Air quality model guideline

Alberta

Title:	**Air Quality Model Guideline**
Number:	ISBN 978-1-4601-4776-4
Program Name:	**Air Policy**
Effective Date:	**November 15, 2021**
This document was updated on:	**September 13, 2021**

Alberta Environment and Parks, Government of Alberta
Date of publication: September 13, 2021
ISBN 978-1-4601-4776-4

Air Policy
Alberta Environment and Parks
Main floor, Oxbridge Place
9820 – 106th Street
Edmonton, Alberta T5K 2J6

Preface

The Alberta Environment and Parks (AEP) Air Quality Model Guideline (Guideline) is intended for regulatory applications that require an *Environmental Protection and Enhancement Act* (EPEA) approval, that operate under a Code of Practice for emissions to the atmosphere, or as required by other regulatory agencies within Alberta.

AEP has developed the Guideline to ensure consistency in the use of dispersion models for regulatory applications in Alberta. The practices recommended within this Guideline are a means to ensure that these objectives are met.

The Guideline outlines AEP's air quality modelling (also commonly referred to as dispersion modelling or air dispersion modelling) requirements and methods. Although some specific information on models is given, the user should refer to user guides and reference materials for the model of interest for further information on air quality modelling. The Guideline will be reviewed regularly to ensure that the best and most practical available tools are being used to predict air quality.

Additional information relevant to dispersion models can be located at these web pages:

https://www.alberta.ca/air-quality-modelling.aspx
http://www.epa.gov/scram

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1.0 Introduction

Air quality modelling is an essential component of a regulatory approval application. It provides valuable information for the Director to assess the impact of current and proposed industrial emissions against suitable ambient air quality metrics as well as explore feasible opportunities for continuous improvement. However, modelling is complex and requires considerable skill to execute and interpret. Careful attention must be paid to the choice of the appropriate model(s) and their configuration. This includes the use of appropriate meteorology, the proper accounting of the impact of nearby sources on the project, and the modelling of representative and realistic operations that can or will occur at the facility. If clarification is required for the regulatory context of a modelling assessment contact the Director before a modelling assessment is undertaken. This Guideline provides detailed guidance on suitable air quality modelling methods and approaches that should be used to assess air emissions sources and their impact on air quality. It sets out:

- the statutory authority;
- an overview of the approach;
- guidance on appropriate technical methods, and
- the information required to demonstrate that a source maintains air quality below the Alberta Ambient Air Quality Objectives (AAAQOs)[1].

It is not intended to provide a technical description of the theory behind air quality modelling - such information is widely available in other published documents, and references are provided within this text.

Detailed advice on the types and uses of air quality models is provided in Sections 2.0 to 3.0. Section 4.0 provides information on the preparation of source information as input to modelling assessments. Section 5.0 provides guidance on the treatment of terrain and buildings within a modelling domain. Section 6.0 provides information on the appropriate meteorological data to be used in an assessment. Section 7.0 provides guidance on the content and preparation of information to be reported in an assessment. Section 8.0 provides guidance for regional modelling. Section 9.0 provides links to related air modelling information and resources. Section 10.0 provides the references for this document. Appendix A lists the contents of screening assessments. Appendix B lists the expected contents of refined and advanced assessments. Appendix C summarizes the expected technical skills and competencies required to perform air quality modelling. Appendix D lists the allowed model options for screening and refined models. Appendix E provides a list of recommended default surface characteristics suitable for modelling. Appendix E provides a list of acceptable ozone values suitable for modelling. Appendix G provides a list of acceptable default NH_3 and H_2O_2 values suitable for modelling.

1.1 Purpose of the Air Quality Model Guideline

AEP has developed the Air Quality Model Guideline to ensure consistency in the use of air quality models in air quality assessments required as part of the regulatory approval process. The objectives are to:

- provide for uniform benchmarking of information relevant to the approval application;
- provide a structured approach to the selection and application of models;
- ensure appropriate and consistent model application;
- ensure that there is a sound scientific basis for the use of alternatives, when alternatives are appropriate, and
- detail the required content of assessments submitted to the Director.

For most regulatory applications only primary substances are to be considered. Sections 2.0 to 5.0 of the Guideline address primary substances directly emitted from a source. In a few regulatory applications, particularly for projects requiring a regional study for an environmental impact assessment (EIA), modelling of primary and secondary substances, e.g., ozone and secondary particulate matter, may be required. Concentrations and/or deposition of secondary substances, when required, may be modelled as described in Section 8.0.

[1] Alberta regulatory modelling is not required to demonstrate compliance with the Canadian Ambient Air Quality Standards (CAAQS). These standards are intended for regional air quality management and comparison to monitored ambient air quality at designated monitoring stations.

1.2 Statutory Authority

This Guideline is issued by AEP, under Part 1, 14 (4), the *Environmental Protection and Enhancement Act, 2020* (EPEA). This document replaces all previous versions of the Alberta Air Quality Model Guidelines. For the purposes of this document "Director" means, subject to Section 25 of EPEA, a person designated as a Director for the purposes of this Act by the Minister.

This guideline should be read in conjunction with "Using Ambient Air Quality Objectives in Industrial Plume Dispersion Modelling and Individual Industrial Site Monitoring" (AEP 2013, or as amended), the air monitoring directive (AEP 2016, or as amended) as well as the "Environmental and Protection Enhancement Act Guide to Content for Industrial Approval Applications" (AEP 2014, or as amended).

1.3 Air Quality Models

AEP works with Albertans to protect and enhance the quality of the air through a regulatory management approach that includes the use of, amongst other things:

- air quality models;
- ambient air quality objectives;
- air emission inventories;
- source emission standards;
- approvals;
- ambient air quality monitoring;
- source emission monitoring;
- environmental reporting;
- inspections/abatement, and enforcement, and
- research.

An air quality model is a set of mathematical relationships or physical models, based on scientific principles that relates emitted air substances to their resulting ambient concentrations and deposition. Model predictions are useful in a wide variety of air quality decisions, including determining appropriateness of facility location, monitoring-network design, and stack design. Models also provide information on the areas most influenced by emissions from a source, the contribution of weather to observed trends, and the air quality expected under various scenarios. Dispersion modelling requires knowledge of the physical properties of sources, source emission rates and the local meteorology and topography.

The purpose of an air quality model is to provide a means of calculating the estimated ambient ground-level concentration and/or deposition rate of an emitted substance given information about the source emissions and the nature of the atmosphere. The amount released can be determined from knowledge of the industrial process or actual measurements. However, predictive compliance with an ambient air quality objective is determined by the concentration and/or deposition rate of the substance at ground level, not to concentrations of the substances at the emission source. In order to assess whether the emissions from a source meet the ambient air quality objectives it is necessary to determine the ground-level concentrations and/or deposition rate that may arise at various directions and distances from the source. This is the function of the air quality model.

2.0 Air Quality Modelling Protocol

An air quality dispersion model is a set of mathematical equations describing the dispersion and/or deposition of a substance from source(s) to receptor(s). These models require:

- information on the emission characteristics of the source(s) (Section 4.0);
- the selection of the appropriate modelling domain with consideration of local terrain and necessary receptor sampling (Section 5.0);
- the use of appropriate meteorology (Section 6.0); and
- consideration of the impact of non-modelled sources within the modelled study area by the addition of an appropriate baseline value (Section 7.0).

Modelling is an important tool that provides insight into the impact of industrial development and can be used to predict future scenarios based on different emission source profiles, e.g., different stack parameters or operating conditions, different technology options, short-term episodes, and long-term trends.

2.1 Modelling Decisions

All activities that emit substances into the atmosphere that are subject to an EPEA approval or operate under a Code of Practice, or as required by other regulatory agencies in Alberta, are required to undertake the appropriate air quality modelling to demonstrate their impact on air quality relative to the AAAQOs listed in “Ambient Air Quality Objectives and Guidelines Summary” (AEP 2019, or as amended). Additional modelling to demonstrate the impact on air quality for substances with ambient air quality guidelines (AAAQGs), listed in “Ambient Air Quality Objectives and Guidelines Summary” (AEP 2019, or as amended), may also be required in applications where it is reasonable to expect a local concern about these substances, e.g., dust fall from a mine. In cases where modelling is conducted for comparison to AAAQGs, follow the guidance as for modelling for AAAQOs except where otherwise directed.

When a renewal or an amendment is required for existing facilities that emit substances into the air, a new modelling assessment conducted in accordance with the current Alberta Air Quality Model Guideline must also be submitted as part of the application.

Further air quality modelling as part of the assessment process may also be required at the discretion of the Director when:

- the original modelling did not comply with the current Air Quality Model Guideline;
- there are proposed changes made to the emission sources for the proposed project not included in the original modelling;
- there are emission sources in the study area not properly accounted for in the original modelling;
- there are sensitive receptors in the area not properly accounted for in the original modelling, or
- there are other situations deemed necessary to be considered by the Director.

2.2 Modelling Approach

The choice of dispersion model depends on a number of factors. There is a wide range of models available, and it is important that the proponent select the model that is fit for purpose. It is equally important that the assessment correctly represents the operation of the facility and this is clearly presented to the Director in the submitted assessment. Modelling may also be iterative where design changes may be required and it is necessary to remodel with the design change incorporated to demonstrate compliance. A well-crafted assessment where the impacts of possible design changes have already been considered will aid in the efficient review of the assessment.

The organization of commonly used dispersion models ranging from relatively simple conservative screening models to very sophisticated alternate models has been established, categorizing the models according to how

they might be used within the assessment process. Figure 1 summarizes this modelling approach. Generally, there are four types of assessment:

A ***screening assessment*** is a simple and quick way to estimate a "worst-case" predicted concentration of project impacts. These may be used as an initial assessment where appropriate, with the use of more refined models only being necessary if the screening model is predicting an exceedance of an AAAQO. If, in the professional judgment of the proponent, a refined model is more appropriate the use of a screening model is not necessary.

A ***refined assessment***, because of its higher level of sophistication, more closely estimates actual air quality impacts. Refined modelling should form the basis of most air quality assessments. These assessments will make use of settings for approved regulatory models as specified in this document (see Appendix D).

An ***advanced assessment*** builds on a refined assessment but allows the use of alternate settings other than the prescribed settings specified in a refined assessment. When considering an advanced assessment there are two additional requirements:

1. Permission to submit an advanced assessment must be obtained in writing from the Director before modelling is undertaken. It must be clear from the application why a refined assessment will not be sufficient and how the selected alternate configuration will meet these needs.

2. The proponent must submit a companion refined assessment using the specified default AEP settings (see Appendix D) along with the advanced assessment to demonstrate that the advanced assessment was in fact an improvement over the default refined assessment, while still being conservative, i.e., the advanced assessment does not exceed any AAAQOs for the designated emissions averaging periods.

Note: Submission of an advanced assessment does not automatically guarantee its acceptance over the companion refined assessment but will be evaluated on a case-by-case basis.

An ***alternate assessment*** makes use of alternate model other than the approved regulatory models. As such, they are only to be used in exceptional circumstances and require a considerable amount of effort to demonstrate their fit for purpose. When considering an alternate assessment there are several additional requirements:

1. The alternate assessment must use an air quality model that is open source and current. Models that are proprietary in nature that cannot be run by AEP or any other interested third party are not acceptable. Regulatory dispersion models that have been superseded by more current regulatory models are not acceptable.

2. Use of meteorology other than the AEP regulatory prognostic meteorology supplemented with local meteorology as specified in Section 6 is not acceptable for dispersion modelling. Model assessments based on non-dispersion studies, e.g., wind tunnel studies, must demonstrate sufficient sampling of meteorological parameters, e.g., wind speed, ambient temperature, etc., to demonstrate the results are fit for purpose.

3. Permission to submit an alternate assessment must be obtained in writing from the Director before modelling is undertaken. It must be clear from the application why a refined assessment will not be sufficient and how the alternate assessment will meet these needs. The Director will have to review this request and grant permission to the proponent before an alternate assessment may proceed. The proponent should be prepared that this may significantly delay processing the application.

4. The proponent must submit the most suitable companion refined assessment using default AEP settings (see Appendix D) along with the alternate assessment to demonstrate that the alternate assessment was in fact an improvement over the refined assessment while still being conservative i.e., the advanced assessment does not exceed any AAAQOs for the designated averaging periods.

Note: Submission of an alternate assessment does not automatically guarantee its acceptance over the companion refined assessment but will be evaluated on a case-by-case basis.

Note: In all modelling assessments the version of all the models used and the model options (if applicable) must be explicitly provided. The AEP-allowed screening and refined model option switches are provided in Appendix D.

The flow chart for the selection of the appropriate modelling assessment is shown in Figure 1. Most modelling should flow through the refined model path with simple modelling addressed through a screening model and very rare modelling applications dealt with through an advanced or alternate model. Redesigns may require additional modelling so this should be considered early in the application process to avoid unnecessary delays.

