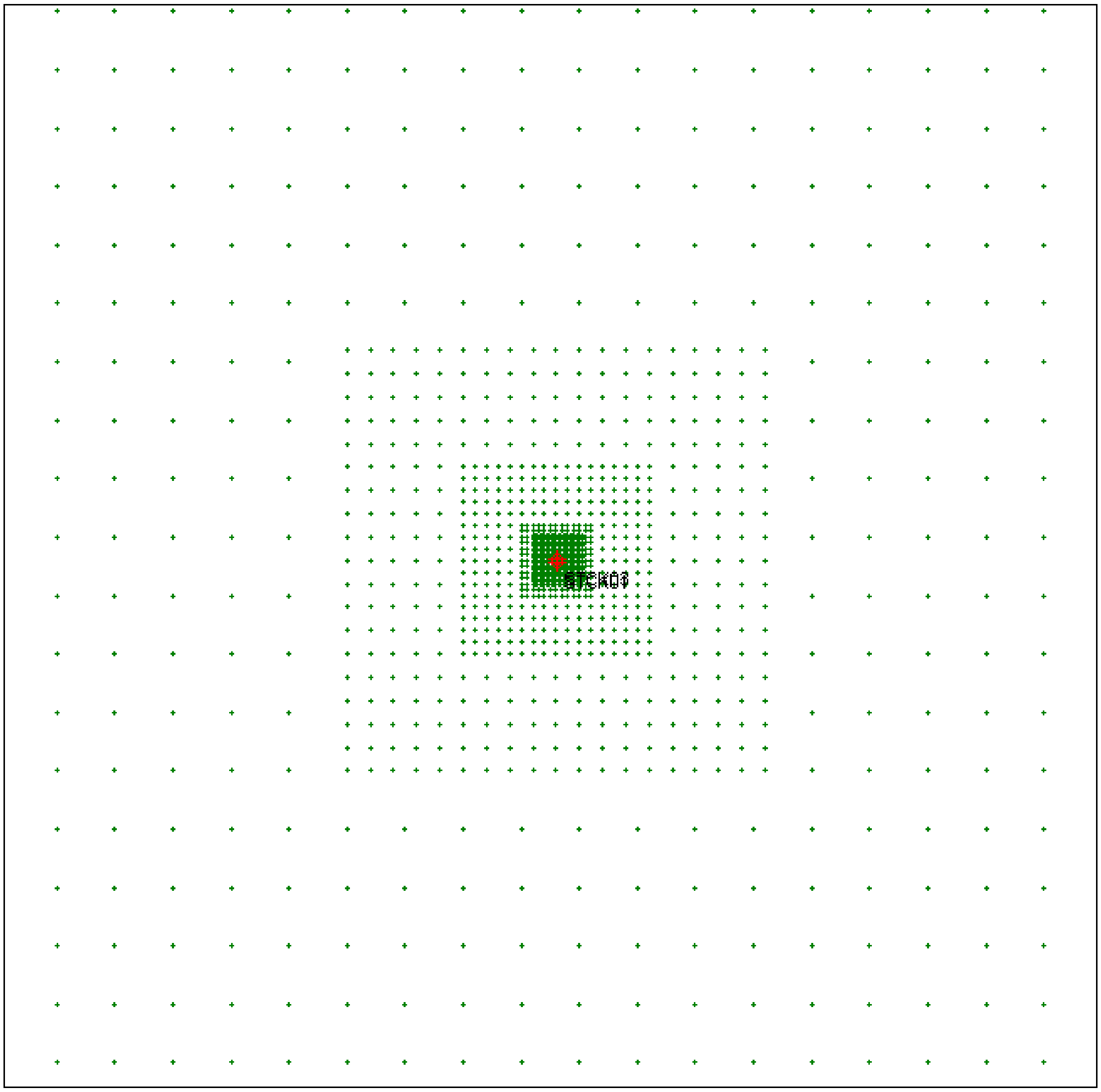


7.1.3 **Multi-Tier Grids**

Each receptor point requires computational time. Consequently, it is not optimal to specify a dense network of receptors over a large modelling area; the computational time would negatively impact productivity and available time for proper analysis of results. An approach that combines aspects of coarse grids and refined grids in one modelling run is the multi-tier grid.

The multi-tier grid approach strives to achieve proper definition of points of maximum impact while maintaining reasonable computation times without sacrificing sufficient resolution. Figure 7.3 provides an example of a type of multi-tier grid that is required under subsection 14 (1) of the Regulation (see Chapter 7.2).

Figure 7.3: Sample Multi-Tier Grid Spacing with 5 tiers of Spacing



7.1.4 **Fenceline Receptors**

With the exception of same structure contamination and certain on-site receptors specified in section 2 of the Regulation, dispersion modelling for on-site receptors, or within the property boundary, is not normally required. As a result, property boundaries are typically delineated in projects and model results are not required within those areas. However, as per the requirements in subsection 14 (2), receptors must be placed along the plant boundary to demonstrate compliance at the nearest reportable geographical locations to the sources.

A receptor network based on the shape of the property boundary that has receptors parallel to the boundaries is often a good choice for receptor geometry. The receptor spacing can then progress from fine to coarse spacing as distance increases from the facility, similar to the multi-tier grid.

7.1.5 **Discrete Receptors**

Receptor grids do not always cover precise locations that may be of interest in modelling projects. Specific locations of concern such as a monitoring station or a residence can be modelled by placing single (discrete) receptors, or additional refined receptor grids, at desired locations. This enables the modeller to assess data on specific points for which accurate data is especially critical. In particular, concentrations of a contaminant at elevated points of impingement can be greater than concentrations found at ground level points of impingement. Depending on the project resolution and location type, elevated receptors can be characterized by discrete receptors, a series of discrete receptors, or an additional receptor grid.

Some ESDM reports such as those completed in response to a notification of a Upper Risk Threshold (URT) exceedance under section 30 of the Regulation require an assessment of concentrations at specific receptor locations. Receptors of particular interest are set out in subsection 30 (8) of the Regulation.

Under Section 30 of the Regulation – Upper Risk Thresholds:

"30 (8) The following places are the places referred to in subsection (7) and in subsection 32 (22):

1.A health care facility.

2.A senior citizens' residence or long-term care facility.

3.A child care facility.

4.An educational facility.

5.A dwelling.

6.A place specified by the Director in a notice under subsection (9) as a place where discharges of a contaminant may cause a risk to human health.

(9) For the purpose of paragraph 6 of subsection (8), the Director may give written notice to a person who is required to notify the Director under subsection (3) stating that the Director is of the opinion that the discharge may cause a risk to human health at a place specified in the notice."

7.2 Area of Modelling Coverage

Section 14 of the Regulation specifies the required area of coverage as follows:

Area of modelling coverage

14. (1) Subject to subsections (2) to (6), an approved dispersion model that is used for the purposes of this Part shall be used in a manner that predicts the concentration of the relevant contaminant at points of impingement separated by intervals of,

(a) 20 metres or less, in an area that is bounded by a rectangle, where every point on the boundary of the rectangle is at least 200 metres from every source of contaminant;

(b) 50 metres or less, in an area that surrounds the area described in clause (a) and that is bounded by a rectangle, where every point on the rectangle is at least 300 metres from the area described in clause (a);

Area of modelling coverage

(c) 100 metres or less, in an area that surrounds the area described in clause (b) and that is bounded by a rectangle, where every point on the rectangle is at least 800 metres from the area described in clause (a);

(d) 200 metres or less, in an area that surrounds the area described in clause (c) and that is bounded by a rectangle, where every point on the rectangle is at least 1,800 metres from the area described in clause (a);

(e) 500 metres or less, in an area that surrounds the area described in clause (d) and that is bounded by a rectangle, where every point on the rectangle is at least 4,800 metres from the area described in clause (a);

(f) 1,000 metres or less, in the area that surrounds the area described in clause (e).

(2) If an approved dispersion model is used for the purposes of this Part with respect to a property on which sources of contaminant are located and any point on the property boundary of the property is within 200 metres of any source of contaminant, the model shall be used in a manner that predicts the concentration of the relevant contaminant at points of impingement along the entire property boundary, and those points of impingement shall be separated by intervals of 10 metres or less.

(3) Subsection (1) or (2) does not apply if the approved dispersion model that is used is,

(a) the ASHRAE method of calculation;

(b) the SCREEN3 dispersion model described in paragraph 4 of subsection 6 (1);

(c) the method of calculation required by the Appendix to Regulation 346; or

(d) a dispersion model or combination of dispersion models that, pursuant to subsection 7 (3), is deemed to be included in references in this Part to approved dispersion models, if the dispersion model or combination of dispersion models is not capable of predicting the concentration of the relevant contaminant at points of impingement described in subsection (1) or (2), as the case may be.

Area of modelling coverage

(4). If an approved dispersion model is used for the purposes of this Part, it is not necessary to use the model in a manner that predicts the concentration of the relevant contaminant at a point of impingement if the distance from the property on which the sources of contaminant are located to that point of impingement is greater than the distance from the property on which the sources of contaminant are located to the point of impingement where, according to the model, the concentration of that contaminant would be highest.

(5) With respect to points of impingement on structures that are above ground level, an approved dispersion model that is used for the purposes of this Part shall be used in a manner that predicts the concentration of the relevant contaminant at a sufficient number of points of impingement on those structures to identify any points where discharges of the contaminant may result in an adverse effect or a contravention of section 19 or 20.

(6) Despite subsections (1) to (5), the Director may give written notice to a person who discharges or causes or permits the discharge of a contaminant requiring that an approved dispersion model that is used for the purposes of this Part be used in a manner that predicts the concentration of the relevant contaminant at points of impingement described in the notice.

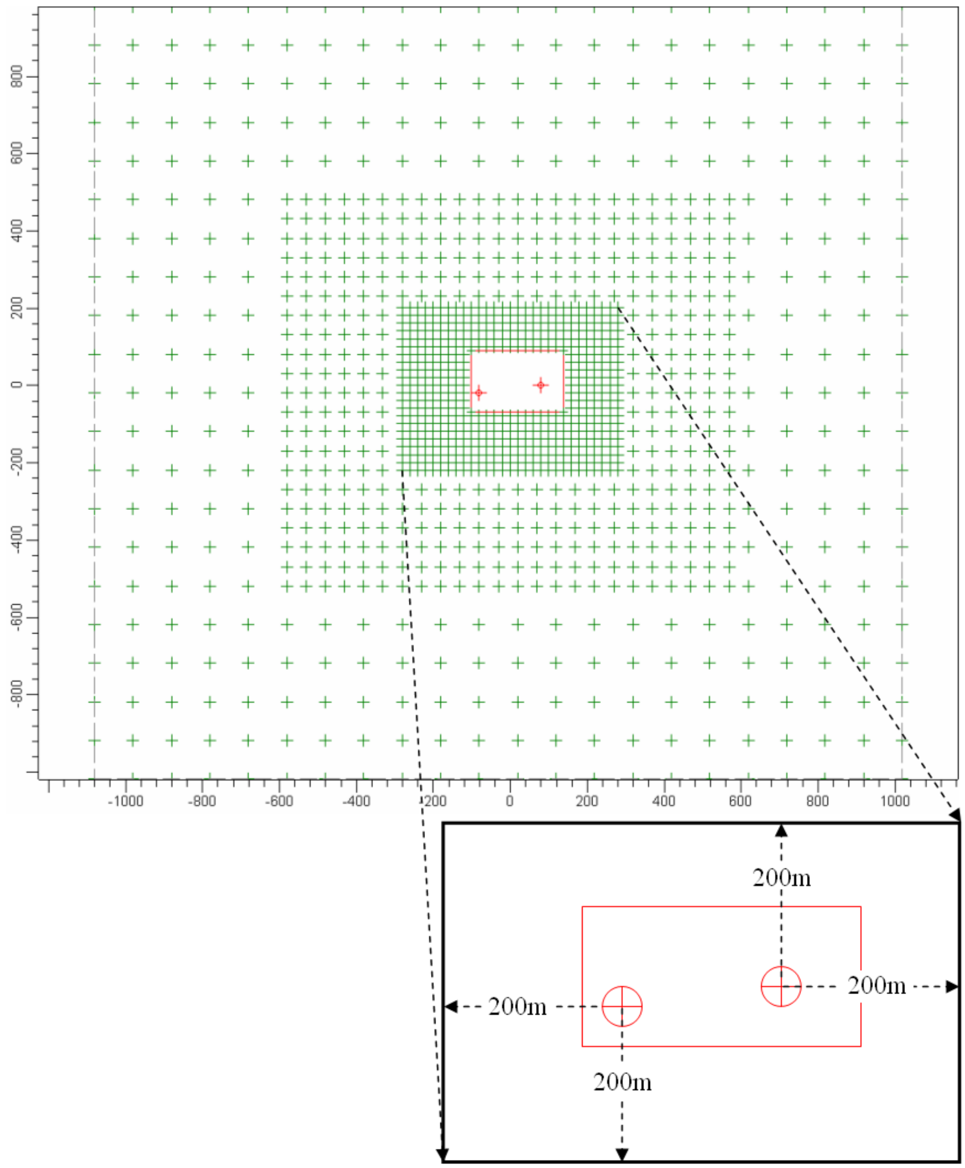
(7) Before the Director gives a person a notice under subsection (6), the Director shall give the person a draft of the notice and an opportunity to make written submissions to the Director during the period that ends 30 days after the draft is given

Subsection 14 (4) requires that receptor definition must ensure coverage to capture the maximum contaminant concentration. For facilities with more than one emission source, the receptor network should include multi-tier grids to ensure that maximum concentrations are obtained. Screening model runs (i.e., SCREEN3, etc.) for the most significant sources on a facility can be used to determine the extent of the receptor grids. Tall stacks may require grids extending 20 to 25 km while ground level maxima for emissions from shorter stacks (10 - 20 m) might be obtained using grids extending a kilometre or less from the property line.

As set out in subsection 14 (1) of the Regulation, the densities of the receptors progress from fine resolution near the source(s), to a coarser resolution farther away. Receptors shall be defined in a manner that predicts the concentration of the relevant contaminant at points of impingement separated by intervals that are consistent with the requirements specified in section 14 of the Regulation.

Figure 7.4 illustrates the application of the above receptor densities to a sample site.

Figure 7.4: Example of Multi-Tier Grid under the Regulation Showing Property Boundary



Subsection 14 (2) requires that receptors shall also be placed along the entire property boundary, and shall be separated by intervals of 10 metres or less. Receptors within the boundary shown in Figure 7.4 may be eliminated.

As set out in subsection 14 (5) of the Regulation, discrete receptors are required at locations where there are elevated points of impact such as apartment buildings and air intakes on nearby buildings. These are needed to ensure that maximum impacts are obtained. Other discrete receptors may be required for the types of receptors listed in subsection 30 (8) of the Regulation.

The above are minimal requirements to aid the modeller in defining adequate receptor coverage. The final extent and details are the responsibility of the modeller who must demonstrate that the point of impingement where concentration of the contaminant is highest has been identified. Certain stack characteristics, such as tall stacks, may inherently require larger receptor coverage.

8.0 OTHER MODELLING CONSIDERATIONS

8.1 Dispersion Modelling Results for Annual Averages

Earlier versions of the AERMOD dispersion model (versions 14134 and earlier) have some limitations regarding the generation of annual average results when more than one year of meteorological data are used. These versions of AERMOD do not output the maximum “annual” POI for each of the 5 years in the meteorological data unless each year is modelled separately. When multi-year data sets are used, such as those used to demonstrate compliance under O.Reg.419/05, these versions of AERMOD average the results from all of the hours of meteorology in the period (i.e. five years) to produce one “period average” POI concentration at each grid point. This is the case regardless of whether the PERIOD or ANNUAL averaging periods are selected in the model.

AERMOD versions 15181 (2015) and later have addressed this issue and the modelled annual average maximum POI concentrations are calculated based on the maxima for each of the 5 meteorological years.

Note that modellers are required to use the most recent version of AERMOD posted on the EBR Registry, unless they have received a notice under section 7 of the Regulation to use a different version. The model run should be conducted either with the appropriate 5-year regional meteorological data set or a site-specific meteorological data set approved by the ministry under section 13 of the Regulation, if applicable. Because the hourly POI concentrations are automatically converted to annual averages by AERMOD, it is not necessary or appropriate to remove any meteorological data from the model run to account for meteorological anomalies.

If a modeller uses a pre-2015 version of AERMOD, the ministry would prefer that modellers evaluate the maximum POI for each year. This can be done by running each model year individually and evaluating the outputs via post processing to determine the maximum annual POI. The maximum annual POI from those five years is then compared to the annual standard.

If a modeller wishes to avoid the above-mentioned post-processing steps for pre-2015 model versions, the maximum annual POI from the single model run described above (i.e. which in actuality is the 5-year average), is then multiplied by 140%. This is intended to act as a conservative screening check against an annual standard. If the 140% value is greater than the corresponding annual standard, then individual model runs must be conducted for each year in the meteorological data set.

8.2 USE OF ASHRAE

The ASHRAE method of calculation is based on copyrighted equations that are available in the chapter on building air intake and exhaust design in the ASHRAE Handbook - HVAC Applications. The equations are used to assess points of impingement located on the same building or structure as a source, such as an air intake located downwind of an exhaust on the same building. This is known as same structure or self-contamination, and applies when the intake does not belong to the emitting facility. Another approved dispersion model such as AERMOD must also be used in order to calculate the POI concentration at all other locations (i.e. at non-same-structure point of impingement locations).

The ASHRAE Handbook presents both a flush vent approach and a more comprehensive methodology. The flush vent can be used as a conservative screening method for all sources. Both methods calculate an initial plume spread followed by a further downwind dilution with the result being a dilution factor which is the number of times the concentration of contaminant in the exhaust flow is diluted by the time it reaches the intake.

The flush vent screening method assumes that the exhaust is located flush with the roof. The equation requires:

- the equivalent circular diameter of the exhaust;
- the exhaust exit velocity;
- the building height,
- the surface roughness/roughness length, and,
- the “stretched-string” distance between the nearest edge of the source release point and the nearest edge of the intake.

The equation shall be evaluated over a series of wind speeds and specific directions to determine the minimum dilution (maximum concentration). For flush mount assessments however, the critical wind speed is typically 2 m/s. Note that the selected roughness length should be consistent with those presented in Chapters 5.4 or 6.3 for the upwind land use, as appropriate.

The more comprehensive methodology breaks up the downwind dilution into a series of release regimes ranging from free standing stacks to flush vents. Refer to the ASHRAE Handbook for more details. The chapter on Building Air Intake and Exhaust Design can be purchased/downloaded at the ASHRAE website.

As discussed in Chapter 2.3.3 Use of ASHRAE – Same Structure Combination Model, ASHRAE is required under section 9 of the Regulation for assessing same structure contamination. ASHRAE must be used once section 20 applies to a facility. If section 19 applies to a facility and it does not wish to use ASHRAE, the facility may use the Scorer-Barrett equation set out in the Appendix to Regulation 346 to assess same structure contamination (paragraph 3 of subsection 9 (1) of the Regulation).

ASHRAE can also be used to evaluate standards with annual averaging periods. The 1-hour average value from ASHRAE can be converted to an annual average by using the formula in section 17 of the Regulation (i.e., divide by a factor of 12.5 from 1-hour to an annual average). Note that these factors assume continuous emissions.

8.3 Use of Specified Models

There are some unique situations and/or settings (i.e. a tall stack located at a shoreline) where AERMOD may not be the most appropriate dispersion model to accurately predict the maximum POI concentrations from a facility. In these cases, the Director may specify the use of a model that is not listed in subsection 6 (1) of the Regulation (an "alternative model") in a notice issued under section 7 of the Regulation. Acceptable Alternative Models and their use are further described in Appendix A.

A facility may request the use of an alternative model, or the ministry may require the use of an alternative model. Facilities requesting the use of an alternative model must provide the ministry with the rationale for choosing a particular alternative model, as well as demonstrate an understanding of the model, its data requirements, and the quality of data required for the model. A form to request that a notice under section 7 of the Regulation be issued is available on the ministry website here.