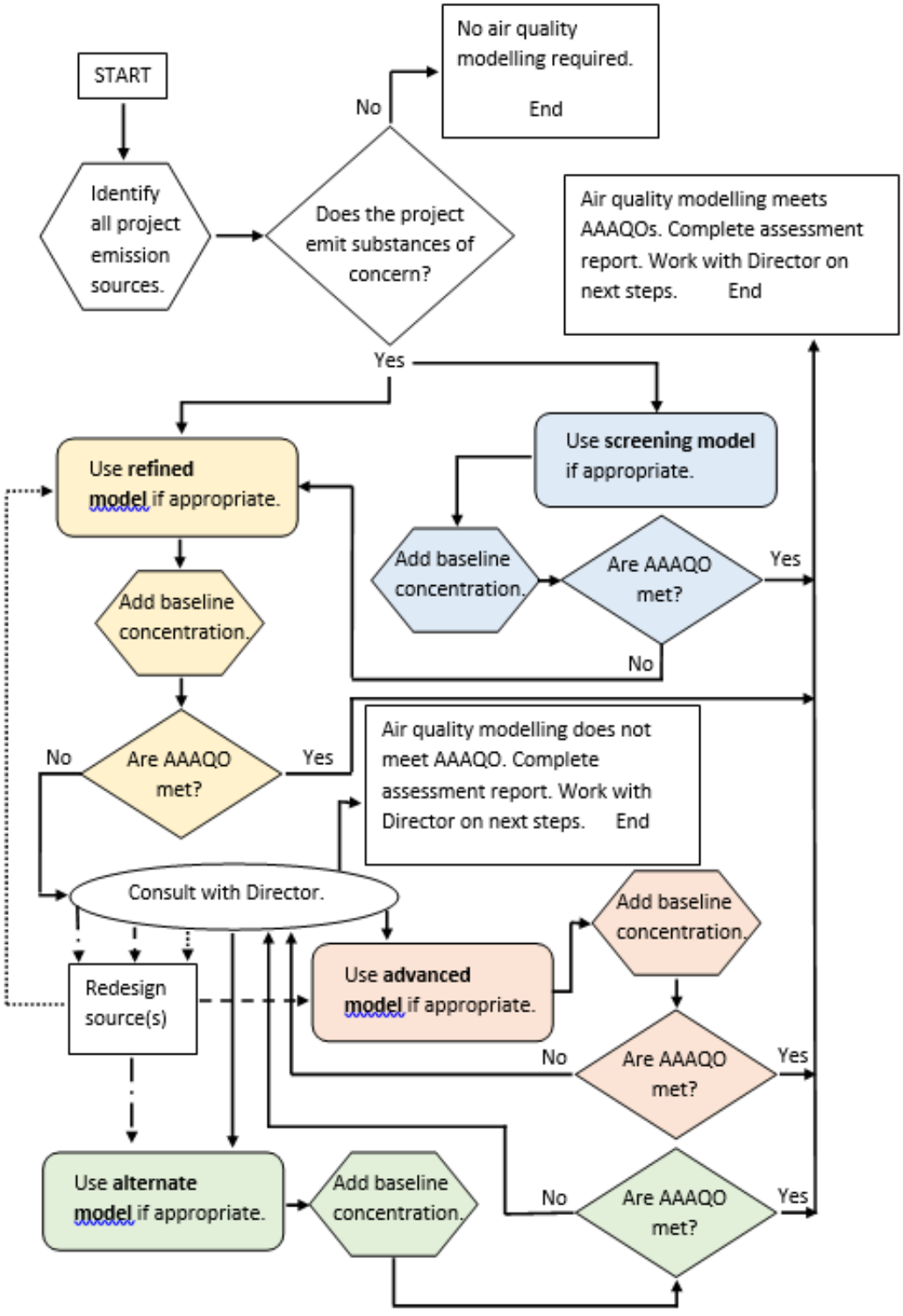

Figure 1 Flow chart describing the decision making process to choose the appropriate air quality model for an assessment.

3.0 Approved Regulatory Air Quality Models

The air quality modelling approach provided is expedient, as the aim is to progressively reduce uncertainty by moving from simple and cautious models to complex and more representative ones, as circumstances warrant. One screening model (AERSCREEN) and two refined/advanced models (AERMOD/CALPUFF) are recommended by AEP.

All of the approved regulatory models discussed in this guideline are considered short-range. That means that only air quality within 50 km of the source is predicted reliably, except for CALPUFF, which can be used up to about 200 km.

AERSCREEN and AERMOD rely upon a plume splitting algorithm based upon the divided streamline of the plume to estimate the amount of plume that be will transported over complex terrain. The plume that is trapped on the windward side is dispersed assuming a horizontal dispersion coefficient that is symmetric and may not be representative of the stagnation that is occurring resulting in artificially high ground level concentrations of a substance. The simple acknowledgement of this in the assessment is not sufficient as the effects of the dispersion of the windward component of the plume may not be properly accounted for. Hence, for projects in complex terrain CALPUFF is the preferred model.

The criteria for determining whether terrain is complex or simple is given by (Rowe 1982):

- Simple terrain (parallel air flow) - terrain whose elevation does not exceed 2/3 of the plume height (plume rise + stack height) at stability category F with a wind speed of 1 m/s and a flow rate of Qmax/2.
- Complex terrain – topography where elevations are greater than those used to define simple terrain.

The maximum elevated terrain within the modelling domain allowed above the base of a stack to be considered simple terrain in a modelling domain can be calculated using spreadsheet found at

https://www.alberta.ca/air-quality-modelling-overview.aspx

Figure 2 summarizes the logic for determining whether or not complex terrain modelling should be undertaken.

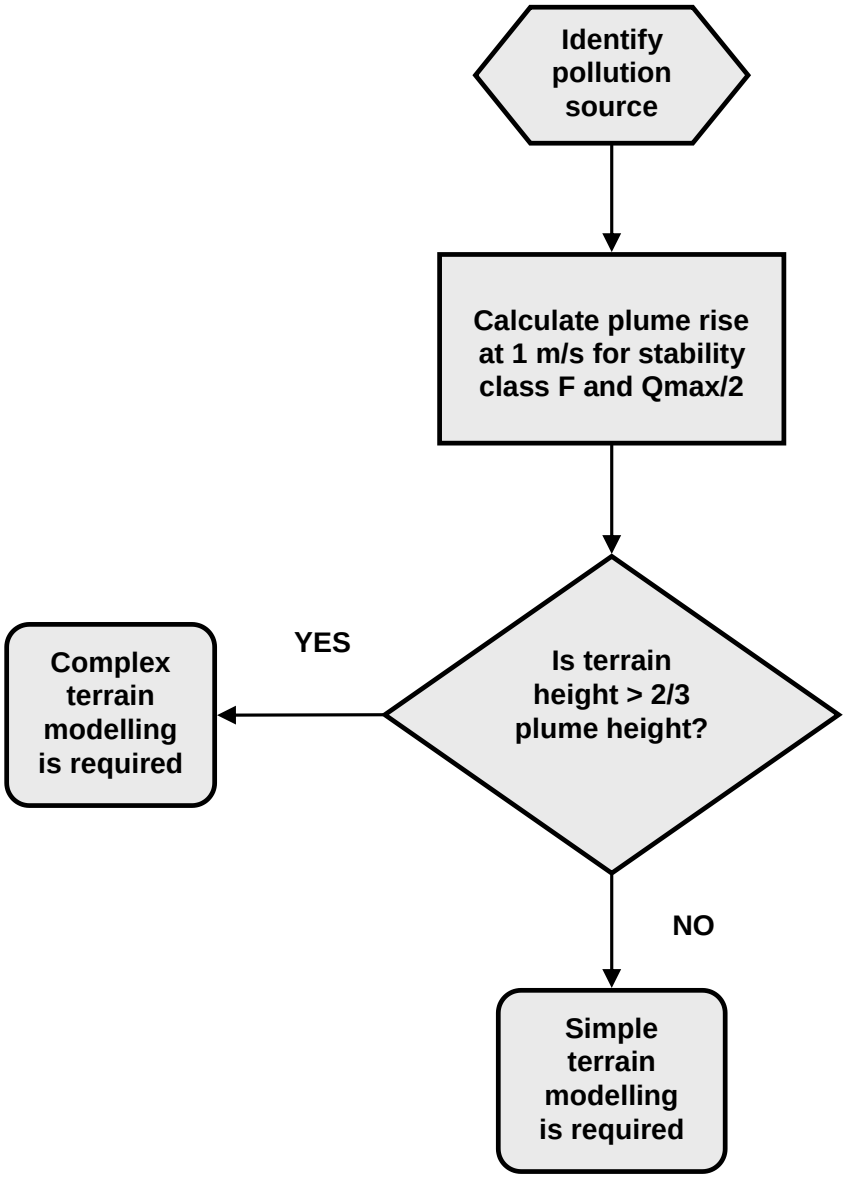

Figure 2 **Flow chart for simple and complex terrain determination for air quality modelling**

3.1 Screening Model

The simplest modelling assessments involve evaluating the impact of a single source by employing a screening method such as AERSCREEN. The screening model results serve as a benchmark for each type of source and for comparison against other sources.

3.1.1 AERSCREEN

AERSCREEN is the U.S. EPA recommended screening model used to produce estimates of worst-case scenarios. AERSCREEN interfaces with the AERMOD model and performs modelling runs in the AERMOD screening mode. AERSCREEN generates a site-specific matrix of worst-case scenario meteorological conditions with MAKEMET, the default MAKEMET options should be used. The PRIME downwash algorithms (see Section 5.2 for additional information on the use of this option) and AERMAP terrain processors are incorporated.

AERSCREEN is only able to model a single point, capped stack, horizontal stack, rectangular area, circular area, flare, or volume source (U.S EPA 2016). When considering more than one source each source must be run separately and the maximum ground level concentrations from each run must be summed, regardless of location, to provide the maximum modelled ground level concentration.

In very limited circumstances multiple point sources may be merged, if appropriate (see Section 4.3), into one point source in preparation for a screening assessment.

The results of the AERSCREEN assessment must include the addition of a representative baseline concentration (that is derived in accordance with Section 7.2). If the maximum modelled assessment ground level concentration plus the baseline concentration are below the AAAQO, it should not be necessary to undertake further modelling, except as required (See Section 2.1).

3.1.1.1 AERSCREEN Averaging Periods

AERSCREEN produces hourly averages and includes time factors for 3-hr, 8-hr, 24-hr and annual averages, which should be used when available. For any other super-hourly averaging periods, where there is no pre-determined value generated by the model, apply the following formula:

$$\textit{Impact parameter} = 1.1233 * (\text{averaging period in hours})^{-0.2906} \quad (1)$$

Multiply the calculated *impact parameter* (appropriate for the averaging period in question) by the maximum predicted 1-hour concentration to obtain the relevant average.

3.2 Refined/Advanced Models

Assessments using refined/advanced regulatory model are required to address the impacts of single or multiple sources within the modelling domain, if any of the following conditions apply:

- The screening assessment predicts exceedances of an AAAQO;
- The area is environmentally sensitive (e.g., a national park), and/or
- Public concerns need to be addressed (e.g., sensitive receptors present in the modelling domain).

Brief descriptions of the regulatory refined models are presented below.

3.2.1 AERMOD-PRIME

AERMOD was developed by the U.S. EPA (2004), in collaboration with the American Meteorological Society. This is a multi-source steady-state plume model. In the stable boundary layer (SBL), the concentration distribution is assumed to be Gaussian in both the vertical and horizontal planes. In the convective boundary layer (CBL), the horizontal distribution is assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function (pdf). Additionally, in the CBL, AERMOD treats “plume lofting,” whereby a portion of

plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the CBL. AERMOD also tracks any plume mass that penetrates into the elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate.

AERMOD should be run using the most current U.S. EPA regulatory default options with some exceptions allowed (see Appendix D). Deviation from model options listed in Appendix D is deemed to be an advanced assessment. As such, the requirements for this type of assessment listed in Section 2.2 must be met.

3.2.2 CALPUFF

The CALPUFF model is a multi-layer, multi-species, non-steady-state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on substance transport, transformation, and removal. CALPUFF can use the three-dimensional meteorological fields developed by the CALMET model, or simple, single-station winds in a format consistent with the meteorological files used to derive steady-state Gaussian models. Particular attention should be paid to setting up a (nested) CALMET meteorological grid that will properly account for terrain effects. As a rule of thumb, the spacing of the CALMET grid in the region being studied should be of the order of $1/10^{th}$ of the dimension of the feature, e.g., a valley, being resolved.

The current default model options from the current developers of the CALPUFF modelling system serve as the basic set of model options to be used for CALPUFF modelling applications. AEP recommended deviations from these options are provided in Appendix D. Hence, the AEP default model options are a blend of released model options and AEP recommended options. Deviation from the model options listed in Appendix D is deemed to be an advanced assessment. As such, the requirements for this type of assessment listed in Section 2.2 must be met.

3.3 Alternate Models

When proposing an assessment with an alternate model, details of the project must be discussed with and accepted in writing by the Director prior to commencing the modelling. In some cases the particular circumstances of topography, climate, source configuration, emissions characteristics, sensitivity of receptors, local concerns, or other unusual features will require the selection of a non-recommended air quality model better suited to the situation.

The use of an alternate air quality model must be supported by at least one of the following:

- a detailed observational study (field, wind tunnel, or water channel);
- theory supported by comparisons in literature, and/or
- theory supported by comparison with on-site data.