Use of alternative models is considered to be a Tier 3 modelling assessment and requires consultation with the ministry prior to making the request for a section 7 notice. Note that when the Director issues a notice under section 7 of the Regulation, the model specified in the notice becomes an "approved" model for that facility.

Specified Dispersion Models

7. (1) The Director may give written notice to a person who discharges or causes or permits the discharge of contaminants from a property stating that the Director is of the opinion that, with respect to discharges of a contaminant from that property,

(a) one or more dispersion models specified in the notice would predict concentrations of the contaminant at least as accurately as an approved dispersion model;

Specified Dispersion Models

(b) a combination specified in the notice of two or more dispersion models would predict concentrations of the contaminant at least as accurately as an approved dispersion model;

(c) a combination specified in the notice of one or more dispersion models and one or more sampling and measuring techniques would predict concentrations of the contaminant at least as accurately as an approved dispersion model; or

(d) one or more approved dispersion models specified in the notice would predict concentrations of the contaminant less accurately than,

(i) a dispersion model or combination specified under clause (a), (b) or (c), or

(ii) another approved dispersion model.

(2) Before the Director gives a person a notice under subsection (1), the Director shall give the person a draft of the notice and an opportunity to make written submissions to the Director during the period that ends 30 days after the draft is given.

(3) If a notice is given under subsection (1) with respect to discharges of a contaminant from a property, a reference in this Part to an approved dispersion model shall be deemed, with respect to those discharges,

(a) to include a dispersion model or combination specified under clause (1) (a), (b) or (c); and

(b) not to include a dispersion model that is specified under clause (1) (d).

(4 Revoked

(5) Subsection (3) does not apply to a discharge of a contaminant until,

(a) three months after the notice is given under subsection (1), unless clause (b) applies; or

(b) one year after the notice is given under subsection (1), if the notice includes a notice under clause (1) (c).

(6) Subsection (5) does not apply for the purpose of preparing a report to

Specified Dispersion Models

which subsection 22 (1.1) or (1.2), 23 (3), 24 (2), 30 (5) or 33 (6) applies.

(7) Subsection (5) does not apply to a discharge of a contaminant if subsection (3) would have the effect of permitting the discharge.

(8) If a notice is given to a person under subsection (1) and section 20 does not apply to the person in respect of a contaminant, subsection (3) applies to the person in respect of the contaminant only after section 20 begins to apply to the person in respect of the contaminant.

(9) Despite subsection (8), if a notice is given to a person under subsection (1) and section 20 does not apply to the person in respect of a contaminant, subsection (3) applies to the person in respect of the contaminant for the purpose of preparing a report to which subsection 22 (1.2), 23 (3), 24 (2), 30 (5) or 33 (6) applies.

(10) If a notice given under subsection (1) is amended by a notice given under section 52, the notice under section 52 takes effect, and subsection (3) begins to apply to the amended notice,

(a) three months after the notice is given under section 52, unless clause (b) or (c) applies;

(b) one year after the notice is given under section 52, if the amendment adds a statement described in clause (1) (c) to the notice given under subsection (1), unless clause (c) applies; or

(c) on the day the notice is given under section 52, if the application of subsection (3) to the amended notice would have the effect of permitting a discharge that would otherwise be prohibited.

(11) If a notice given under subsection (1) is revoked by a notice given under section 52, the notice under section 52 takes effect, and subsection (3) ceases to apply to discharges of the contaminant,

(a) three months after the notice is given under section 52, unless clause (b) applies; or

(b) on the day the notice is given under section 52, if the revocation of the notice given under subsection (1) would have the effect of permitting a discharge that would otherwise be prohibited.

8.4 Use of Modelled Results in Combination with Monitoring Data

Monitoring and modelling should be considered complementary tools in determining concentrations of contaminants at point of impingements. If monitors measure accurately and are well located they can provide information on the magnitude and variability of a facility's emissions in addition to their potential impact. However, monitoring data is usually limited to a few locations and a limited number of measurements which can bias the interpretation of the results. Conversely, modelling allows estimates of concentrations over a large number of receptors and a wide range of meteorological conditions. However, modelling results can also be biased by various factors including uncertainties or omissions in the quality of the emission data, or available information on local meteorological conditions. Using modelling results in combination with monitoring data provides a more complete and realistic analysis of the potential maximum POI concentrations.

The US EPA Guideline on Air Quality Models states that modelling is the approved method for determining concentrations and that monitoring alone would normally not be accepted. To assess compliance with ministry POI Limits, the ministry would consider model results along with monitoring data. Compliance cannot be demonstrated by monitoring information alone. If model results do not agree with measured data, a number of factors which could contribute to the disagreements shall be considered. For example, the facility's source characteristics, emissions, and meteorological data are factors which shall be reviewed. The adequacy of the locations and amount of monitoring data along with the data accuracy shall also be considered. In some cases, the Director may specify the values of dispersion modelling parameters under a subsection 13.1 (1) Notice. For more information on combined modelling/monitoring analysis and the requirements of the Regulation, see the ESDM Procedure Document and sections 10, 11, and 12 of the Regulation.

In some situations, the use of a combination of modelling and monitoring data to determine facility emission rates is required by subsection 12 (1) of the Regulation unless certain conditions are met. For further information on this methodology, please refer to the Technical Bulletin on "Combined Assessment of Modelled and Monitored Results as an Emission Rate Refinement Tool" available from the ministry Standards Development Branch.

Decisions on the adequacy of the monitoring data will be made on a case-by-case basis in consultation with the ministry. Pre-consultation with the ministry is required under paragraph 3 of subsection 11 (1) if a comparison of model results with monitoring data is undertaken for compliance assessment purposes. A form is available on the ministry website here.

For cases where reliable information is available on the emission rates and source characteristics for a facility, modelled results can identify maximum impact areas and concentration patterns that could assist in locating monitoring sites. Model runs using a number of years of meteorological data would show the variations in the locations and the magnitude of maximum concentrations. Modelling results can also be used to provide information on the potential frequency of exceedences of high concentrations, but only when used with more site-specific meteorological data. For more information, see the "*Guideline for the Implementation of Air Standards in Ontario*" (GIASO).

8.5 Determination of Frequency of Exceedence

As mentioned earlier, model results can provide information on the frequency of exceedance of standards or guideline values. There are several circumstances when determination of the frequency of a certain concentration being exceeded may be required. Two situations are when an URT may be exceeded and when a facility is making a request for a site-specific standard. For example, paragraph 3 of subsection 30 (7) and subparagraph 2 iii of subsection 33 (1) (site-specific standard request) generally require the following:

> *A written statement specifying the number of averaging periods for which the approved dispersion model predicts that discharges of the contaminant may result in a contravention of section 20 … because of the concentration of the contaminant at points of impingement … expressed as a percentage of the number of averaging periods ….*

The use of a local representative meteorological data set and a refined emission inventory that uses variable emissions (if applicable) are important if the frequency results are to be representative. The ministry regional data sets are not to be used to determine frequency of exceedence without prior approval from the ministry.

There are a couple of different ways to obtain frequency information. Using the MAXIFILE keyword in the model OUTPUT Pathway creates a file that lists, in date order, the concentrations that are above a specified threshold (i.e. a POI Limit) for each grid point. This allows one to calculate the frequency of exceeding a particular threshold concentration. The POSTFILE keyword in the OUTPUT Pathway allows one to obtain all modelled concentrations for each receptor. Note that a POSTFILE can get very large. The frequency analysis should be determined at every receptor that is over a ministry POI Limit. It should be noted that the grid point at which the maximum POI occurs is not necessarily the location of the highest frequency of exceedences).

8.6 Modelling Adjacent Properties

Section 4 of the Regulation sets out the conditions where, for the purpose of compliance with ministry POI Limits, two or more adjacent properties would be considered to be a single property. In these cases, section 3 requires modelling of the aggregate emissions from all sources of contaminant located within the adjacent properties and the property would be defined by the external property line around the adjacent properties.

Adjacent Properties

4. (1) Two properties are adjacent for the purposes of this Regulation if the boundary of one property touches or, were it not for an intervening highway, road allowance, railway line, railway allowance or utility corridor, would touch the boundary of the other property,

(2) For the purposes of this Regulation, except section 34, two or more properties on which different sources of contaminant are located shall be deemed to be a single property if each of the properties is adjacent to one or more of the other properties and,

- ***a. the persons responsible for the sources of contaminants have jointly notified the Director in writing that they wish the properties to be deemed to be a single property;***
- ***b. the Director has reasonable grounds to believe that a contravention of section 19, or 20 may occur as a result of discharges of a contaminant from the different sources of contaminant if the properties are deemed to be a single property, and the Director has given written notice of that belief to the persons responsible for the sources of contaminant;***
- ***(b.1)the persons responsible for the sources of contaminant are required to prepare a report to which subsection 22 (1.1) applies, the Director has reasonable grounds to believe that a contravention of section 19 may occur as a result of the discharges of a contaminant from the different sources of contaminant if section 19 applies and the properties are deemed to be a single property, and the Director has given written notice of that belief to the persons responsible for the sources of contaminant; or***
- ***(c) the persons responsible for the sources of contaminant are required to prepare a report to which subsection 22 (1.2), 23 (3), 24 (2), 30 (5) or 33 (6) applies, the Director has reasonable grounds to believe that a contravention of section 20 may occur as a result of the discharges of a contaminant from the different sources of contaminant if section 20 applies and the properties are deemed to be a single property, and the Director has given written notice of that belief to the persons responsible for the sources of***

Adjacent Properties

contaminant

(2.1) Subject to subsection (2.2), clause (2)(a) does not begin to apply until 60 days after the Director receives the notice referred to in that clause.

(2.2) Clause (2)(a) does not apply if the Director has reasonable grounds to believe that an adverse effect may occur if one or more of the properties are excluded form the single property and gives written notice of that belief to the persons responsible for the sources of contaminant.

(2.3) The Director shall not give a person a notice under subsection (2.2) unless the Director first gives the person a draft of the notice and an opportunity to make written submissions to the Director during the period than ends 30 days after the draft is given.

(3) Before the Director gives a person a notice under clause (2)(b), (b.1) or (c), the Director shall give the person a draft of the notice and an opportunity to make written submissions to the Director during the period that ends 30 days after the draft is given.

(4) Subsection (2) applies only if every property on which a source of contaminant is located,

(a) uses raw materials, products or services from one or more of the other properties on which the sources of contaminant are located; or

(b) provides raw materials, products or services to one or more of the other properties on which the sources of contaminant are located.

(5) Clause (2)(c) only applies for the purpose of preparing the report referred to in that clause.

9.0 GLOSSARY OF TERMS

AERMAP: The terrain pre-processor for AERMOD. AERMAP allows the use of digital terrain data in AERMOD.

AERMET: The meteorological pre-processor for AERMOD.

AERMIC: **A**merican Meteorological Society/**E**nvironmental Protection Agency **R**egulatory **M**odel **I**mprovement **C**ommittee.

AERMOD: The current US EPA short-range regulatory air dispersion model that was developed by AERMIC. AERMOD is a next-generation air dispersion model that incorporates concepts such as planetary boundary layer theory and advanced methods for handling complex terrain.

AERSCREEN: The screening version of AERMOD, that produces estimates of concentrations without the need for a full set of meteorological data.

Air Emissions: An example of a "discharge", as the term is defined in subsection 1 (1) of the Environmental Protection Act.

Albedo: Portion of the incoming solar radiation reflected and scattered back to space.

Alternative Model: is a model specified in a notice issued by the Director under section 7 of the Regulation, that may be used if conditions warrant.

Air: has the same meaning as in subsection 1 (1) of the Environmental Protection Act; namely, open air not enclosed in a building, structure, machine, chimney, stack or flue.

AMS: American Meteorological Society.

Approved Dispersion Models: means a model listed in section 6 of the Regulation or specified in a notice issued under section 7 of the Regulation.

Calm: Cessation of horizontal wind, or wind speed below 1 m/s.

Complex Terrain: Terrain exceeding the height of the stack being modelled.

DEM: Digital Elevation Model. Digital files that contain terrain elevations typically at a consistent interval across a standard region of the Earth's surface.

Dispersion Model: A group of related mathematical algorithms used to estimate (model) the dispersion of contaminants in the air due to transport by the mean (average) wind and small scale turbulence.

Diurnal: Daytime period.

Emission Factor: Typically used with a product production rate or a raw material consumption rate to assess the rate at which a contaminant is released to the air.

ESDM Report: Emission Summary and Dispersion Modelling Report (see also section 26 of the Regulation) (see also Guideline A-10: Procedure for Preparing an Emission Summary and Dispersion Modelling Report.

Flagpole Receptor: Any point of impingement located above ground level (see subsection 14 (5) of the Regulation).

Inversion: An increase in ambient air temperature with height. This is the opposite of the usual case.

Lee side: The lee side of a building is the side that is sheltered from the wind.

Mixing Height: Top of the neutral or unstable layer and also the depth through which atmospheric contaminants are typically mixed by dispersive processes.

Ministry: the Ontario Ministry of the Environment and Climate Change.

Monin-Obukhov Length: A constant, characteristic length scale for any particular example of flow. It is negative in unstable conditions (upward heat flux), positive for stable conditions, and approach infinity as the actual lapse rate for ambient air reaches the dry adiabatic lapse rate.

NWS: National Weather Service. A US government organization associated with the National Oceanic and Atmosphere Administration.

Pasquill Stability Categories: A classification of the dispersive capacity of the atmosphere, originally defined using surface wind speed, solar insolation (daytime) and cloudiness (night time). They have since been reinterpreted using various other meteorological variables.

Receptor: Air dispersion models compute the concentrations of contaminants emitted from user-specified sources at user-defined spatial points. Modellers commonly refer to these points as receptors. These receptors are used in the modelling exercise to determine concentrations of contaminants at points of impingement as defined in section 2 of the Regulation. See also section 14 of the Regulation.

Regulation: means Ontario Regulation 419/05: Air Pollution - Local Air Quality, as amended from time to time.

Screening Model: A relatively simple model or analysis technique to compute conservative concentrations to determine if a given source of contaminant is likely to pose a threat to air quality.

Simple Terrain: An area where terrain features are all lower in elevation than the top of the stack of the source.

Upper Air Data (or soundings): Meteorological data obtained from balloon-borne instrumentation that provides information on pressure, temperature, humidity and wind away from the surface of the earth.

US EPA: United States Environmental Protection Agency (US EPA).

Wind Profile Component: The value of the exponent used to specify the profile of wind speed with height according to the power law.

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APPENDIX A

ALTERNATIVE MODELS

APPENDIX A: ALTERNATIVE MODELS

A-1. ACCEPTABLE ALTERNATIVE MODELS

The following list contains alternative models that are currently accepted by the Ministry of Environment and Climate Change (ministry) for site-specific consideration.

- CALPUFF/CALMET
- CAL3QHCR
- SDM – Shoreline Dispersion Model
- Physical Modelling (i.e. wind tunnel assessments)
- AERSCREEN

Use of any alternative model (i.e. one that is not listed in subsection 6 (1) of the Regulation) requires approval from the Director, via issuance of a notice under subsection 7 (1) of the Regulation. Pre-consultation with EMRB and submission of a form to request the use of the specified model is required. The form for this request is available at the following link here.

A-2. ALTERNATIVE MODEL USE

A-2.1 Use of CALPUFF/CALMET

CALPUFF[34] is a puff model that is capable of fully accounting for hour-by-hour and spatial variations in wind and stability. Puff models, in general, perform well at downwind distances from a few kilometres to more than 100 km. CALPUFF contains additional algorithms that allow it to emulate AERMOD at short distances where puff models are generally less reliable. Further, CALPUFF has been evaluated and found to be reasonably accurate at distances up to 300 km. Thus, CALPUFF can be recommended for use for all distances up to 300 km.

CALPUFF is a more complex model with increased meteorological data requirements that is particularly useful in modelling situations that involve long-range transport (up to 300 km, light wind and calm conditions, wind reversals such as land–sea (or lake) breezes and mountain–valley breezes, and complex wind situations found in very rugged terrain). The meteorological data used by the CALPUFF system must be pre-processed by the CALMET meteorological model, and as such differs from the meteorology that is used for AERMOD. CALMET produces three dimensional wind fields that allow wind speeds and directions to vary, both in the horizontal and vertical directions. Therefore, the model inputs, run-time and data analysis aspects of using CALPUFF are much more time intensive than other models such as AERMOD.

The decision as to whether the use of CALPUFF is justified requires competent meteorological judgment. There are no hard and fast rules that can be applied. Situations where the use of CALPUFF could be justified include complex terrain, near large lakes and for facilities with very tall stacks.

A-2.2Use of CAL3QHCR

CAL3QHCR(35,36) is a roadway dispersion model that can process a year of hourly meteorological data, with corresponding emissions, traffic and intersection signalization data. CAL3QHCR is particularly recommended for modelling of intersections. At signalized intersections, it accounts for idling emission rates from vehicles. CAL3QHCR calculates the concentrations in the vicinity of a roadway or intersection at averaging periods from 1-hour to annual. CAL3QHCR can accommodate up to 120 “links,” including both free-flowing roads and signalized intersections, and predict concentrations of carbon monoxide (CO), particulates (PM) and other inert contaminants within a few kilometres of the roadway. Its regulatory use in the US is for CO concentrations near roads and intersections.

A link may constitute a (nearly) straight section of road, a signalized intersection, a bridge, an elevated road on fill, or a cut (depressed) roadway. A curved road can be represented as a series of links. Traffic data can be either as a general function of hour-of-day and day-of-week, or every hour of the year, depending on the detail required. CAL3QHCR is particularly useful when the worst case meteorological conditions are not known in advance, requiring a year of meteorology to be run to identify a worst case. It is also useful for obtaining averaging periods longer than 1-hour (e.g., 8-hour, 24-hour, etc.) directly from the computations, without the need for conservative averaging period conversions.

CALINE4(37) is another roadway model designed to calculate a single 1-hour average concentration for a defined single hour of meteorological data for local roadways including intersections. This is most useful when a worst-case 1-hour meteorology (e.g. light wind parallel to the roadway) is known. If a worst case meteorology is not known, or direct calculation of longer averaging periods is required, the CAL3QHCR model would be a better choice.

A-2.3Use of the Shoreline Dispersion Model

The SDM (Shoreline Dispersion Model[38]) can calculate a year or more of hourly concentrations including the effect of shoreline fumigation on plumes from stack sources located near a body of water . Shoreline fumigation is only included when conditions exist such that the event is likely to occur. At other times, it calculates concentrations based on a standard Gaussian plume model. SDM is relatively easy to use, and is appropriate for sources located at a shoreline. The data requirements and ease of use are typical of Gaussian plume models.

Use of SDM to assess the potential concentrations due to shoreline fumigation conditions would typically be done in combination with the AERMOD model to assess concentrations during non-fumigation conditions. More complicated situations may require the use of CALPUFF which requires more time and data as described above.

A-2.4Use of Physical Modelling

Physical modelling is a term that comprises modelling in a wind tunnel or water channel. Some situations are sufficiently complex that the available computer models cannot be relied upon. In such cases, the use of physical modelling may be considered. Physical modelling is without question the most costly of any modelling approach. Further, it can account for only one meteorological event at a time. Often, only neutral and stable conditions can be modelled. Even with these limitations, physical modelling can provide useful information for complex situations that cannot be reliably simulated by computer models.

A-2.5Use of AERSCREEN

AERSCREEN is a screening-level air quality model based on the AERMOD dispersion algorithms. AERSCREEN is currently the preferred screening model in the US EPA list of dispersion models. This model consists of two main components: 1) the MAKEMET program which generates a site-specific matrix of meteorological conditions for input to the AERMOD model; and 2) the AERSCREEN command-prompt interface program. The AERSCREEN interface makes use of the pre-processor programs AERMAP and BPIPPRM to automate the processing of terrain and building information respectively. Along with the meteorological file produced by MAKEMET, AERSCREEN interfaces with AERMOD using the SCREEN option on the CO MODELOPT card to perform the modelling runs. The SCREEN option in AERMOD restricts the averaging period to 1-hour averages while the AERSCREEN interface performs plume centreline calculations to find the receptor distance with the highest impact, similar to the automated distance option in SCREEN3.