Alternate air quality models must meet the criteria for model acceptability (Section 2.2) and must demonstrate that they perform better than the recommended refined or advanced model while still being conservative. In general, a performance evaluation consists of the following (U.S. EPA, 1992a):

- accuracy of peak predicted concentrations (against site-specific air quality data),
- a correlation analysis;
- visual presentation and interpretation of appropriate isopleths showing predicted concentration patterns;
- test of model precision, and/or
- test of model bias.

As noted before, older deprecated regulatory dispersion models or proprietary dispersion models that are not open source or require specially configured hardware to run are not acceptable alternate models.

Table 1 provides a list of dispersion models recommended by the department for use in Alberta and the appropriate assessment level. The specific situations under which they can be applied are also outlined in Table 1.

Table 1 Assessment Level and Corresponding Acceptable Air Quality Model(s)

Air Quality Assessment	Approved Air Quality Model	Restrictions			
		Switches	Model Domain	Meteorology	Other
Screening	AERSCREEN		≤ 50 km	MAKEMET	Few sources; simple terrain.
Refined	AERMOD	Appendix D	≤ 50 km	Regulatory Mesoscale or onsite (if available)	Simple terrain; okay for particle deposition assessment but not acid deposition assessments
	CALPUFF	Appendix D	≤ 200 km	Regulatory Mesoscale plus all meteorology in modelling domain (if available)	Complex and simple terrain
Advanced	AERMOD	Non-default or deviation from prescribed switches. Written approval of Director before modelling; side by side comparison with Refined model required	≤ 50 km	Regulatory Mesoscale or onsite (if available)	Simple terrain; okay for particle deposition assessment but not acid deposition assessments
	CALPUFF	Non-default or deviation from prescribed switches Written approval of Director before modelling; side by side comparison with Refined model required	≤ 200 km	Regulatory Mesoscale plus all meteorology in modelling domain (if available)	Complex and simple terrain
Alternate	Other	Written approval of Director and AEP before modelling; side by side comparison with Refined model required		Regulatory Mesoscale plus all meteorology in modelling domain (if available) or as applicable (for non-dispersion modelling assessments)	Open source; deprecated regulatory models are not allowed

Note: Non-model specific control parameters, e.g., formatting of input/output files, etc., may be set to suit the needs of the particular project. These administrative settings do not influence the level of the assessment.

Note: Onsite meteorology must be from a station within the fence line of the project.

4.0 Source Input Data

All air quality dispersion models require some form of input data that describe how much of a substance is being emitted, details on how the substance is being emitted, and the environment into which the emission occurs. Where the model assumes that the emissions are not chemically transformed in the atmosphere, or there is no change in exit velocity or stack temperature, the predicted concentration is directly proportional to the emission rate, i.e., if the emission rate is doubled, the predicted ground level concentration also doubles. Given this dependency, it is important that emission values and stack parameters input into the model are representative of the situation. The use of outdated or unrealistic emission limits for approved sources may lead to unrealistic or frequent exceedances not attributable to regulatory model conservatism but rather to the choice of inappropriate emission limits.

Relatively small contributions from sources that meet the facility de minimis reporting requirements specified in Table 4 Conditions Required for Deeming a Source as Negligible of Alberta's Annual Emissions Inventory Report Standard and Guidance Document (AEP 2018, or as amended) may be excluded unless:

- They are identified as a source within the proponents approval;
- They are near the fence line and, in the professional opinion of the proponent, they may impact a nearby sensitive receptor;
- They emit a substance known or likely to be of concern to the community; or
- If required by the Director.

Note: In all assessments, a table listing the source parameters, emission rates and emission quantification methods, etc., for all sources must be included. Consult Appendix A and B for a minimum listing of reporting requirements. Under certain circumstances, e.g., a very complex assessment, the Director may require additional reporting.

4.1 Source Types

Emission sources can be categorized into four types based on geometrical shape: point, line, area, and volume sources. All of the dispersion models listed in Section 3.0 can be used for point, line, area, and volume source types; however, with AERSCREEN, there are limitations for multiple source situations. The different source types are defined as follows:

Point sources are discrete sources that are stationary and emitting substances into the atmosphere from a specific point of origin such as stacks or flares. The source parameters normally required for point sources include the UTM or grid coordinates, emission release height (i.e., stack height), exit velocity, stack diameter, exit temperature and mass emission rates of the substance of concern.

Line Sources are sources where emissions are in linear form, distributed over a line such as roads, rail lines and conveyor belts. Parameters normally required for line sources include the dimensions of the line and the mass emission rates. Some models may not treat line sources explicitly – in this case, sources of this type can be handled as area sources (long, thin rectangles) or as a string of volume sources.

Area sources are clusters of point or line sources (e.g., fugitive emissions from industrial processes). Parameters normally required for area sources include the coordinates of the area perimeter, the emission release height, and the mass emission flux rate of the substance of concern (i.e., mass emission rate per unit of area, $g/s.m^2$). Examples of area sources include lagoons and retaining ponds, open pit mines, mine fleets, aggregated point sources.

Volume sources are three-dimensional sources such as area sources distributed with a vertical height, for example, dust emissions from an aggregate storage pile, emissions from tanks. Parameters normally required for volume sources include the coordinates of the volume dimensions and the mass emission rates.

Note: The EPA TANKS software is no longer maintained. We will continue to recommend the use of the equations/algorithms specified in AP-42 Chapter 7 for estimating VOC emissions from storage tanks. The equations specified in AP-42 Chapter 7 (https://www.epa.gov/ttn/chief/ap42/ch07/index.html) can be employed with many current spreadsheet/software programs.

4.2 Source Emission Scenarios

Air quality modelling undertaken to support an approval for a new facility, a renewal, or an amendment must clearly demonstrate the potential impacts on air quality and/or deposition of the approved activity. This modelling must include impacts that can occur under a number of different operating scenarios, e.g., during an upset, as well as consider constraints imposed within the approval, e.g., the maximum limit and/or upset limit. The guidance provided here should help the proponent prepare an assessment that captures the various possible emission scenarios and avoid unnecessary delays in the application process.

For clarity, we include the following definitions to assist developing the required scenarios:

Typical emissions: These are the emissions released by a facility that is operating under normal stable operating conditions. A facility should be operating under these conditions most of the time. For an existing facility applying for a renewal or amendment, the typical emissions for existing sources can be determined as per the method provided in Alberta's Annual Emissions Inventory Report Standard and Guidance Document (AEP 2018, or as amended). For a new facility, or a facility applying for renewal with an amendment, the proposed emission rates for the new sources must be estimated on the basis of engineering principles and expected typical operating conditions.

Maximum allowed/proposed emissions: Facilities may have an approval emission limit for the facility, or sources within the facility, set based on a maximum emission rate. When the facility has a facility limit this will have to be allocated to the individual sources operating under the limit in a representative manner for modelling purposes. For facilities with an approval that does not specify a maximum emission limit for any of the sources, the source emission rate should be determined on the basis of engineering principles and operational conditions. In some cases, a facility may set a maximum emission limit specific for upset conditions. When any maximum emissions limits (upset, routine) are specified for a source in an approval, these must be used when calculating their respective maximum emission rate scenarios.

Upsets*:* These events occur outside of stable normal operating conditions, which can result from a variety of reasons and should not occur very often. These events could produce significantly more emissions than normal stable operations. A facility may or may not have a maximum upset limit in its approval. Upset emissions may be attributed to flaring events, but can also be attributed to non-flaring emissions (i.e., stack emission, stack bypasses, or venting).

Planned startup/shutdown*:* Starting up or shutting a facility (or specific equipment within a facility) are considered to be infrequent events. However, they are usually planned and will follow a prescribed standard operating procedure to mitigate, amongst other things, excessive emissions. Planned startups/shutdowns (including turnarounds) are not be considered upsets, whereas unplanned startups/shutdowns should be considered upsets.

Note: In some instances the typical emission rates may be reported as being greater than the maximum emission rate. This may occur if the source was not operating normally for the year from which the maximum emission rate is derived, the wrong maximum emission rate was used, a possible error in reporting occurred or some other reason. Care should be made to ensure representative maximum and typical emissions rates for a given mode of operation are used.

Figure 3 provides the logic flow for the proponent to determine which emission scenario(s) will be required as part of an assessment. The approach defined in Figure 3 can be applied to assessments for both new projects (Section 4.2.1), and renewal or amendment of existing projects (Section 4.2.2).

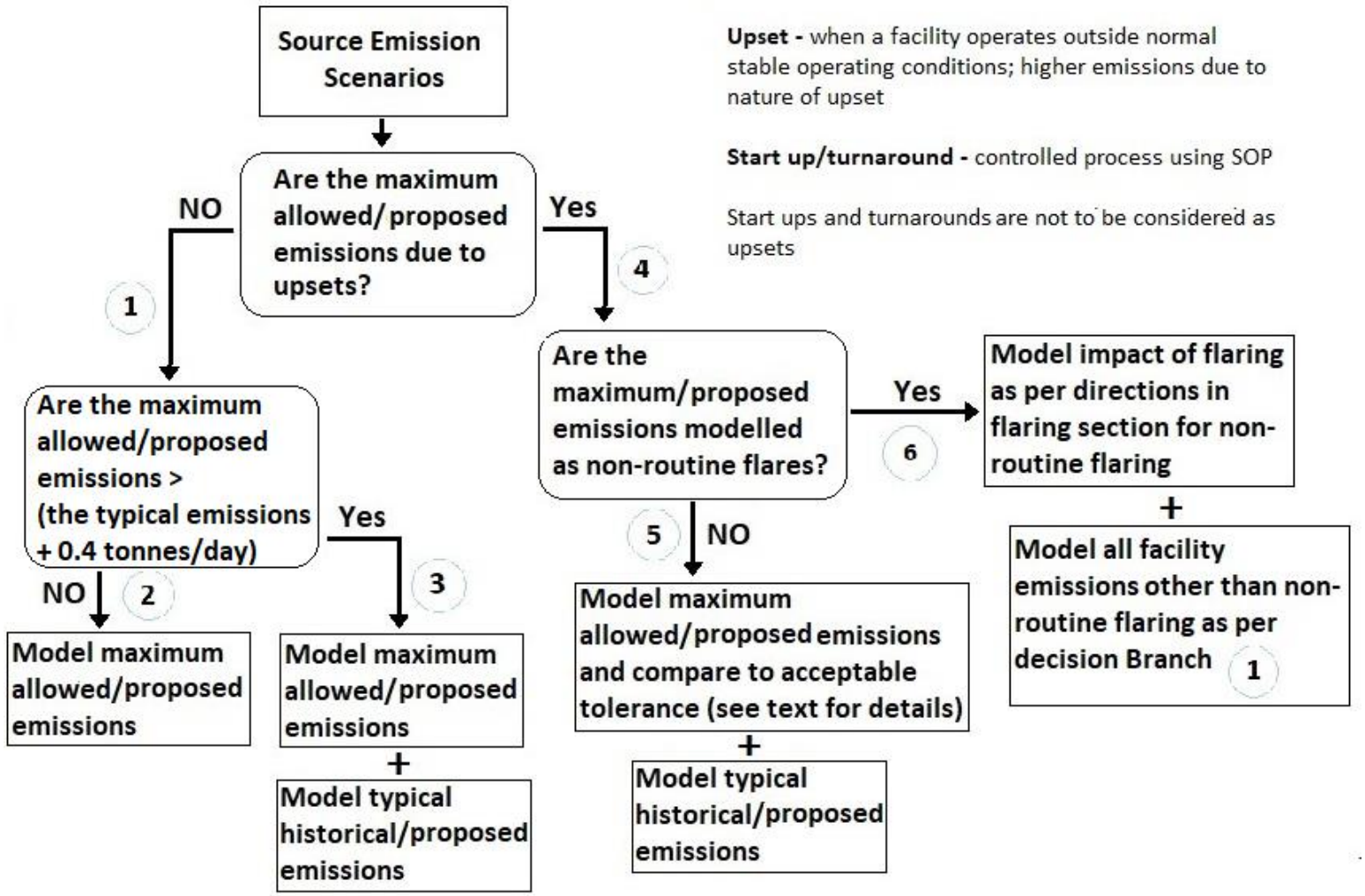

Figure 3 **Decision tree for the selection of emission scenarios required for a modelling assessment. The logic is applicable to new, renewal and amendment applications (see text for details)**

4.2.1 New Facility

In the case of new facilities or a facility that has new development under a new approval, the maximum emission rate and typical emission rate for each new source (project source) would be proposed rates. Emission parameters can be determined or derived from, in order of preference:

1. Design and engineering estimates, or
2. Emission factor estimates from published sources (e.g., manufacturer specifications or AP-42, (U.S. EPA 1995a).

Are the maximum allowed/proposed emissions for any project sources due to upsets?
The first decision point (as outlined in Figure 3) will be to determine if any project sources, for any substances of concern, have a maximum emission rate due to upsets. If not of the proponent should follow *Branch 1* of Figure 3 (indicated by the circled 1), otherwise the proponent should follow *Branch 4*.

Are the maximum allowed/proposed emission rates > the typical emission rates +0.4 tonnes/day for any project source?
When following *Branch 1*, the next decision point is to determine if the maximum proposed emission rate differs from the typical emission rate for any project source, for any substances of concern. A maximum emission rate is considered to differ from a typical emission rate for a project source, for any substance of concern, if the maximum emission rate exceeds the typical emission rate, for that substance of concern, by more than 0.4 tonnes/day[2].

If the maximum and typical emission rates for all project sources, for all substances of concern, do not differ, the proponent is only required to model the maximum emission rate for all project sources, for all substances of concern (*Branch 2*). Modelling must also include all non-project sources at their maximum emission rate (note the exception below for annual averages) and the addition of the appropriate baseline to capture the contribution from non-modelled sources (see Section 7.0 for a complete description of these sources).

When these maximum and typical emissions rates do differ modelling must follow *Branch 3*, and the proponent must include two emission scenarios in their modelling assessment:

1. The maximum emissions scenario should model all project sources operating at their maximum emission, rates for all substances of concern. Modelling must also include all non-project sources operating at their non-upset maximum emission rate plus the addition of the appropriate baseline to capture the contribution from non-modelled sources (see Section 7.0 for a complete description of these sources).

2. The typical emissions scenario is identical to the maximum emissions scenario, except all project sources deemed to differ in their maximum and typical emission rate for any substance of concern, must model these sources at their typical emission rates with all other project sources operating at their maximum emission rate for these substances of concern. Modelling must also include all non-project sources at their non-upset maximum emission rate plus the addition of the appropriate baseline to capture the contribution from non-modelled sources (see Section 7.0 for a complete description of these sources).

Are the maximum/proposed project emissions due to non-routine flares?
If any project maximum emission rates are due to upsets, then modelling as per *Branch 4* should be followed. The proponent must then determine whether or not the upsets are attributed to non-routine flaring or otherwise. If the upsets are due to non-routine flaring, the modelling should follow *Branch 6*. If the upsets are due to processes other than non-routine flaring modelling should follow *Branch 5*. In the very rare situation where both types of upsets are possible at a facility both branches and relevant scenarios will have to be included.

When modelling the impact of non–routine flaring following *Branch 6* the first scenario is to assess the impact of the non-routine flaring upsets, with other scenario(s) required to assess all other operating conditions:

2 Based on 2018 Alberta Annual Emissions Inventory Report (AEP 2021a), the maximum emission rates for reporting facility sources were often within 0.4 tonnes/day of the source's typical emission rate with a notable group of sources (5 – 15% of the total reported sources for each of the CACs) exceeding this threshold.

1. Model non-routine flaring upsets for all substances of concern released by the upset as per the guidance provided for these events as specified in Section 4.5.

2. Model all project sources for all substances of concern other than the non-routine flared sources as per *Branch 1*. If a flare used for non-routine flaring also functions for other purposes it must be included in this modelling functioning as such with the appropriate limits. As noted, if some of the other project sources include upsets through processes other than non-routine flaring they must be modelled as per *Branch 5*.

When modelling the impact of upsets for sources other than non-routine flares the proponent should follow *Branch 5*. The modelling should include:

1. The maximum emissions scenario with all project sources for all substances of concern with an upset limit, excluding any non-routine flare sources acting as such, operating at their proposed maximum upset limit and all other project sources operating at the maximum emission rates. Modelling must also include all non-project sources operating at their non-upset maximum emission rate plus the addition of the appropriate baseline to capture the contribution from non-modelled sources (see Section 7.0 for a complete description of these sources). Results from this scenario should be interpreted as per the guidance provided in “Using Ambient Air Quality Objectives in Industrial Plume Dispersion Modelling and Individual Industrial Site Monitoring”, (AEP 2013) or as amended.

2. The typical emissions scenario should be identical to the maximum emissions scenario, except project sources with maximum upset limit should be modelled at the greater rate of either their non-upset maximum emission rate, if specified, or their typical emission rates for all substances of concern. Modelling must also include all non-project sources at their non-upset maximum emission rates plus the addition of the appropriate baseline to capture the contribution from non-modelled sources (see Section 7.0 for a complete description of these sources).

Annual Average Calculations

When modelling is undertaken to predict annual average concentrations, proposed typical emission rates for the project sources and non-project sources (with the addition of a suitable baseline) will be adequate for the purpose. Upset limits do not need to be considered for this scenario as they are by definition short duration events and are of concern for short duration averaging periods.

Example 1 (*Branch 2*): A facility has twelve sources, all of which have maximum emission rates for all substances of concern within 0.4 tonnes/day of their typical emission rates. The assessment in case should comprise all project sources operating at their maximum emission rate for all substances of concern plus all nearby industrial sources impacting the study area operating at their non-upset maximums with the addition of the appropriate baseline.

Example 2 (*Branch 3*): A facility has four sources, with one source having a non-upset maximum emission rate 0.4 tonnes/day greater than its typical emission rate for three substances of concern. In this case, two modelling scenarios must be included in the assessment. The first scenario will be a maximum emission rate scenario as conducted in Example 1 for all substances of concern. The second scenario will require the modelling be repeated but in this case the source with non-upset maximums identified as differing from its typical emission rate will have to set its emissions to the typical emission rate for the three substances of concern. All other project and non-project sources will have their emission rates for the same three substances of concern set to their non-upset maximum limits plus the addition of the appropriate baseline.

Example 3 (*Branch 5*): A facility has three sources, one of which has an upset limit. In this case, the assessment will require two scenarios. The first assessment will be for the maximum emission assessment similar to Example 1 except the source with the upset limit must use the corresponding upset maximum emission rate for the substances of concern specified by the emission limit. For all other substances of concern emitted by this source during the upset the proponent must use a realistic emission rate that would be reasonably expected during these events. Allowance for any exceedances of substances of concern attributable to this upset are provided in “Using Ambient Air Quality Objectives in Industrial Plume Dispersion Modelling and Individual Industrial Site Monitoring” (AEP 2013, or as amended). The second scenario is similar to Example 2 except the source with the upset limit is now modelled at typical emission rates for all substances of concern.

Example 4 (*Branch 6*): A facility has fifteen sources, of which three are flare stacks used for non-routine flaring. One of these flare stacks is usually used as a continuous flare. This assessment will require at least two or possibly three scenarios. The first scenario should model the non-routine flares separately as per the guidance for non-routine flaring (Section 4.5). When more than one non-routine flare is present at the facility care should taken to explain any possible interaction between these events that may occur. The second scenario should then consider all of the project sources other than the non-routine flares, except the non-routine flare that usually operates as continuous source, which should be treated as a continuous source in this scenario. The scenario must then follow *Branch 1* to complete the assessment.

Example 5 (*Branch 5* and *Branch 6*): In a very few cases a facility may have sources that experience upsets that are not flare sources as well as non-routine flaring sources. In this case, the proponent should first model the non-routine flare upsets as per the first scenario in Example 4 and then follow *Branch 5* to complete the assessment.

4.2.2 Approval Renewals or Amendment

For approval renewals or amendments, the proponent must follow the same logic used to determine emission scenarios for new sources (as specified in Section 4.2.1). The emission scenarios for the maximum emission rate must be set to the currently approved or proposed maximum emission limit, if one exists. The typical emission rate should be based on the average of the last three years of typical emissions for that project emission source. If a facility or a particular source at a facility was undergoing extensive maintenance/upgrades or some other significant operational change in a particular year this may not be representative of typical operations and should not be included in this averaging. Stack emission parameters for renewal/amendment scenarios can be determined or derived from, in order of preference:

1. Approval limits;
2. Continuous emission monitoring conducted according to the *Continuous Emission Monitoring System* (*CEMS) Code* (AEP 2021b, or as amended);
3. Manual stack surveys conducted according to the *Alberta Stack Sampling Code* (AEP 1995, or as amended);
4. Site specific source measurements;
5. Design and engineering estimates, or
6. Emission factor estimates from published sources (manufacturer specifications or AP-42 (U.S. EPA 1995a, or as amended)).

Emission limits for authorized emission sources specified in EPEA approvals may be tied to specific process and control technology that may not be directly usable as input into an air quality model. The modelling assessment must, in all cases, clearly state the emission rates for all sources in appropriate units, where they may be directly used in an authorization. The conversion method used to derive the modelling ready emission rates must also be included in the assessment.

If sources operate only during specific periods of time, the modelling emissions scenarios can be restricted to those periods of time, provided that conservatism is maintained. If this type of assessment is selected, special approval conditions may apply to restrict the operation of the facility to the periods that were considered in the assessment.

4.3 Merged Sources: Stacks

The emissions from a facility can come from a number of different types of sources, locations, and characteristics. If the plumes from nearby similar stacks are close enough to merge, the plume rise can be enhanced. None of the recommended models account explicitly for the merged plume rise situation although modelling the sources as separate sources is generally a conservative assumption since the modelled plume rise in this situation will be lower than in reality.

Sources that emit the same substance from several stacks with similar parameters that are within 100 m of each other and whose stack parameters (stack temperature, stack height, flow rate, exit velocity) do not differ by more than 20% may be modelled by treating all of the emissions as coming from a single “representative” stack (U.S. EPA 1992b, Section 2.2). For each stack compute the parameter M:

$$M = h_s * V_s * T_s / Q_s$$

where:

M = merged stack parameter which accounts for the relative influence of stack height, plume rise, and mass emission rates on ground level concentrations,
h_s = stack height (m),
V_s = stack volumetric flow rate (m^3/s) = $(\pi/4)*d_s^2*v_s$,
d_s = stack inside diameter (m),
v_s = stack gas exit velocity (m/s),
T_s = stack gas exit temperature (K), and
Q_s = stack substance mass emission rate (g/s).

The stack that has the lowest value of M is used as the "representative" stack. The emission from all of the merged stacks is then assumed to be emitted from the representative stack with the total substance mass emission rate, Q_T, given by:

$$Q_T = Q_1 + Q_2 + \ldots + Q_n.$$

All relevant merged stack information should be included in the modelling assessment report.

4.4 Fugitive Emission Sources

Fugitive emission sources are often difficult to characterize since their emissions may vary with wind speed, temperature and time of day or process changes. Compounding this is the control efficiency of mitigation measures applied to reduce emissions, which may only be crudely estimated. If no better emission information is available, e.g., from a site specific monitoring program, fugitive emissions may be estimated from the AEIR (AEP 2018, or as updated), Canadian Association of Petroleum Producer (CAPP) emission estimates (CAPP 1999, CAPP 2002, CAPP 2007, CAPP 2014, CAPP 2018), AP-42 emission factors (US EPA 1995), WebFIRE (US EPA 2016), or other reputable source as appropriate.

When modelling fugitive emissions care should be given to the choice of appropriate source type, i.e., whether the choice of an area source or volume source to best represent the nature of the emissions. Consideration should also be given to seasonal variability of the emissions from these sources where appropriate.

4.5 Flaring and Incineration

Continuous and non-routine flares should always be designed in conformance with the most current guidelines and standards recommended by AEP or the Alberta Energy Regulator (AER), as appropriate.

Non-routine flares typically represent sub-hourly events and should be modelled and assessed using guidance from the most current version of the "*Non-Routine Flaring Management: Modelling Guidance*", (AEP 2014, or as amended). The AER provides tools for flaring calculations, posted on their website, which are acceptable modelling tools for the intended purposes of non-routine flaring or incinerating.

Continuous flares should be modelled as continuous sources (consideration of their continuous rates and typical rates as per Figure 3) and should not use the risk-based approach developed to assess non-routine flaring. Pseudo-parameters for a continuous flare must be created using the AER non-routine flaring tool. In all flaring modelling where the AER pseudo parameters are used make sure to use the no stick downwash (NOSTD) option as well as turn off the flaring option in AERSCREEN/AERMOD as these are already accounted for in the AER non-routine flaring tool.

Incinerators should also be designed in conformance with the most current guidelines and standards recommended by AEP or the Alberta Energy Regulator (AER), as appropriate. Incinerator stacks can be modelled with emission parameters based on actual source measurements or detailed engineering design estimates. In circumstances where the incinerator stack emission parameters are not known, pseudo parameters derived by

AER provided tools may be used. If pseudo parameters are utilized, ensure the appropriate estimated stack exit temperature (as derived by the AER provided tools) meets design and regulatory requirements.

Note: Flares and incinerators must be modelled as per the purpose to which they will be used. For example, if a flare stack designated for use in non-routine operations is also used as a continuous flare then the impact of both flaring modes must be clearly demonstrated in the assessment (See Section 4.2).

4.6 Non-vertical Releases and Stacks with Rain Caps

Model non-vertical releases and stacks with caps using the appropriate options provided in AERSCREEN, AERMOD and CALPUFF.

If there are horizontal stacks or rain caps on a point source stack, there is effectively no vertical velocity of the effluent although the plume may still rise due to buoyancy if the effluent is warmer than the ambient air. In the case of a rain cap, the exit velocity may even be negative (i.e., downward oriented) and the plume will start to rise from a lower point than the actual stack exit.