The AERSCREEN User's Guide[39] also lists a second method for running AERMOD in a screening mode. The stand-alone MAKEMET program can be used to generate the matrix of meteorological conditions and then AERMOD is run directly with the SCREEN option. The second approach allows more user flexibility in defining the receptor network, however the approach using the AERSCREEN interface should produce more conservative results depending on the receptor resolution selected when directly running of AERMOD with MAKEMET meteorological data. Note that applications running the AERSCREEN interface or directly running AERMOD with the SCREEN option are for single sources only. Results from multiple sources can be combined as discussed earlier in Chapter 3.1.2.

A-3.EXPLANATION OF USE REQUIREMENTS

A-3.1CALPUFF/CALMET

At a minimum, CALMET should be run using input data from three or more surface and upper air meteorological stations. In addition, output from a prognostic atmospheric model such as the Weather Research and Forecasting Model (WRF) or other similar meteorological models may be used to improve CALPUFF performance. CALPUFF can also be run in one of its screening modes, or with a single meteorological data source. This however, defeats the benefits of CALPUFF's ability to account for spatial variations in the wind field. It still accounts for time variations in wind and stability, however, so there may, in some limited cases, be a benefit in running CALPUFF in this mode. It should, however, be run using CALMET developed meteorology, from several meteorological stations in the majority of cases.

Whenever possible, five years of meteorological data should be used to drive CALPUFF. However, if adequate data is sparse a shorter period of data may be used (subject to approval). Further, if there are breaks in the meteorological data, care should be taken that all months are adequately represented so that seasonal variations in meteorology are adequately accounted for.

CALPUFF also requires terrain and land use data.

CALPUFF has a large number of input options available, and as an alternative model the manner in which it is used must be acceptable to the Director. Modellers who wish to use CALPUFF should consult with the ministry regarding which model options will be used in the runs, prior to submitting modelling results using CALPUFF. It is preferable that this be done prior to issuance of the required Section 7 notice, as these conditions may be written into the notice. This will determine the current recommendations for the input options to be used, as well as the selection of meteorological data to be used. In general, the recommendations of the Interagency Workgroup on Air Quality Modelling (IWAQM) Phase 2 report[40], or any more recent recommendations, should be followed. The IWAQM recommendations notwithstanding, the MPDF option should be set to "1," i.e., "yes," so that CALPUFF will emulate AERMOD in the near field. The MPDF in CALPUFF selects the use of a probability density function (pdf) instead of a Gaussian function to describe the contaminant distribution through the plume in the vertical during convective (i.e., unstable) conditions for near-field calculations. This is the approach used in AERMOD.

Similar to the use of CALPUFF, applicants that intend to run the CALMET meteorological pre-processor themselves should have a written agreement with the ministry on the options to be set and the meteorological data to be used.

A-3.2Line Source/ Roadway Dispersion Models

If roadway contributions to concentrations in a specific area are clearly secondary, emissions due to vehicle movements can typically be adequately included in AERMOD or CALPUFF modelling. In this case, roadway sources may be treated as volume or area/line sources in AERMOD or CALPUFF. If the impacts of individual roadways are more significant, a "roadway" or line source model should be considered. These include CALINE-4 or CAL3QHCR which can be used to assess the effects of the roadway alone. This would be appropriate if existing concentrations of a contaminant from other sources (e.g., CO) are either low or are well defined. If a "worst case" meteorology is defined (e.g., one metre per second wind speed parallel to the roadway, at F stability), then CALINE-4 can be used to predict the worst case 1-hour average concentration. This can be used as a screening estimate of maximum concentrations at longer averaging periods (e.g., 8-hour, 24-hour) by applying the averaging period conversion factors set out in section 17 of the Regulation.

More refined modelling for longer averaging periods should be completed using the CAL3QHCR model when the roadway emissions dominate the concentrations. CAL3QHCR[(36)] requires meteorological data pre-processed using MPRM, RAMMET or PCRAMMET. The model should be run for five years of meteorology, which is available from EMRB upon request.

A-3.3Shoreline Models

In situations where water bodies affect the meteorology near the shoreline area significantly, CALPUFF would be the model of choice. However, CALPUFF requires substantial resources in terms of data, computer power and time. In the case where the dominant sources are located on a shoreline, and other sources in the area are clearly secondary, the SDM (Shoreline Dispersion Model[(38)]) may be used. SDM is a far simpler and less costly model to use than CALPUFF. It is a matter of professional judgement as to when shoreline effects are sufficient to warrant a shoreline model. For this reason, and for the reason that the model of choice may be more complicated to run (i.e. CALPUFF), it is important that the modeller pre-consult with EMRB before modelling using an alternative model is initiated.

APPENDIX B

ELIMINATION OF METEOROLOGICAL ANOMALIES

(AN EXAMPLE)

AN EXAMPLE CASE STUDY FOR THE ELIMINATION OF METEOROLOGICAL ANOMALIES FROM THE MAXIMUM VALUES TABLE FOR 1HR AND 24HR AVERAGED CONCENTRATIONS

APPENDIX B. ELIMINATION OF METEOROLOGICAL ANOMALIES

In this Appendix, an example of the methodology for the elimination of meteorological anomalies is presented. Note that the elimination of these anomalies is optional. Model results will always be conservative if the meteorological anomalies are not eliminated.

Figure B.0.1 contains a sample AERMOD Output Pathway definition, and the four bolded lines were added to generate the MAXTABLE option. The MAXTABLE as specified below will give the top 100 modelled values across the entire modelling domain.

Figure B.0.1: Selecting the MAXTABLE Option in AERMOD

```
****************************************
** AERMOD Output Pathway
****************************************
**
OU STARTING
   RECTABLE ALLAVE 1ST
   RECTABLE 1 1ST
   RECTABLE 24 1ST
   MAXTABLE ALLAVE 100
** Auto-Generated Plotfiles
   PLOTFILE 1 ALL 1ST file.AP\01H1GALL.PLT
   PLOTFILE 24 ALL 1ST file.AP\24H1GALL.PLT
OU FINISHED
```

Once the model run is complete, a listing of the ranked concentrations can be retrieved from the model output file. Sample excerpts of an AERMOD output file are shown in Table B.1.and Table B.0-2, which contain a portion of the Maximum Value tables of ranked 1st to 80th for the 1-hr and 24-hr concentrations respectively. The following example illustrates the elimination of meteorological anomalies from the maximum values table for 1hr and 24hr averaged concentrations, and the identification of the final concentrations (or compliance points).

Step 1: Open the AERMOD output file using a text editor;

Step 2: Locate the 1-hr Maximum Values Table ("THE MAXIMUM 100 1-HR AVERAGE CONCENTRATION VALUES"), and print the number of pages containing the data (~4 pages). A sample excerpt is shown in Table B.1.

Step 3: The first column of the table shows the Rank (starting with 1); the second column shows the concentration; and the third column identifies the meteorological date and time of occurrence (first two digits designate the year). For each meteorological year, cross out the eight hours with the highest 1-hr concentrations starting from the beginning of the table. From Table B.1. the following hours can be eliminated:

```
1996Rank:  3,  7,  9, 45, 47, 61, 68, 70 & 77

1997Rank:  2,  6,  8, 22, 43, 46, 49, 56

1998Rank:  5, 14, 19, 20, 23, 24, 28, 31

1999Rank:  1,  4 & 5, 10, 11, 12, 16, 18, 26

2000Rank: 13, 15, 17, 21, 25, 27, 29, 32
```

Note that the 4th and the 5th highest ranked concentrations occurred at different locations but in the same hour and thus both are eliminated. This also occurs for the 70th and 77th highest ranked concentrations.

Step 4: Once the total of forty 1-hr periods have been eliminated from the 5-year data set, the final concentration would be the remaining highest ranking concentration in the table – in this example, the final concentration is 62.98217 which is ranked 30th highest overall and occurs in 1999.

Step 5: Similarly, from the 24-hr Maximum Values Table (Table B.2.), cross out the highest 24-hr concentration for each meteorological year starting from the beginning of the table. From Table B.2., the following 24-hr periods can be eliminated: 1996 Rank 22; 1997 Rank 4; 1998 Rank 1 and Rank 18; 1999 Rank 9; 2000 Rank 6 as shown in the table below. For 1998, both Rank 1 and Rank 18 occur on the same day (at different locations) and thus both are eliminated since this is considered one meteorological anomaly.

Step 6: Once the total of five 24-hr periods have been eliminated, the final concentration for modelling would be the remaining highest ranking concentration in the table – in this example, the final concentration is 47.52893 which is ranked 2nd highest and occurs in 1998.

Table B.1.

Table B.0-1: Maximum 100 1-Hr Average Concentration Values (only 80 shown; compliance point block-highlighted)

RANK	CONC	(YYMMDDHH)	AT	RECEPTOR(XR,YR)	OF TYPE	RANK	CONC	(YYMMDDHH)	AT	RECEPTOR(XR,YR)	OF TYPE
1.	**~~65.10020~~**	(99061006)	AT	(-100.00, 0.00)	DC	41.	62.82240	(00101302)	AT	(100.00, 0.00)	DC
2.	**~~64.53565~~**	(97120410)	AT	(100.00, 0.00)	DC	42.	62.80699	(00042122)	AT	(0.00,-100.00)	DC
3.	**~~64.34751~~**	(96012310)	AT	(0.00,-100.00)	DC	43.	**~~62.80058~~**	(97012722)	AT	(0.00, 100.00)	DC
4.	**~~64.13493~~**	(99071606)	AT	(100.00, 0.00)	DC	44.	62.79989	(99102108)	AT	(100.00, 0.00)	DC
5.	**~~64.05058~~**	(98071606)	AT	(100.00, 100.00)	DC	45.	**~~62.79814~~**	(96091420)	AT	(0.00, 100.00)	DC
6.	**~~63.89120~~**	(97082119)	AT	(100.00, 0.00)	DC	46.	**~~62.78178~~**	(97012124)	AT	(0.00, 100.00)	DC
7.	**~~63.77862~~**	(96062920)	AT	(0.00, 100.00)	DC	47.	**~~62.78073~~**	(96120821)	AT	(100.00, 0.00)	DC
8.	**~~63.76183~~**	(97081219)	AT	(-100.00, 0.00)	DC	48.	62.77896	(99060906)	AT	(0.00,-100.00)	DC
9.	**~~63.73594~~**	(96022809)	AT	(100.00, 0.00)	DC	49.	**~~62.76951~~**	(97121909)	AT	(100.00, 0.00)	DC
10.	**~~63.68734~~**	(99120716)	AT	(100.00, 0.00)	DC	50.	62.74012	(00022608)	AT	(-100.00, 0.00)	DC
11.	**~~63.58372~~**	(99082419)	AT	(-100.00, 0.00)	DC	51.	62.72754	(99031508)	AT	(0.00,-100.00)	DC
12.	**~~63.44833~~**	(99082005)	AT	(0.00,-100.00)	DC	52.	62.72545	(00122108)	AT	(0.00, 100.00)	DC
13.	**~~63.41516~~**	(00021609)	AT	(100.00, 0.00)	DC	53.	62.71577	(98111617)	AT	(-100.00, 0.00)	DC
14.	**~~63.39690~~**	(98041819)	AT	(100.00, 0.00)	DC	54.	62.69680	(98120517)	AT	(-100.00, 0.00)	DC
15.	**~~63.31585~~**	(00101608)	AT	(-100.00, 0.00)	DC	55.	62.69494	(00031922)	AT	(-100.00, 0.00)	DC
16.	**~~63.22644~~**	(99120416)	AT	(100.00, 0.00)	DC	56.	**~~62.69208~~**	(97020705)	AT	(100.00, 0.00)	DC

17. ~~**63.22321**~~ (00062102) AT (0.00, 100.00) DC

18. ~~**63.16488**~~ (99082621) AT (-100.00, 0.00) DC

19. ~~**63.16318**~~ (98050824) AT (0.00,-100.00) DC

20. ~~**63.14574**~~ (98110617) AT (100.00, 0.00) DC

21. ~~**63.12983**~~ (00061501) AT (0.00, 100.00) DC

22. ~~**63.11957**~~ (97021907) AT (0.00, 100.00) DC

23. ~~**63.11029**~~ (98061121) AT (-100.00, 0.00) DC

24. ~~**63.10670**~~ (98041419) AT (-100.00, 0.00) DC

25. ~~**63.07385**~~ (00061323) AT (-100.00, 0.00) DC

26. ~~**63.06678**~~ (99061005) AT (-100.00, 0.00) DC

27. ~~**63.05209**~~ (00050506) AT (100.00, 0.00) DC

28. ~~**63.04682**~~ (98062524) AT (-100.00, 0.00) DC

29. ~~**63.04501**~~ (00102423) AT (0.00,-100.00) DC

30. 62.98217 (99101719) AT (0.00,-100.00) DC

31. ~~**62.96085**~~ (98022718) AT (-100.00, 0.00) DC

32. ~~**62.96041**~~ (00030618) AT (0.00, 100.00) DC

33. 62.94170 (98112009) AT (0.00,-100.00) DC

34. 62.91700 (00121621) AT (-100.00, 0.00) DC

35. 62.91359 (99121305) AT (0.00,-100.00) DC

36. 62.91128 (00031921) AT (-100.00, 0.00) DC

37. 62.89389 (98120509) AT (-100.00, 0.00) DC

57. 62.68309 (99052302) AT (0.00,-100.00) DC

58. 62.68141 (00040721) AT (-100.00, 0.00) DC

59. 62.67597 (98012103) AT (0.00,-100.00) DC

60. 62.65615 (00022519) AT (-100.00, 0.00) DC

61. ~~**62.65247**~~ (96060824) AT (-100.00, 0.00) DC

62. 62.65057 (00121322) AT (-100.00, 0.00) DC

63. 62.63590 (00122401) AT (0.00, 100.00) DC

64. 62.61233 (99031001) AT (0.00,-100.00) DC

65. 62.57222 (00061504) AT (0.00, 100.00) DC

66. 62.57042 (98090203) AT (0.00, 100.00) DC

67. 62.56813 (00082419) AT (0.00,-100.00) DC

68. ~~**62.53071**~~ (96091702) AT (0.00,-100.00) DC

69. 62.52769 (97060203) AT (-100.00, 0.00) DC

70. ~~**62.51928**~~ (96112822) AT (0.00, 100.00) DC

71. 62.51467 (99092418) AT (0.00,-100.00) DC

72. 62.48830 (00013102) AT (100.00, 0.00) DC

73. 62.48801 (00092303) AT (-100.00, 0.00) DC

74. 62.47909 (00121104) AT (0.00,-100.00) DC

75. 62.47895 (00092301) AT (-100.00, 0.00) DC

76. 62.47134 (00090207) AT (0.00,-100.00) DC

77. ~~**62.46949**~~ (96112822) AT (100.00, 0.00) DC

38.	62.86679	(99081902)	AT (0.00,-100.00)	DC	78.	62.43554	(98122101)	AT (-100.00, 0.00)	DC
39.	62.83199	(00022101)	AT (100.00, 0.00)	DC	79.	62.43499	(96042105)	AT (100.00, 0.00)	DC
40.	62.82443	(98111003)	AT (-100.00, 0.00)	DC	80.	62.42564	(99121509)	AT (0.00, 100.00)	DC

Table B.2.

Table B.0-2: Maximum 100 24-Hr Average Concentration Values (only 80 shown; compliance point block-highlighted)

RANK	CONC	(YYMMDDHH)	AT RECEPTOR(XR,YR)	OF TYPE	RANK	CONC	(YYMMDDHH)	AT RECEPTOR(XR,YR)	OF TYPE
1.	~~**48.10681**~~	(98020424)	AT (0.00,-100.00)	DC	41.	36.57086	(00050224)	AT (0.00,-100.00)	DC
2.	**47.52893**	**(98020524)**	AT (0.00,-100.00)	DC	42.	36.31826	(98103124)	AT (50.00,-100.00)	DC
3.	43.21863	(98012224)	AT (-100.00, -50.00)	DC	43.	36.28111	(97011424)	AT (50.00, 50.00)	DC
4.	~~**40.01320**~~	(97031524)	AT (100.00, 0.00)	DC	44.	36.19683	(99010424)	AT (50.00, 50.00)	DC
5.	39.50042	(98110224)	AT (50.00,-100.00)	DC	45.	36.11743	(98032124)	AT (-50.00, -50.00)	DC
6.	~~**39.31218**~~	(00041724)	AT (-100.00, 0.00)	DC	46.	36.02768	(99092124)	AT (0.00,-100.00)	DC
7.	39.21030	(00042424)	AT (0.00,-100.00)	DC	47.	35.96717	(98021324)	AT (0.00,-100.00)	DC
8.	39.20195	(00071124)	AT (0.00,-100.00)	DC	48.	35.92574	(98020624)	AT (50.00,-100.00)	DC
9.	~~**39.06937**~~	(99012224)	AT (-100.00, 0.00)	DC	49.	35.58223	(99011424)	AT (-50.00,-100.00)	DC
10.	38.69060	(98022524)	AT (50.00, -50.00)	DC	50.	35.57988	(96121924)	AT (100.00, 0.00)	DC
11.	38.66324	(99122324)	AT (100.00, 0.00)	DC	51.	35.50787	(97021024)	AT (100.00, 0.00)	DC
12.	38.58439	(97081824)	AT (0.00,-100.00)	DC	52.	35.47686	(96110824)	AT (50.00,-100.00)	DC
13.	38.49494	(99010524)	AT (100.00, 50.00)	DC	53.	35.47508	(96040524)	AT (50.00,-100.00)	DC