4.7 Local Buildings and Downwash

To take account of local building effects, models generally require information related to the dimensions and location of the structures with respect to the stack. If the stack is located on the top of a building, or adjacent to a tall building, it may be necessary to consider the size of these buildings. As a general guide, building downwash problems may occur if the height of the top of the stack is less than 2 ½ times the height of the building upon which it sits. It may be necessary to consider adjacent buildings if they are within a distance of 5 times the lesser of the width or peak height from the stack (5L). This distance is commonly referred to as the building's *region of influence*. If the source is located near more than one building, assess each building and stack configuration separately. If a building's projected width is used to determine 5L, determine the *apparent width* of the building. The apparent width is the width as seen from the source looking towards either the wind direction or the direction of interest. The stack height calculation does not dictate a minimum stack height; it determines whether building sizes need to be considered to account for possible building downwash conditions.

For example, the models require the apparent building widths (and heights) for every 10 degrees of azimuth around each source. Due to the complexity of building downwash guidance, the U.S. EPA has developed a computer program for calculating downwash parameters. The U.S. EPA Building Profile Input Program (BPIP) is designed to calculate building heights (BH's) and the *apparent width* (U.S. EPA 1995b), and it is available from the U.S. EPA SCRAM web site. Building downwash should not be analyzed for area or volume sources.

The Plume Rise Model Enhancement (PRIME) algorithm that is integrated into AERMOD and CALPUFF is the preferred method used in the models to account for building downwash. AERSCREEN also uses all the advantages of the PRIME algorithm and uses BPIP to calculate building information to run the model. However, it is also known that PRIME was developed using a limited set of building profiles that can lead to unreasonable estimates of ground level concentrations under certain circumstances. This is an ongoing area of research and it is expected this will be corrected by the U.S. EPA in the near future.

In the interim, if modelling is conducted using PRIME and high downwash values are predicted that the proponent judges to be excessive there are several options available to them:

1. The proponent may use the ISCST3 downwash algorithm if either of the following conditions are met (Schulman and Scire 2012):

   Wide Buildings: Width > 4 x Height of Good Engineering Practice (GEP) stack
   or
   Long Buildings: Length > 4 x Height of Good Engineering Practice (GEP) stack

   Use of the ISCST3 algorithm (not the ISCST3 model) under these circumstances does not constitute the use of an alternate model but its use must be noted in the assessment.

2. The proponent may use either ORD (Monbureau et al. 2018) or PRIME 2/AWMA (Petersen et al. 2017, Petersen and Guerra 2018) alpha options as described under AERMOD system. Use of these downwash options would constitute an alternate model and must follow the protocol defined in Section 3.3. Note: If U.S EPA accepts either of these options as a beta or regulatory option then this option may be used without the additional requirements for using alternate models.

Note: Building downwash should not be applied to area, volume or line sources.

4.8 Primary Particulate Emissions

Primary particulates can be emitted from a variety of sources including point sources (stacks), volume sources (piles) and line sources (roads). To determine the particle size distribution use actual measured data if available, otherwise use the manufacturer's specifications or emission factors. To determine the aerodynamic profiling by mass use the following (Lawrence 2012):

Let $PM_{2.5}$ (mass) = (P1 + P2 + P3 +P4) (mass) with
P1 (mean particle diameter) = 0.625 μm
P2 (mean particle diameter) = 0.875 μm
P3 (mean particle diameter) = 1.125 μm
P4 (mean particle diameter) = 1.875 μm

Let PM10 (mass) = $PM_{2.5}$ (mass) + (P5 + P6) (mass) with
P5 (mean particle diameter) = 4.25 μm
P6 (mean particle diameter) = 8 μm

Let > PM10 (mass) = P10 (mass) + P7 (mass) with
> PM10 (mean particle radius) = 20 μm

Details on how to apply this to TSP reported from a stack survey is provided below.

4.8.1 Primary Particulate Emission from Stack Surveys

Stack surveys will typically report the total suspended particulate (TSP) in the effluent stream. TSP may be comprised of fine particulate matter smaller than 2.5 μm (≤ $PM_{2.5}$), coarser matter smaller than 10 μm (≤ PM_{10}) or coarser matter still (> PM_{10}). In order to properly model the impact of particulate (both $PM_{2.5}$ and TSP) it is necessary to first determine the particle size distribution (≤ $PM_{2.5}$, ≤ PM_{10}, > PM_{10}) and then the aerodynamic properties of the particles for the source.

Example: Create the appropriate input to model TSP and $PM_{2.5}$ from a pulp and paper source that is emitting 10 g/s of TSP. In Alberta's Annual Emissions Inventory Report Standard and Guidance Document (AEP 2018, or as amended) a pulp and paper source has ($PM_{2.5}$/TSP) = 0.560 and (PM_{10}/TSP) = 0.737 (recall that PM_{10} is cumulative and includes the $PM_{2.5}$ mass fraction).

AERMOD Solution:

To set up AERMOD it is necessary to first define the mass fraction. For this problem a table of input values for particulate modelling is as follows:

PM Species	Mean Particle Diameter (µm)	Mass Fraction*	Particle Density (g/cm^3)	Mass Emission Rate (g/s)
P1 ($PM_{2.5}$)	0.625	0.1400	1	1.400
P2 ($PM_{2.5}$)	0.875	0.1400	1	1.400
P3 ($PM_{2.5}$)	1.125	0.1400	1	1.400
P4 ($PM_{2.5}$)	1.875	0.1400	1	1.400
P5 (PM_{10})	4.250	0.0885	1	0.885
P6 (PM_{10})	8.000	0.0885	1	0.885
P7 ($PM_{>10}$)	20.000	0.2630	1	2.630

* The mass fraction is assumed to be distributed uniformly amongst the different diameter bins associated with a particular PM species.

CALPUFF Solution:

The CALPUFF modelling system also models TSP in analogous way to AERMOD with an initial distribution PM species (P1, P2, etc.) by mass that is summed at each receptor using POSTUTIL or other appropriate tool. For this problem, the input table for TSP would be:

PM Species	Size Range (µm)*	Mean Diameter (□m)	Geometric sigma**	Associated Mass Bin		
				PM2.5	PM10	> PM10
P1 ($PM_{2.5}$)	0.50 - 0.75	0.625	0.000	X	X	X
P2 ($PM_{2.5}$)	0.75 – 1.00	0.875	0.000	X	X	X
P3 ($PM_{2.5}$)	1.00 – 1.25	1.125	0.000	X	X	X
P4 ($PM_{2.5}$)	1.25 – 2.50	1.875	0.000	X	X	X
P5 (PM_{10})	2.50 – 6.00	4.250	0.000		X	X
P6 (PM_{10})	6.00 – 10.00	8.000	0.000		X	X
P7 ($PM_{>10}$)	> 10.00	20.000	0.000			X

* For information purposes only, not an input.
** The mass fraction is again assumed to be distributed uniformly amongst the different diameter bins associated with a particular PM species.

Note: Both AERMOD and CALPUFF by default assume a particle density of $1 g/cm^3$. This should not be changed unless the proponent is modelling a source where the particle density is known to be considerably denser than the default value (e.g., a hard rock mining operation). In this case, the proponent should consult the Newfoundland guidance document “Guideline for Plume Dispersion Modelling” (Lawrence 2012) to determine the appropriate change in mean particle diameter. Use of a non-default particle density value should be noted in the assessment.

4.9 Modelling TRS

If TRS (reduced species of Sulphur, e.g., H_2S, CS_2, COS, C_2H_6S, CH_4S, $C_2H_6S_2$, and others) emissions rates are measured or estimated as such these should be input into the model as TRS. If individual species of TRS are measured or estimated separately then TRS should be formed as the simple mass sum of these species as the source and then modelled as TRS. If TRS is being modelled for odour management purposes refer to Section 7.1.2 for additional guidance for calculating the appropriate sub-hourly AAAQG.

5.0 Terrain, Receptors and Modelling Domain

Dispersion models require digital elevation information, as terrain can have a significant impact on the flow of substances. It is also important to model an adequate study area to ensure the possible expanse of substance impacts are captured.

5.1 Terrain Situation

When using the regulatory meteorological data set it is recommended that the proponent use the digital elevation data used to create the meteorology. When modelling with onsite meteorology the proponent should choose the best available sources of terrain data suitable for AERMOD and/or CALPUFF from the following:

1. The digital elevation data available from the regulatory meteorological data set.

2. Natural Resources Canada's Canadian Digital Elevation Data (CDED) provides terrain data in USGS DEM type data for a 1:50,000 and a 1:250,000 scale maps (NAD83). It is available to download from the appropriate subdirectory under:

   http://ftp.geogratis.gc.ca/pub/nrcan_rncan/elevation/cdem_mnec/

   For this data note the following:

   - The 1:50,000 map scale data has a grid resolution range of 0.75 to 3 arc-seconds. For data south of 68° N latitude, the grid resolution is roughly 20 m, depending on latitude.
   - The 250,000 map scale data has a grid resolution range of 3 to 12 arc-seconds, depending on latitude. For data south of 68° N latitude, the grid resolution is roughly 90 m, depending on latitude.

3. The distribution of Provincial Digital Base Map Data to the public is provided by AltaLIS Ltd. The data can be ordered from the AltaLIS website at:

   https://www.altalis.com

   Note: The web links provided are only guaranteed to be current at time of publication of this document. If these sites are no longer available, it is the responsibility of the proponent to update this information. The proponent should always use the best information available.

5.2 Selecting Receptor Grid

The user needs to define the locations at which ground-level concentrations are to be predicted. These locations are termed 'receptor' locations. In selecting receptor locations, it is important to identify all sensitive receptors in the study area and adequately sample the receptor grid at these locations to ensure the predicted maximum ground level concentrations at these locations are properly captured. Sensitive receptors include, but are not limited to, individual residences, residential areas, schools, hospitals, fire halls, commercial day care and seniors' centres, campgrounds, parks, recreational areas and facilities, and sensitive ecosystems.

All modelling assessments should use a Cartesian receptor grid, which can be regularly or irregularly spaced. Since the number of allowed receptors is limited, they should be more densely located where maximum impacts are expected. To ensure the maximum ground level concentrations are obtained, the model should be run with the following set of receptors, at a minimum:

- 20 m receptor spacing in the general area of maximum impact and the property boundary;
- 50 m receptor spacing within 0.5 km from the source;
- 250 m receptor spacing within 2 km from the sources of interest;
- 500 m spacing within 5 km from the sources of interest, and
- 1000 m spacing beyond 5 km.

For each scenario in the assessment it is suggested the model be run at least twice. Firstly, with a coarse grid to determine the areas of high impact and/or concern. Secondly, with the finer grid in the vicinity of the impacted area to obtain the maximums. Additional modelling may be required if there is a need to further refine the ground level predictions. Only the scenarios with the final receptor configuration, not the intermediate receptor configurations, need to be included in the assessment.

In areas with many industrial sources, or for large buoyant sources (100 m tall stacks, high exit temperature), a larger 250 m grid, and a coarse grid out to a distance of 20 km may be necessary to find the area of maximum impacts. In some cases, an even larger grid may be necessary.

The model domain for any assessment should not exceed the limitations of the model. If it is necessary to model at points beyond the model limitations, the results should be interpreted with extreme caution.

Note: The only allowed exception to the 20 m receptor spacing rule at the property boundary is for very large area sources, i.e., the project boundary perimeter is larger than 50 km, where sampling at this rate will require excessive computing resources. If there are any sensitive receptors near the boundary affected by waiving the 20 m receptor spacing requirement then the requirement for high resolution sampling around the sensitive receptor takes precedence. All other receptor spacing rules still apply.

5.3 Facility Boundary

Models are typically used to predict ambient concentrations for comparison with the Alberta Ambient Air Quality Objectives (AAAQOs) or Alberta Ambient Air Quality Guidelines (AAAQGs). The areas of applicability of the AAAQOs and AAAQGs are not simply defined by the facility boundary but must take into account areas beyond the facility boundary where it is reasonable to expect public access. The facility boundary is determined by the facility fence line and/or the perimeter of disturbed area that defines where public access is normally restricted. As an example, if a public access road passes through the facility, the facility boundary along this feature is defined by the road allowance.

5.4 Modelling Domain

The modelling domain must encompass the project impacts on the surrounding environment in a cumulative manner. The modelling domain must:

1. Include all predicted ground-level concentrations of substances from the project at or above 10% of their respective AAAQO. Be sure to include this contour on all isopleth plots of predictions. When modelling more than one substance ensure the modelling domain is based on the most spatially extensive AAAQO predictions.

2. The project facility should be in the centre of the study area, if deviation is required contact the Director prior to modelling commencement.

3. Ensure that the assessment takes into account all industrial sources within the modelling domain. If there are other industrial sources outside of the modelling domain that will contribute to the modelled ground level concentration of substances from the project then the modelling domain must be expanded to include the additional source(s). See Section 5.4.1 for additional details.

4. A representative baseline value must always be added to all predicted concentrations for all assessment scenarios for all averaging periods. See Section 7.2 for guidance on creating appropriate baselines.