14. 38.38240 (98022424) AT (50.00,-100.00) DC 54. 35.36801 (99112824) AT (100.00, 0.00) DC

15. 38.33889 (99081824) AT (0.00,-100.00) DC 55. 35.32301 (00122224) AT (100.00, 50.00) DC

16. 38.33855 (97121024) AT (-100.00, -50.00) DC 56. 35.25390 (99042424) AT (0.00,-100.00) DC

17. 38.30874 (99032524) AT (0.00,-100.00) DC 57. 35.24054 (98122324) AT (100.00, 50.00) DC

18. ~~**38.23639**~~ (99020424) AT (50.00,-100.00) DC 58. 35.20003 (97091024) AT (-100.00, 50.00) DC

19. 38.17769 (00120124) AT (0.00,-100.00) DC 59. 35.19956 (96030624) AT (0.00,-100.00) DC

20. 38.17244 (98101024) AT (50.00,-100.00) DC 60. 35.14633 (97011124) AT (100.00, 50.00) DC

21. 38.16967 (99121724) AT (100.00, 0.00) DC 61. 35.09946 (96110124) AT (100.00, 50.00) DC

22. ~~**38.11966**~~ (96100924) AT (50.00,-100.00) DC 62. 35.09356 (99031324) AT (0.00,-100.00) DC

23. 37.95693 (98100624) AT (-100.00, 0.00) DC 63. 35.01658 (00111824) AT (100.00, 0.00) DC

24. 37.84420 (98011624) AT (0.00,-100.00) DC 64. 34.99058 (96010224) AT (0.00,-100.00) DC

25. 37.72802 (96091824) AT (50.00,-100.00) DC 65. 34.98722 (97011324) AT (100.00, 50.00) DC

26. 37.70357 (98123124) AT (100.00, 50.00) DC 66. 34.98309 (98101124) AT (50.00,-100.00) DC

27. 37.70138 (99022124) AT (0.00,-100.00) DC 67. 34.89045 (00011724) AT (0.00,-100.00) DC

28. 37.68097 (98040524) AT (50.00,-100.00) DC 68. 34.84517 (97070424) AT (100.00, 0.00) DC

29. 37.40958 (00102824) AT (0.00,-100.00) DC 69. 34.70854 (98040624) AT (50.00,-100.00) DC

30. 37.38273m(99102524) AT (50.00, 50.00) DC 70. 34.65571 (98013024) AT (50.00, -50.00) DC

31. 37.35784 (97020624) AT (100.00, 0.00) DC 71. 34.63356 (98071024) AT (50.00,-100.00) DC

32. 37.30082m(99010424) AT (100.00, 50.00) DC 72. 34.59713 (98031024) AT (50.00, -50.00) DC

33. 37.23205 (96101024) AT (50.00,-100.00) DC 73. 34.57745 (98032724) AT (50.00, 50.00) DC

34. 37.04751 (00110524) AT (0.00,-100.00) DC 74. 34.46351 (99011324) AT (0.00,-100.00) DC

```
 35. 36.90880 (99031324) AT (  50.00,-100.00) DC  75. 34.36126 (99031924) AT (  50.00, -50.00) DC
 36. 36.87509 (97041924) AT (  50.00,-100.00) DC  76. 34.32848 (98010324) AT (  50.00,  50.00) DC
 37. 36.84701 (99121424) AT (-100.00,   0.00) DC  77. 34.26509 (97011124) AT (  50.00,  50.00) DC
 38. 36.71939 (99022024) AT (   0.00,-100.00) DC  78. 34.18020 (98030824) AT (-100.00,   0.00) DC
 39. 36.71157 (98090824) AT (  50.00,-100.00) DC  79. 34.09071 (97110924) AT (  50.00,-100.00) DC
 40. 36.68082 (99091624) AT (   0.00,-100.00) DC  80. 34.06385 (00122824) AT (   0.00,-100.00) DC
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APPENDIX C

INSTRUCTIONS ON THE USE OF THE MODELS IN THE "APPENDIX TO REGULATION 346"

(Appendix to Regulation 346 Models)

APPENDIX C: Instructions on the Use of the Models in the "Appendix to Regulation 346"

C-1. Introduction and Applicability

Ontario Regulation 346 was the previous legislation under the *Ontario Environmental Protection Act* that regulated local air quality in the province of Ontario. The Appendix to Regulation 346 contained a mathematical description of three dispersion model calculations which were to be used to demonstrate compliance with ministry Point of Impingement (POI) Limits. Two of those models, the Virtual Source model and the Point Source model have been translated into a software program known as the Regulation 346 Dispersion Modelling Package which is made available by the Ministry of the Environment.

O. Reg. 346 was replaced with Ontario Regulation 419/05 on November 30th, 2005. Subsection 6 (1) of the Regulation presents the list of approved dispersion models that, depending on a facility's industrial classification (NAICS Code), must be used to demonstrate compliance with ministry POI Limits. "*The method of calculation required by the Appendix to Regulation 346, if section 19 applies to the discharges.."* is specified in paragraph 5 of subsection 6 (1), and thus is an approved dispersion model for applicable facilities, and can only be used to demonstrate compliance with Schedule 2 standards and guidelines (i.e. it can only be used if section 19 applies to discharges from the facility).

C-2. The Regulation 346 Dispersion Modelling Software

The Regulation 346 dispersion model is a simple, yet effective tool for calculating short-term (1/2 hour) maximum contaminant concentrations that result from contaminant emissions to air. The software package has been setup to search through the range of meteorological conditions specified in the regulation, at all ground level receptors located off the facility's property to identify the meteorological condition which will give the highest half-hour average concentration at a point of impingement. In addition the Regulation 346 Package can calculate the concentration at specific points of impingement, such as air intakes on the roofs of nearby buildings or impingement on the sides or roof of an apartment building.

For most industrial operations, the POI at which the maximum half-hour concentration will occur is typically located on or beyond the facility property line. In some instances, emissions from adjacent properties or facilities are modelled together as a single facility with a single property boundary that includes all adjacent properties. The requirements for adjacent properties are outlined in section 4 of the Regulation. Where there is a potential for Same Structure Contamination, the concentration may need to be assessed inside the property line, using an additional approved dispersion model as detailed in subsection 9 (1) of the Regulation.

C-2.1.Model Sources

For the typical circumstance where the POI is located at or beyond a company's property-line, the sources will be modelled as either virtual sources or point sources. The difference between whether a source can be considered a point or virtual source is determined by whether or not the release of the pollutant is mixed into the region beside a building due to the strong turbulent air currents near the building.

The key concept in deciding between a point and virtual source is the maximum building height. For the situation where the facility is a large rectangular structure the maximum building height will be the height of the highest point on that building excluding stacks, masts or small structures such as elevator penthouses. The following rules distinguish a point from a virtual source:

- A source can be considered a point source if the stack height above ground is more than twice the maximum building height (for buildings less than 20 metres high) otherwise the source is a virtual source;
- For a building greater than 20 metres high, the source is treated as a point source if the stack height is more than 20 metres above the roof height otherwise the source is a virtual source;
- An additional criterion occurs when a nearby tall building is upwind of the emission source. If a building higher than the height of the stack above the ground is within 100 m of the stack then when the wind blows from the tall building toward the emission source, the source is treated as a virtual source due to the tall building.
- Fugitive emissions from open sources from which the emissions are mixed into a volume of air prior to dispersing are typically modelled as virtual sources. Examples include roadways and material handling sources such as stockpile formation and vehicle loading.

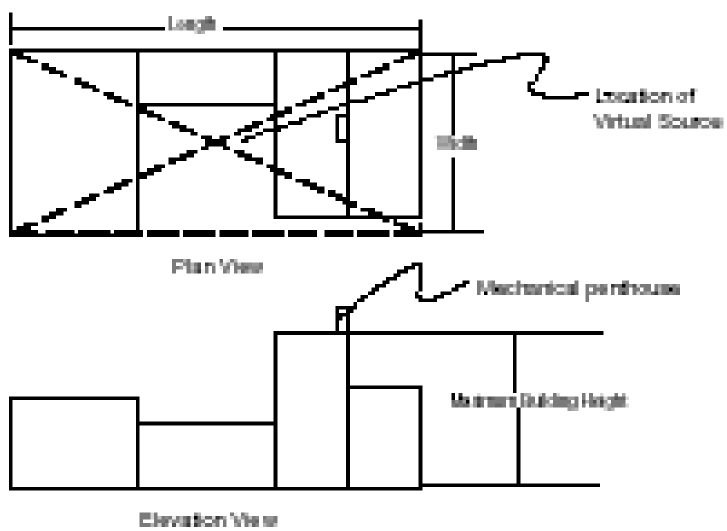
C-2.1.1.**Modelling with Virtual Sources**

For a virtual source associated with a building, the emissions are assumed to be mixed into the turbulent region beside the building. An initial horizontal and vertical mixing which depends on the height and the width of the building is then used in the calculations. For virtual sources, the maximum concentration will occur along the property line. The parameters used in a virtual source calculation are: the contaminant emission rate, the maximum width, length and height (usually the maximum building height) of the virtual source, the location of the geometric centre of the virtual source, the orientation angle of the virtual source and the location of the property line.

The terms length and width have very specific meanings in the Appendix to Regulation 346. The building width is the shorter dimension. The building length is the longer dimension. The orientation is the acute angle formed by the building length intersecting the X-axis (default of 0 degrees). A counter-clockwise rotation increases the orientation. The location of the virtual source is the centre of the building (or source) when observed in the plan view.

For situations where the plant is a series of different buildings or sources the dispersion calculation can encompass all of them as one virtual source provided they are all connected or within 5 metres of each other. For these complicated virtual sources it is helpful to superimpose the rectangular shape of the virtual source on a copy of the plan view of the facility. The dimensions of the virtual source will be those of the smallest rectangle that can be constructed to encompass the contiguous structure. The maximum building (or source) height will be the height of the highest point on any of the structures that make up a significant portion of the overall virtual source excluding stacks, masts or small structures like elevator penthouses; and the location of the virtual source is the centre of the single rectangular building (or source) when observed in the plan view. Figure C.1.1 is an example of a virtual source that encompasses a number of individual buildings or tiers.

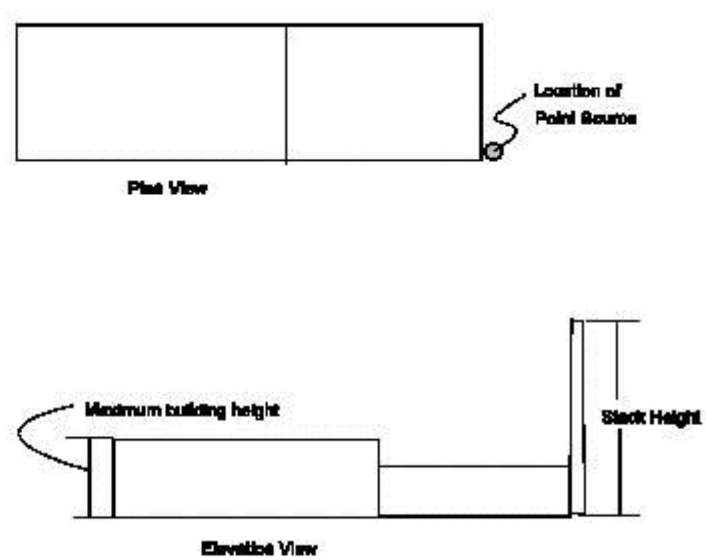
Figure C.1.1: Example Virtual Source



C-2.1.2. **Modelling with Point Sources**

If the discharge takes place outside of the turbulent air currents near the building the emission would travel downwind as an elevated plume and then mix down to ground level some distance away. This elevated plume emission is known as a point source. For point sources the emissions released from the stack top will travel downwind as an elevated plume. The material would be slowly mixed horizontally and vertically. At some distance from the stack, the material would be mixed down to ground level resulting in the ground-level concentration maximum occurring a distance from the stack. Because emissions from a point source would have to be mixed horizontally and vertically over a significant volume before the plume is mixed to ground level, a given emission rate usually results in a smaller maximum ground-level concentration if it is released from a point source as opposed to a virtual source. The maximum concentration typically occurs at some distance away from the source usually also some distance away from the property-line. The important parameters used in a point source are: the contaminant emission rate, the discharge velocity, the discharge temperature, the stack diameter, the stack height and the stack location, the location of the property line and the location of any off site receptors that the plume may impact on. The emission source is treated as a point source if the stack is higher than the criteria described above. Figure C.2-1 shows an example of a point source.

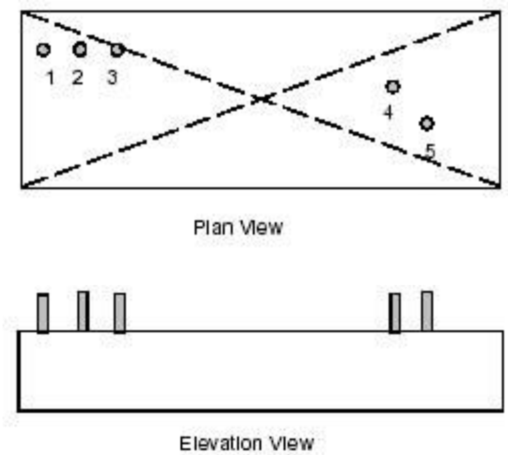
Figure C.2-1: Example Point Source



C-2.1.3. **Single Dispersion Sources**

In the common circumstance where all emissions from a facility are emitted as a single virtual source, there is a very useful shortcut that can be employed. Since for a virtual source the emissions discharged from a building are released into the turbulent zone around the building all the discharges can be lumped together and considered to be emitted from a common virtual source (Figure C.3-1).

Figure C.3-1: Example - Single Virtual Source Scenario



For this source configuration the emissions from Sources 1, 2, 3, 4 & 5 can be lumped together to be emitted from the one virtual source.

If these are the only sources then the dispersion calculation can be further simplified by running the virtual source once for a unit emission rate of 1 g/s. The resultant POI concentration at the property line can be used as a dispersion factor where the product of the dispersion factor and a contaminant emission rate is the POI concentration of that contaminant at the property line.

C-2.1.4. Complex Modelling Scenarios

While many industrial facilities can be described as a single virtual source there are other situations where a contaminant is emitted by more than one virtual or point source or a combination of many virtual and point sources. For these situations the modelling exercise is more complicated.

When there is more than one distinct virtual or point source that is emitting the contaminant the dispersion modelling exercise must be carried out for all the sources together and repeated for each individual contaminant.

C-3. Same Structure Contamination if Section 19 of O.Reg.419 Applies

For most industrial operations, compliance with the point of impingement at which the maximum half-hour concentration will occur will be on or beyond the property line. There are, however some circumstances where the concentration needs to be assessed inside the property line (same structure contamination). This circumstance often occurs when the source is in an industrial mall, where the impact of contaminants released by tenants at one unit is assessed in terms of their impact on other neighbouring tenants in the building. The Regulation 346 model includes a very simplified calculation to estimate possible impacts of emission releases on air intakes, open doors or windows on the source's own building. This approach can be used to assess same structure contamination if section 19 of the Regulation applies to discharges from a facility.

Regulation 346 addresses same structure contamination through use of the Scorer-Barrett equation. Concentrations depend on the stretched string distance from the release point of the emission source to the receptor (i.e., an air intake, a doorway or an operable window). The stretched string distance is the shortest distance from the release point to the receptor without intercepting the building.

Concentration ($\mu g/m^3$) = $0.6 \times 10^6 \times$ Emission Rate (g/s)/L^2

Where,

L = 1.57 times the stretched string distance in metres (if the receptor is lower than the emission point);

otherwise,

L = the stretched string distance.

Note that the Scorer-Barrett equation may only be used by facilities for which section19 applies. Facilities subject to section 20 of the Regulation (i.e. those required to use the US EPA models) are required to use the ASHRAE method for assessment of same structure contamination. ASHRAE may also be used to model same structure contaminant when section 19 applies.

C-4. Models in the Appendix to Regulation 346 Dispersion Modelling Package

Although there are ten programs included in the software package, only the first four programs are needed to assess compliance with Schedule 2 ministry POI Limits. Briefly, the purposes of those four programs in the Regulation 346 Dispersion Modelling Package are:

Table C.4-1:Dispersion Modelling Software Package for the Models in Appendix to Regulation 346

Source Data Manager	Used to input information on the facility's property line coordinates and on the emission source characteristics.
Point of Impingement	Used to input information on the location of nearby buildings.

Source Data Manager	Used to input information on the facility's property line coordinates and on the emission source characteristics.
Manager	
Maximum Ground Level Concentration	This program uses the files produced in the Source Data Manager and calculates the maximum half-hour Point of Impingement concentration outside of the facility's property.
Concentrations at Points:	This program uses information from both data manager programs, (1) and (2), and calculates the maximum concentration at each receptor given in the Point of Impingement Manager.

This Table contains two columns with no row headings. The first column contains terms commonly used in the software, the second column contains the corresponding description.

List of Routines:

1. Source Data Manager
2. Point of Impingement Data Manager
3. Maximum Ground Level Concentration
4. Concentration at Points
5. Required Stack Height
6. Isopleths
7. Contour Printout
8. Contour Plot
9. General Concentration Plot
10. Interpolation

Typical Inputs: Input default values are displayed within square brackets.

C-4.1 Description and Objective of the Various Programs and Routines

1.Source Data Manager

Used to input the source and property line information in advance of running the concentration program. The output is stored in a file for later editing or use. This routine is essential if a property line is to be defined. It can also save a lot of typing time if multiple sources are to be run more than once.

2. Point of Impingement Data Manager

Used to input the points of impingement in advance of running the concentration program. The output is stored in a file for later editing or use. This routine is not essential, but can save a lot of typing time if multiple receptors are to be run more than once.

3. Maximum Ground Level Concentration

Used to compute the maximum ground level concentration from any combination of sources. If the property line has been defined, the program computes the maximum concentration off-property and on the property line. No point of impingement data is required.

4. Concentration at Points

Used to compute the maximum concentration from any combination of sources at any combination of points of impingement. Both source and point of impingement data are required as input.

5. Required Stack Height

Used to compute the height of stack required so that the maximum concentrations at ground level, at the property line and at points of impingement meet a specified standard. The program computes the height for only 1 source at a time.

6. Isopleths

Used to compute concentration isopleths for any combination of point sources and Virtual Sources. The isopleths are computed over a grid superimposed over a vertical or horizontal plane. You may specify a particular stability, wind direction and wind speed. The result, stored in non-readable form, can be printed using Contour Printout or plotted using Contour Plot.

7. Contour Printout

Used to print the results of an Isopleth or Interpolation run in readable form. Can be used to view contour results if a plotter is not available.

8. Contour Plot

Used to plot the contours of a file created by Isopleth or Interpolation. The result can be routed to a plotter or to an output file (in non-readable form) for later plotting.

9.General Concentration Plot

Used to compute and plot concentrations for any combination of sources. The concentrations are plotted along a line between two arbitrary endpoints. You may specify a particular stability, wind direction and wind speed. The result can be outputted to a plotter or to an output file (in non-readable form) for later plotting.

10.Interpolation

Used to compute values over regularly spaced, points. The output is written to a file in non-readable form. The file can be subsequently outputted using Contour Printout or plotted using Contour Plot.

C-4.2 **Model Input Parameters**

Input parameters for the various routines are summarized below:

1.Titling Information

e.g. Date, Title. All are optional. Be sure, though, to enter an output filename as the first input or else the program output will default to the printer.

2.Point/Virtual Source

Indicates whether the source is a point source (e.g. a stack) or a virtual source (e.g. emission from a building vent).

3.Emission Rate

In grams/second. For a single source, concentration (in ug/m^3) is directly proportional to the emission rate.

4.Stack Height

Enter the height of the stack from ground level to the top of the stack.

5.Stack Diameter

Enter the inner stack diameter.

6.Stack Exit Gas Velocity

If unknown, can be computed from flow rate and stack diameter.

7.Coordinates

A local coordinate system is typically defined for the site. For example, this can be done by arbitrarily defining (0,0) at, the location of the largest source, or alternatively

(0,0) could be defined as the location of the lower left corner of the property. All other coordinates are in metres, with the X-axis often chosen to represent the east-west direction.

8.Building Width/Length/Orientation

The building width is the shorter dimension. The building length is the longer dimension. The orientation is the acute angle formed by the building length intersecting the X-axis (default of 0 degrees). A counter-clockwise rotation increases the orientation.

9.Open/Closed Receptor

Used when entering an elevated (i.e. above ground level) receptor. A closed receptor will only allow concentration to be computed at the height specified. An open receptor will allow a search from ground level to the height specified for the maximum concentration at that (x,y) location.

10.Selecting the Appropriate Building Height

Since many building have varying heights, it is important to select the appropriate building height relative to the wind direction and influence of taller portions of the building (or sections of a building) within a specific are of influence. Based upon information within the US EPA's "User's Guide for the Industrial Source Complex (ISC3) Dispersion Models – Volume II – Description of Model Algorithms, September 1995", the area of influence as a result of the taller portion of the building will be defined by a function of the distance L (where L is the lesser of the building height or the projected building width)…

- a distance of 5 times L from the edge of the taller portion for areas **down-wind** of the taller portion;
- a distance of 2 times L from the edge of the taller portion for areas **up-wind** of the taller portion; and
- a distance of 0.5 times L from the taller portion for areas parallel to the taller portion.

As discussed previously, for virtual sources the selected building height should be the height of the tallest building tier excluding stacks, masts or small structures such as elevator penthouses.

Table C.4.2-1:Summary of Commands for the Models in the Appendix to Regulation 346

<u>SDBMGR Commands</u>

The SDBMGR command options are as follows:

RS - reset: prepares the program for a new data set;

IN - input: input a source data set;

ED - edit: edit a source data set; and

LI - list: list a source data set.

SDBMGR edit command options are as follows:

AS - add a source

DS - delete a source

MS - modify a source

EH - edit the text header

AP - add a point to the property-line

DP - delete a point from the property-line

MP - modify a point on the property-line