5.4.1 Cumulative Effects Assessment of Nearby Sources

All industrial emission sources within 5 km of the project boundary must be included in the modelling assessment. In cases where there are additional industrial sources outside of this 5 km catchment that are contributing (additively) to the ground level concentrations of substances from the project under assessment these additional sources must also be included in the emissions inventory and modelling assessment. Determination of which sources outside of this 5 km catchment may be impacting a project can be made using professional judgment

and/or after consultation with the Director. Particular care should be taken to include all relevant sources in industrialized regions, e.g., the Industrial Heartland, to ensure a realistic assessment of the cumulative impacts are presented. Failure to do so may require additional modelling to complete the cumulative effects assessment.

When conducting a cumulative assessment emission estimates for non-project industrial emissions should be based on the following in order of preference:

1. Approval limits;
2. Alberta's Annual Emissions Inventory Report data;
3. Manufacturer's emission data;
4. Emission factors, or
5. If none of the aforementioned values are available emissions can be estimated by any method authorized by the department such as manual stack surveys or continuous emission monitoring.

It is the responsibility of the project proponent to obtain the best available representative emissions data from non-project industrial sources.

6.0 Meteorological Input Data

AERSCREEN is able to generate a site-specific worst-case meteorological data set, the input of meteorological data is not required into the AERSCREEN model.

For refined or advanced assessments more representative meteorological data, both temporally and spatially, for the modelling domain should be used. Meteorological data can come from two sources: ground meteorology or modelled meteorology (or a combination of the two) depending upon the application. Within this context, AEP allows the following:

1. Applications for which there is on-site (within facility boundary, not modelled) meteorology available, that is judged to be representative of the modelling domain, may use the on-site meteorology in an air quality modelling assessment provided it meets the following criteria:

   There is a minimum of one year of hourly on-site meteorology available. On-site meteorology must be related to the longer term (seasonal or annual) meteorology by statistical methods. Relating on-site meteorology to data from climate or meteorological stations having longer collection periods ensures that on-site data are temporally representative of meteorology for the entire modelling domain. An on-site meteorological data set should not be used if fewer than 90% of the annual data are available. When missing data values arise, they should be handled in one of the ways listed below (U.S. EPA 2000), in the following order of preference:

   a. If there are other on-site data, e.g., temperature measurements at another height, they may be used when the primary data are missing and corrections based on established vertical profiles should be made. Site-specific vertical profiles based on historical on-site data may also be appropriate to use after consultation with AEP.

   b. If there are only one or two missing hours, linear interpolation of missing data may be acceptable. Caution should be exercised when the missing hour(s) occur(s) during day/night transition periods.

   c. If representative off-site data exist, they may be used, only for missing data values. In many cases, this approach is acceptable for cloud cover, ceiling height, mixing height, and temperature. An assessment to determine whether this data is adequately representative will involve an examination of the surrounding terrain, surface characteristics, and the height of the source versus the height of the measurements. Meteorological data should be considered representative only when the monitoring site and the facility site are in climatologically similar regimes (U.S. EPA 2000).

The upper air sounding data should be taken from the most representative or closest upper air monitoring station or the current AEP meteorological data set (provided the AEP data and on-site data temporally coincide) available on the AEP website:

https://www.alberta.ca/meteorological-data-for-dispersion-models.aspx

2. For all other applications, five years of modelling must be undertaken with data taken from the AEP meteorological data set serving as the basic meteorological data set to be used (in CALPUFF applications this would be the initial guess field) to be supplemented by ground based meteorology, where appropriate. In summary:

   a. The AEP meteorological data set supplemented with meteorology from all readily available (publically accessible) ground meteorology within the modelling domain whose meteorology temporally coincides with the five years provided in the AEP data set. Missing meteorological data from these stations should be treated as per the instructions for similarly treating missing data for on-site meteorology (outlined above). Complete information on which stations were used and the extent to which any of their data were treated must be provided as part of the assessment process.

   b. When there are no available ground meteorology in the modelling domain, or the ground meteorology does not temporally coincide with the AEP meteorological data set, or the ground meteorology is incomplete then the AEP meteorological data set should be used by itself.

No other meteorological data sets are acceptable for regulatory dispersion modelling assessments.

6.1 Surface Characteristics

Surface characteristics determine the degree of ground turbulence caused by the passage of winds across surface structures.

For AERMOD assessments, the following method is to be used for selecting the rural or urban surface roughness categories. A listing of recommended default surface characteristics (Surface Roughness Length, Albedo, Bowen Ration) by season for Alberta is provided in Appendix E. If in the professional opinion of the proponent different values should be used an explanation as to why this is the case and the values used must be included in the assessment.

The USEPA's AERSURFACE (U.S. EPA 2020) creates realistic surface characteristic data for input into regulatory models. The present tool relies on NLCD products created by the Multi-Resolution Land Characteristics Consortium (https://www.mrlc.gov/) in partnership with the USGS. Tables E 1 through E 3 are AEP's recommended settings for Alberta based on the most recent version of AERSURFACE (U.S. EPA 2020) and the most recent Canadian land coverage data, 2015 Land Use Cover of Canada (https://open.canada.ca/data/en/dataset/4e615eae-b90c-420b-adee-2ca35896caf6). When determining surface characteristics the order of preference is:

1. The land use data used to create the regulatory meteorological data set.

2. If in the professional opinion of the proponent they can develop more realistic surface characteristics using AERSURFACE as per the *AERMOD Implementation Guide* (U.S. EPA 2008) they may do so provided justification in writing is provided as part of their assessment.

Note: When using AERSURFACE or similar tool it is preferred that the land use within a 3-km radius of the source is classified rather than the default 1 km. If more than 50% of the land use falls within the following categories—heavy or light industrial, commercial, and compact residential (two-story dwellings, limited lawn sizes)—it is considered to be urban. For all other locations, except forests, use the rural coefficients of surface roughness. Forests should be treated as urban locations when determining their surface roughness.

Note: When modelling includes flaring the proponent may use the AER non-routine flaring tool to generate these land use values for flare modelling.

For CALPUFF modelling CALMET surface characteristics are determined by the terrain data input into the model. CALMET surface characteristics should be mapped in to the surface characteristics provided in Appendix E.

7.0 Model Output and Post Analysis

Model output is to be submitted to the director for review and acceptance as part of the modelling assessment. The recommended information should include sufficient information such as all tables of maximum predicted concentrations, figures (i.e., concentration isopleths), charts, input/output model control files, and all other specified information necessary to complete the assessment. Appendix A and Appendix B provide a listing of the required documentation to be included in an assessment. Under certain circumstances, e.g., a very complex assessment, the Director may require additional reporting.

In particular, the model output should be sufficient to:

1. Demonstrate the objectives of the assessment have been met;

2. Clearly explain the methodology employed and other supporting information to prove that the model has been applied properly; and

3. Ensure the model output can be used effectively and efficiently to inform the Director.

It is crucial that the submitted documentation includes sufficient detail so the reviewer can understand the assumptions and steps involved in the assessment. Failure to do so will certainly delay the processing time and may result in the assessment being rejected.

7.1 Model Outputs

7.1.1 Calculation of Hourly and Super-hourly Values for Comparison to AAAQOs and AAAQGs

The input to dispersion models consists essentially of emissions and meteorological data. The output from dispersion models consists of concentration values or deposition values. Predicted concentrations are expressed as micrograms per cubic metre ($\mu g/m^3$) of air while deposition rates should be expressed in kilograms per square metre (kg/m^2). Concentrations of gases may also be expressed as the ratio of the volume of the substance to the volume of air. In this case, concentrations are expressed as parts per million (ppm) or parts per billion (ppb). The following equation is recommended for converting the concentrations in $\mu g/m^3$ to ppm at standard conditions (T_{std} = 25°C, P_{std} = 101.325 kPa):

$$[ppm] * 40.8862 * \text{molecular weight} = [\mu g/m^3] \quad (2)$$

The concentration of a substance will vary from second to second because of turbulence in the atmosphere. For practical use, concentrations are expressed as averages over specified time periods. AAAQOs and AAAQGs are usually stated for 1-hour averages, 24-hour averages, 30 day averages and annual arithmetic averages, although other time periods are used for some substances, e.g., 30 minute averaging for odour management (See Section 7.1.2)

Predicted concentrations at ground level can be high due to extreme, rare, and transient meteorological conditions and can be considered outliers. Therefore, hourly values above the 99.9th percentile for each receptor in each year can be disregarded. For example, the highest eight 1-hour predicted average concentrations for each receptor in each single year should be disregarded. For all super-hourly averaging periods (averaging periods longer than one hour) the eight highest hourly predicted concentrations that were disregarded for the 1-hour averaging period must be included when calculating the 99.9th percentile value. From the complete hourly data set for each year 8-hour averaging would remove only the top 8-hour average, 24-hour averaging and averaging periods longer would not remove any averaged concentrations.

If a substance of concern does not have an associated AAAQO or AAAQG value, the lesser of Ontario Ambient Air Quality Criteria (Ontario, 2020, as amended), British Columbia Air Quality Objectives and Standards (British Columbia, 2020, as amended) or Texas Commission of Environmental Quality Effects Screening Levels (Texas, 2016, as amended) concentrations should be used. If neither Ontario, British Columbia nor Texas has a value for

the substance of concern, consult with AEP to determine the appropriate course of action before modelling is commenced.

If maximum predicted concentrations exceed an AAAQO in an assessment, the applicant must contact the Director to discuss the next steps to address the predicted exceedances. The same approach is required for any AAAQG the Director requires to be included in the assessment).

Further direction on the necessary actions required to meet AAAQOs is contained in "*Using Ambient Air Quality Objectives in Industrial Plume Dispersion Modelling and Individual Industrial Site Monitoring"* (AEP 2013, or as amended).

7.1.2 Calculation of Sub-hourly Values for Comparison to AAAQOs or AAAQGs

Air quality models usually consider hourly averaging periods as the minimum averaging period of concern. Hence, the use of hourly meteorological data for determining AAAQOs and AAAQGs is a standard practice. In cases where it is necessary to calculate a sub-hourly AAAQO or AAAQG based on hourly data the appropriate scaling factor must be used. For air quality modelling assessments this can be assumed to be (Ontario 2016):

$$C_{sub\text{-}hour} = C_{hour} \times (\text{sub-hourly time/hour})^{-0.28} \quad (3)$$

For example, for a 30-minute AAAQO or AAAQG, the modelled hourly value is multiplied by a factor of 1.21 to determine the 30-minute value.

When assessing sub-hourly AAAQOs or AAAQGs for odour management, e.g., odourant 'A', it is acceptable to eliminate the top 43 values (99.5% tolerance per 8760 independent hourly values per year at each receptor). Do not apply the tolerance allowed for infrequent events (See Section 4).

Note: If one year of on-site sub-hourly meteorology is available (see Section 6) and used in an odour assessment the 99.5% tolerance should be applied to this data as is.

If a sub-hourly AAAQO or AAAQG for a substance is required for a particular assessment other than for odour management then the standard 99.9% tolerance should be applied.

7.2 Baseline Concentrations

Baseline air quality includes substances from anthropogenic and biogenic sources that are not directly included in the dispersion model. The correct choice of a representative baseline value requires considerable professional judgement. When selecting the appropriate ambient monitoring station to use to derive the baseline values it is important to consider the nature of the missing emissions that will be represented by the baseline values and the similarity of baseline monitor location to the project, i.e., similar topography, climate normals and air quality regime.

For example, if a modelling assessment is conducted for a project in a heavily industrialized area and the modelling domain is quite extensive then a monitoring station that operates under similar climatological conditions that also captures similar traffic and residential/commercial heating emissions as well as biogenic emissions in the area but not industrial emissions would be an appropriate choice. On the other hand, for an assessment in a relatively pristine area where all of the relevant industrial emissions associated with the project are included then the choice of a monitoring station from a small rural community under similar meteorological conditions would be appropriate.

When conducting a screening or refined assessment, the baseline value for the same substance must be added to the predicted value before a comparison to the AAAQO is made. Assessing the effects of the baseline component becomes more complex when short-term objectives (1-hour, 24-hour averages) are being considered.

The following method should be used to determine a baseline concentration:

1. All monitoring data should be subjected to validation and quality control to ensure its accuracy. Hourly, continuous ambient monitoring data is preferred over passive monitoring data where available.

2. The most recent three years of hourly ambient data should be averaged to form a baseline provided each year is at least 75% complete. If more than 25% of the hourly ambient data is missing (blanks) from a given year then it is acceptable to use the next most recent year of ambient data, provided it meets the 75% completeness criteria. Some additional considerations to the selection of the appropriate ambient data include:

    a. If less than three years of hourly ambient data is available then average over the available data provided at least one complete year of data is available. If one complete year of data is not available then the monitoring station cannot be used to construct a baseline.

    b. If an analyzer is changed during the period being used to construct a baseline the statistics of the monitoring data may change. This can be checked by visually comparing the mean and variance of monitoring data before and after the analyzer change. A noticeable step change in the mean value and/or a noticeable increase in the variance suggests the monitoring data statistics are different and the data from the two analyzers should not be combined. If there is a noticeable difference in analyzer performance and there is not sufficient data to form a baseline with the current analyzer (at least one full year) then a different station must be used to form the baseline.

3. Screening assessments for all averaging periods should be based on average of the reduced hourly data set for each year, i.e., the top hourly values above the 99.9th percentile non-blank ambient baseline data are removed. Do not include blank data as zero values when determining the 99.9th percentile. For all averaging periods greater than one hour, the maximum calculated average for each averaging period, to be used as the baseline value for modelling purposes, must then be based on the reduced hourly ambient data sets. No further removal of maximum values for other averaging time periods is allowed.

4. Refined and advanced assessments should be calculated in a similar manner as the screening assessment but now based on a 90% percentile. This allows for some variability in the baseline due to anthropogenic or unusual local sources.

Example. Suppose a screening assessment must consider a substance with an hourly and 24-hour AAAQO. The available monitoring for the three most current years of a substance have a completeness of 93% of hourly values for the most recent year, a completeness rate of 97% for hourly values for the second most recent year and a completeness rate of 83% for hourly values for the third most recent year. The relevant baseline values for this scenario would then be:

1. Hourly baseline value: For the most recent (non-leap) year, there would be 8146 non-blank hourly values available to construct a baseline, 8497 non-blank hourly values from the second most recent (non-leap) year and 7270 non-blank hourly values from the third (non-leap) year. From these data sets, the 99.9% value would be the 9th highest hourly value for the most two most recent years and 8th highest hourly value for the third year. The baseline hourly value to be used in the assessment would then be average of these 99.9% hourly values.

2. 24-hour baseline value: In forming the 24-hour baseline value for the assessment the top 99.9% hourly values that had been excluded when determining the hourly baseline value should be set to blank. Hence, the most recent year would have a reduced data set of 8137 non-blank hourly values. Similarly, the second and third most recent years would have 8488 and 7262 non-blank hourly values. All 24-hour averages for each year must then be calculated using the reduced data set with the blank values in place as they occur. Once this is determined then each year's 24-hour averages may then be ranked separately with the 24-hour average baseline for the assessment being the average of the top ranked 24-hour average from each year.

Note: Modelling assessments that include TSP also require a TSP baseline value to be added to the modelling results. Monitoring of TSP in Alberta is not normally available so TSP baseline values should be derived from the most representative available PM_{10} monitoring data after scaling by a factor of two (doubled) (Brook et al. 1997). If suitable TSP monitoring data is available it should be used to form a representative baseline rather than a PM_{10} derived baseline.

Note: For substances of concern modelled in an assessment that are not commonly monitored the proponent should apply a representative baseline value based on best available information from the literature.

7.3 Relationship between Nitrogen Oxides (NO_x) and Nitrogen Dioxide (NO_2)

Of the several species of nitrogen oxides, only NO_2 has an AAAQO. Since most sources emit uncertain ratios of these species and these ratios change further in the atmosphere due to chemical reactions, a method for determining the amount of NO_2 in the plume that takes these factors into consideration must be given. The recommended methods, described below, are implemented using the approach shown provided below. The Total Conversion Method must be presented as part of the assessment for **all** scenarios.

7.3.1 Total Conversion Method

In the conservative screening approach all NO_x emissions are assumed to be NO_2 leading to the maximum possible ground level concentration of NO_2. The results from the Total Conversion Method must be presented as part of the assessment for **all** scenarios. If the NO_2 AAAQOs are met using this method additional modelling of NO_2 provided in Sections 7.3.2, 7.3.3 and 7.3.4 are not necessary.

7.3.2 Ambient Ratio Method (ARM/ARM2)

The ambient ratio method (ARM) is based upon the premise that the NO_2/NO_x ratio in a plume changes as it is transported but attains an equilibrium value some distance away from the source. However, in most cases monitors being placed in the correct location and distance to correctly determine the equilibrium NO_2/NO_x ratio would be fortuitous at best. The ARM method is not intended to be used with local NO_2/NO_x ratios. With this limitation in mind the use of the ARM method must use the following protocol, in order of preference:

1. If there are monitors located between 15 km and 80 km downwind and within the general direction (± 22.5º) of the maximum impact, then the average annual NO_2/NO_x for the most recent year derived from all relevant monitors should be used (OLM/ARM Workgroup – Draft Recommendations 1998).

2. If there are no suitable monitors available then a NO_2/NO_x value of 0.70 may be used for all averaging periods. This represents the average NO_2/NO_x for Alberta for the period 2000 – 2010 for all permanent monitoring stations with at least three years of data.

The ARM2 method is an extension of the ARM method based upon the statistics of the ratio of NO_2/NO_x derived from many ambient monitoring stations (Podrez 2015)[3]. The US EPA recognized there were some restrictions in its use to ensure it was as conservative as more established US EPA Tier 3 methods, e.g., OLM and PVMRM (Owen and Brode 2014). In Alberta these restrictions are applied as follows (IDNR 2020):

1. If the Total Conversion Method's predicted maximum NO_2 ground level concentration for the project sources alone (without non-project sources or background added) are ≤ 200 ppb then use ARM2 with a minimum ARM2 NO_2/NO_x = 0.2 and maximum ARM2 NO_2/NO_x = 0.9 for both project and non-project sources.

2. If the Total Conversion Method's predicted maximum NO_2 concentrations for the project sources alone (without non-project sources or background added) are > 200 ppb then use ARM2 with the modification based on the NO_2/NO_x in-stack ratio (ISR) for the project sources as follows:

    a. If all of the project source ISRs ≤ 0.2 then three options are available:

        i. Use ARM2 with a minimum NO_2/NO_x = 0.2 and maximum NO_2/NO_x = 0.9 for all project and non-project sources.
        Note: This approach is expected to be adequate for most modelling assessments for these sources using ARM2.

3 For completeness: The polynomial defining the ARM2 ratio for AERMOD (v19191) is: $(-1.1723e^{-17})x(NO_x)^6 + (4.2795e^{-14})x(NO_x)^5 + (-5.8345e^{-11})x(NO_x)^4 + (3.4555e^{-8})x(NO_x)^3 + (-5.6062e^{-6})x(NO_x)^2 + (-2.7383e^{-3})x(NO_x) + 1.2441$ where NO_x is the predicted ground level concentration in $\mu g/m^3$. Note that the upper and lower bounds of this conversion are defined by the minimum and maximum NO_2/NO_x ratio as defined within the assessment.

ii. Use ARM2 with the minimum NO_2/NOx equal to the maximum project source ISR and a maximum $NO_2/NO_x = 0.9$ for all project sources. Set a minimum $NO_2/NOx = 0.2$ and maximum $NO_2/NO_x = 0.9$ for all non-project sources.

iii. Use ARM2 with the minimum NO_2/NO_x for each project source set equal to each project source ISR, and a maximum $NO_2/NO_x = 0.9$ for all project sources. Set a minimum $NO_2/NOx = 0.2$ and maximum $NO_2/NO_x = 0.9$ for all non-project sources.

b. If any of the project source ISR > 0.2 then two options are available:

i. Use ARM2 with the minimum NO_2/NOx equal to the maximum project source ISR and a maximum $NO_2/NO_x = 0.9$ for all project sources. Set a minimum $NO_2/NOx = 0.2$ and maximum $NO_2/NO_x = 0.9$ for all non-project sources.

ii. Use ARM2 with the minimum NO_2/NOx for each project source set equal to its own ISR, and a maximum $NO_2/NO_x = 0.9$ for all project sources. Set a minimum $NO_2/NO_x = 0.2$ and maximum $NO_2/NO_x = 0.9$ for all non-project sources.

Determination of the ISR for all project sources should represent typical operating conditions and should be made in the following order of preference:

1. From direct stack testing, provided the testing is representative of normal operating conditions, when available (for existing sources).

2. Source manufacturer's test data (which must be included in the assessment report).

3. From the literature. One listing of ISRs for some source types can be found at:

   https://www.epa.gov/scram/nitrogen-dioxidenitrogen-oxide-stack-ratio-isr-database

   Note: Sources with negative ISRs should not be used.

4. When no representative ISR value can be assigned for a project source then assume a value of 0.2.

Note: For all assessments that make use of the ISR in their NO_2 modelling, regardless of method, a complete listing of project source ISRs and justification for their use must be included in the assessment. Failure to use realistic ISRs may lead to the requirement of additional modelling to confirm the assessment results.

7.3.3 Plume Volume Molar Ratio Method (PVMRM) in AERMOD

The PVMRM approach (in AERMOD) limits the conversion of NO_x to NO_2 based on the amount of ozone available within the volume of the plume as well as the initial ISRs of the sources contributing to the emitted plume. The PVMRM approach also incorporates a technique for merging plumes and calculating the resultant plume volume from multiple sources for purposes of calculating the resultant ambient NO_2/NO_x ratios (Hanrahan 1999 a, b, Alaska Department of Environmental Conservation 2005).

PVMRM has strengths and weaknesses when considering its suitability to air quality modelling applications (US EPA 2014). In particular:

- PVMRM is recommended for relatively isolated, elevated sources.

- PVMRM is not recommended when a significant amount of the emissions (say > 50% by mass) from project sources may not be properly modelled with the PVMRM algorithm, i.e., they are area or line sources, near surface releases, or groups of sources that are in close proximity to each other. Note: Merging of similar stack sources is allowed (See Section 4.3) before PVMRM is applied.

When using the PVMRM the following defaults are recommended:

1. For baseline O_3, it is preferred to use an onsite time-series of hourly O_3 concentrations that match the meteorology being employed, if available. In the absence of such data use one of the hourly O_3 time-series provided in Appendix E as appropriate (urban if the project is within an urban setting, otherwise rural).

2. The default equilibrium ratio of NO_2/NO_x used in the AERMOD-PVMRM model is 0.90. This represents the long-range NO_2/NO_x equilibrium.

3. The determination of the default ISRs is critically dependent on the in-stack ratios for all project sources. To determine the appropriate values of the project (and non-project) source ISRs follow the logic for selecting minimum NO_2/NO_x ratios (to be set to the default ISRs) and equilibrium NO_2/NO_x values specified for the ARM2 method (see Section 7.3.2).

Note: PVMRM2 is not available at this time as a refined model but may be proposed and assessed as an alternate model.

Note: When using PVMRM using the Source Groups option is acceptable to simplify the source grouping but do not use the PSD Group option.

7.3.4 Ozone Limiting Method (OLM)

Use of onsite hourly O_3 data, where available, is always preferred for the OLM. In the absence of such data use one of the hourly ambient O_3 time-series provided in Appendix E as appropriate (urban if the project is within an urban setting, otherwise rural).

The OLM estimates the NO_2 ground level concentration by considering the available ambient O_3 that can titrate NO to NO_2, as well as the thermal NO_2 produced at the stack (as measured by the stack ISR). The OLM is applied via the following equation (Cole and Summerhays 1979; Owen and Brode 2014):

For each model receptor, for each hour, determine the predicted ground level concentrations of $NO_{2,\text{predicted hourly}}$ from N sources (n project sources and (N – n) non-project sources) as follows:

If

$$[O_3]_{ambient\ hourly} > \sum_{i=1}^{N}(1 - ISR_i) * [NO_x]_{predicted\ hourly,i} \quad (4a)$$

then

$$\sum_{i=1}^{N}[NO_2]_{predicted\ hourly,i} = \sum_{i=1}^{N}[NO_x]_{predicted\ hourly,i}. \quad (4b)$$

Equation (4b) simply states the conservative assumption that at any receptor any NO_x not converted into NO_2 at the source by the thermal process will be converted into NO_2 in the presence of sufficient O_3, as determined by Equation (4a).

When this condition is not met at a receptor then the determination of $NO_{2,\text{predicted hourly}}$ is more complicated and has to take into account the amount NO_2 produced by titration with ambient O_3 as well as the thermal NO_2 produced at the stack. In this case, $NO_{2,\text{predicted hourly}}$ is now given by:

$$\sum_{i=1}^{N}[NO_2]_{predicted\ hourly,i} = [O_3]_{ambient\ hourly} + \sum_{i=1}^{N} ISR_i * [NO_x]_{predicted\ hourly,i}, \quad (4c)$$

which can be further broken down into project and non-project source contributions:

$$\sum_{i=1}^{N}[NO_2]_{predicted\ hourly,i} = [O_3]_{ambient\ hourly} + \sum_{i=1}^{n} ISR_i * [NO_x]_{predicted\ hourly\ project\ sources,i} +$$

$$\sum_{i=N-n}^{N} ISR_i * [NO_x]_{predicted\ hourly\ non-project\ sources,i}. \quad (4d)$$

Selection of the appropriate ISRs for the OLM should follow the same procedure as outlined for the ARM2 method (see Section 7.3.2).

The OLM method is preferred for assessments where the PVMRM method may not be appropriate (Owen and Brode 2014).

Note: Use the OLMGROUP option in AERMOD when using OLM to simplify specifying individual groups where appropriate.

Using OLM:

Example 1: In this scenario the project has five sources, all have an ISR ≤ 0.2 so their ISRs were set to 0.2. All of the non-project sources are set to have an ISR = 0.2. A first modelling assessment using these defaults exceeded the NO_2 AAAQO. Additional modelling is required. In a second assessment, the maximum ISR for the project sources (in this case, say a maximum project source ISR of 0.08 was determined) was conservatively used for all project sources. All non-project sources used the default ISR value (0.2). The second assessment passed all NO_2 AAAQOs.

Example 2: This scenario is identical to example 1 but a review of the assessment suggested many of the non-project sources were contributing to the exceedances. Further investigation of the non-project sources determined the maximum ISR for non-project sources was 0.07. Modelling in this case was repeated assuming, conservatively, all non-project sources have an ISR = 0.07 and project sources have an ISR = 0.2 but again the assessment did not meet an NO_2 AAAQO. In this case, if the proponent wishes to continue using OLM they will have to consider the contribution from each non-project source separately using the individual ISRs.

7.3.5 Treatment of NO_2/NO_x Conversion in CALPUFF

For regulatory applications that do not require a determination of the effects of acid deposition the chemistry option in CALPUFF should be turned off. When modelling in the no chemistry mode Total Conversion, ARM and ARM2 methods are directly available for modelling ground level NO_2 concentrations via post processing (CALPOST and POSTUTIL) and should be applied in the manner described above (See Sections 7.3.1 and 7.3.2). When using these methods all NO_x emissions must be entered as NO_x (NO_2 should not be included in the input parameter list).

OLM cannot be directly applied in CALPUFF but can be derived by the appropriate post-processing of the CALPUFF output file (CALPUFF.LST). To implement OLM in CALPUFF NO_x emissions from each source must be first broken into NO and thermal NO_2 using the appropriate ISR using the guidance provided in for the ARM2 method (see Section 7.3.2). Upon completion of the modelling the OLM (Section 7.3.4, Equation (4a-d)) can be applied at each receptor for each hour for all sources to determine the sum of the thermal NO_2 and titrated NO_2.

PVMRM is not available in CALPUFF.

When a wet and dry acid deposition assessment or secondary particulate matter assessment is required as well as an air quality assessment CALPUFF modelling must be undertaken twice. The air quality assessment must be undertaken using CALPUFF in the no chemistry mode as per the guidance provided above. Details on the settings for acid deposition and secondary particulate matter modelling are provided in Section 8.

8.0 Regional Modelling

In rare circumstances regional modelling may be conducted in support of an Environmental Impact Assessment (EIA) or upon request by the Director. More commonly, regional modelling is undertaken to support regional environmental management initiatives or research studies.

8.1 Acid Deposition

Acid deposition takes into account the net effects of acidifying species on soil in conjunction with buffering that may occur due to the deposition of base cations and natural soil processes. Facilities emitting SO_2, NO_x or NH_3 and requiring an EIA must conduct an acid deposition modelling assessment. Facilities (new approved, amending, renewing) within an acid deposition management zone (ADMZ), as identified under Alberta's Acid Deposition Management Framework - ADMF (AEP 2008, or as amended) should complete an acid deposition modelling assessment if:

- The facility's new approved/increased emissions of SO_2, NO_x, and NH_3 are greater than 0.175 tonnes/day [t/d] of total H^+ equivalent given by:

$$Total\ H^+ + \ equivalent\ [t/d] = 2 * \left(\frac{SO_2\ [t/d]}{64}\right) + \left(\frac{NO_x [t/d]}{46}\right) + \left(\frac{NH_3 [t/d]}{17}\right) \qquad (5)$$

- Required by the Director (if local monitoring assessments or other assessments indicate a cause for concern, etc.)

The method for determining an exceedance of this equilibrium by acidifying deposition (critical load) can be found in the ADMF (AEP 2008, or as amended). Proponents are advised to consult this document when they have sources with significant SO_2 or NO_x emissions. The document may be found here:

https://www.alberta.ca/acid-deposition.aspx

For regional acid deposition modelling, CALPUFF, or any other acid deposition model recommended by AEP for this purpose (not AERMOD), may be used. When undertaking acid deposition assessments the appropriate chemical transformation mechanism must be selected to ensure all required acidifying species are included, e.g., SO_2, SO_4^{2-}, NH_3, NO_3^-, HNO_3, NO_2 as well as total N and S and other species as required, in the appropriate gas/particulate mode.

8.1.1 Calculating Acid Deposition Using CALPUFF

When using CALPUFF for acid deposition assessment modelling should be undertaken using the RIVAD / ISORROPIA+aqueous chemical formulation (MCHEM = 6, MAQCHEM = 1, MLWC = 1). In case, the source NO_x emissions must be specified as NO and NO_2. Use the guidance for specifying these species as per the guidance provided for OLM modelling. Details on the RIVAD/ISORROPIA can be found at West Associates 2010.

When using this chemical mechanism it is preferred to use an onsite time-series of hourly O_3 concentrations that match the meteorology being employed, if available. In the absence of such data use one of the hourly O_3 time-series provided in Appendix F as appropriate (urban if the project is within an urban setting, otherwise rural).

When calculating acid deposition with CALPUFF the use of representative values of NH_3 and H_2O_2 is important. If current onsite or remote sensing NH_3 and H_2O_2 data is available they must be used, particularly in areas where there are known sources of NH_3 (e.g., agricultural operations), otherwise use the default monthly NH_3 values and hourly H_2O_2 values provided in Appendix G.

Acid deposition is a long-term effect that will vary from year to year with meteorology. Annual total acid deposition values using typical emission rates should be calculated for each receptor for each year using Alberta's regulatory five year meteorological data set. The **median** of the five annual totals at each receptor should be used as the receptor's annual acid deposition value. When comparing receptor deposition values to the critical load maps (see

the acid-deposition link above) the average of all receptor (median) values within a critical load map cell should be used to determine whether or not an exceedance occurs.

The background deposition value of acidifying species is supposed to represent the impact of background sources not included in the modelling. This can be determined in one of two ways:

a. Monitoring. If there is a suitable background monitor available that is upwind from the study area that only reports the impact of sources not included the modelling this should be set as the background. This must include at least one year of monitoring data.
b. Modelling. If no suitable monitoring is available then the proponent should model all sources, other than the project (or proposed) sources, for which it is reasonable to expect they will impact the study area and set this as the background. The final background deposition value within each critical load cell should be calculated based on Alberta's regulatory meteorological data as per the determination of the total acid deposition values mentioned above.

In all cases, the background deposition must be included in all modelling scenarios to ensure consideration of the cumulative impact of the project and surrounding sources.

Note: Deposition of neutralizing species, i.e., base cation deposition, may be applicable in areas where there is significant crustal disturbance. It is expected this component will settle to the ground near to the source but it is up to the professional judgement of the proponent to determine the appropriate deposition rate based on the best available monitoring data or from the literature. The Director may exercise their discretion in how the proponent incorporates these neutralizing species from the crustal disturbance.

8.1.2 Acid Deposition with Other Models

When not using CALPUFF for acid deposition assessments a modelling plan must be submitted to the Director before undertaking the assessment. Written permission to proceed with the assessment as specified in the plan must be obtained from the Director before undertaking the modelling assessment.

8.2 Ozone and Secondary Particulate Matter (PM)

8.2.1 Ozone Modelling

An advanced assessment or regional airshed management planning study may require ozone modelling. Normally, AEP will accept models developed or recommended by the U.S. EPA for this purpose. Examples of these models include the Models-3/Community Multiscale Air Quality (CMAQ) modelling system, the Comprehensive Air quality Model with extensions (CAMx), the Regional Modelling System for Aerosols and Deposition (REMSAD), Second-order Closure Integrated Puff (SCIPUFF), and the Variable Grid Urban Airshed Model (UAM-V) System. These models can be obtained through the U.S. EPA's Support Centre for Regulatory Atmospheric Modelling (SCRAM).

It should be noted that the preparation of input data for these models typically require significantly more effort than other model assessments. It should also be noted that modelling O_3 correctly requires a considerably larger modelling domain and emissions inventory as well as being sensitive to the choice of boundary conditions.

If air quality modelling of ozone is required by the Director a modelling plan addressing the Director's particular need must be submitted in writing to the Director before modelling commences. Written permission to proceed with the assessment as specified in the plan must be obtained from the Director before undertaking the modelling assessment.

8.2.2 Secondary Particulate Matter

Modelling secondary particulate matter is not usually required for approval applications. However, when required for regional assessments CALPUFF is an acceptable model. When secondary inorganic particulate is of concern use the same default chemistry used for acid deposition assessments (Section 8.1.1). Partitioning of NO_3 into $NO_{3(g)}$ and $NO_{3(s)}$ should be made using the ALM method. $NO_{3(s)}$ should be reported as NH_4NO_3 by multiplying the

$NO_{3(s)}$ concentration by 1.291. $SO_{4(s)}$ should be reported as $(NH_4)_2SO_4$ by multiplying the $SO_{4(s)}$ concentration by 1.376.

If CALPUFF modelling secondary organic particulate using SOA chemistry is desired (MCHEM = 7) this requires considerably more information and care. Modelling with this option should only be undertaken after consultation with the Director to ensure the most appropriate information is used. When using other models, e.g., CMAQ, for this a modelling plan must be submitted to the Director before undertaking the assessment. Written permission to proceed with the assessment as specified in the plan, regardless of the model employed, must be obtained from the Director before undertaking the modelling assessment.

9.0 Obtaining Models and Resources

This section contains instructions for accessing information relevant to dispersion modelling. There are two areas of information, AEP web page, and the U.S. EPA web page. The AEP home page contains general information about AEP, Alberta regulatory information, regional meteorological data sets, and updates of these model guidelines. The U.S. EPA home page has a link to its Support Centre for Regulatory Air Models (SCRAM) page.

9.1 Alberta Environment and Parks Air Quality Modelling Home Page

Alberta Environment and Parks' link to air quality modelling information and data can be found here:

https://www.alberta.ca/air-quality-modelling.aspx

9.2 Alberta Energy Regulator Home Page

The address for the flaring tool web page is:

https://aer.ca/regulating-development/rules-and-directives/directives/directive-060

9.3 U.S. EPA SCRAM Home Page

The SCRAM site covers topics related to dispersion models. The internet site can be accessed at the following address:

http://www.epa.gov/scram

9.4 Canadian Climate Normals

The Canadian Climate normals are available free of charge at the following web site:

http://climate.weather.gc.ca/climate_normals/

This information can be utilized for comparison with dispersion model results and to compare the representativeness of site data or other meteorological data for the region. If sufficient data are available, climatological wind directions, wind speeds, and temperatures can be analyzed to determine the frequency of particular meteorological conditions. This could be compared to the worst-case modelled condition, to help determine possible frequencies of occurrence of elevated concentrations.

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Appendix A Required Content of Screening Assessments

The following information is required in a screening assessment. The Director may request additional information as needed.

Facility Information
- Facility address and company name
- EPEA approval or registration # (if applicable)
- AER facility number (if applicable)
- Industrial sector

Sources and Emissions

Source Data
- Number, location, type (stack, flare, etc.) and category (point, area, line, volume) of sources, quantification method
- Plot plan
- Locations and dimensions of buildings (length, width, height)
- Design capacity (normal or average capacity may also be needed)

Characteristics of Emissions
- Chemical composition (substance type) and emission rates (g/s)
- Stack parameters for stack sources including inside diameter (m), stack height (m), exit velocity (m/s) and stack temperature (K) or heat content (MJ/m3 and cal/s)
- Water content of effluent
- Stack type include if capped or horizontal
- Flaring pseudo-parameters
- Other parameters for non-point sources (vertical, horizontal dispersion, release height)
- Calculations or explanations on how emissions were calculated and the quality of these estimates
- Classification of how sources typically operate (continuous, intermittent, emergency/upset)

Topography
- Description and digital elevation map of modelling domain
- Vegetation cover/land use
- Sensitive receptors nearby (public buildings, homes, etc.)

Results - Air Quality Modelling Predictions
- Summary of baseline concentration data (station used, years considered, data completeness, statistics of data)
- Building downwash effects
- Tabulated predicted ground level concentrations for all relevant averaging periods and relevant emission scenarios (maximum and typical emission scenarios, as required) from the assessment. These should include:
  - Maximum ground level concentrations at all sensitive receptors
  - Maximum ground level concentrations in modelling domain
  - Applicable AAAQO concentration values should be included for comparative purposes.
- Isopleths showing all predicted ground level concentrations for all substances of concern for all relevant averaging periods. Isopleth levels should be set from 10% to 90% in increments of 10% with additional isopleths if needed to highlight an impact. The isopleths should also clearly indicate:
  - the project boundaries
  - the location of any sensitive receptors and their predicted ground level concentrations
  - the location and value of the maximum model ground level concentration in the study area
- Comparison with existing monitoring data (if applicable)
- A soft copy of dispersion model input and output files including any control files used in the assessment. These should also be provided in digital format (i.e., on CD) or electronic format.

Appendix B Required Content of Refined, Advanced and Alternate Assessments

The following information is required in a refined, advanced and alternate assessment. The Director may request additional information as needed.

Facility Information

- Facility address and company name
- EPEA approval or registration # (if applicable)
- AER facility number (if applicable)
- Industrial sector

Sources and Emissions

Data should be summarized in a tabular form.

Source Data

- Number, location, type (stack, flare, etc.) and category (point, area, line, volume) of sources, quantification method
- Plot plan
- Dimensions of nearby buildings
- Design, average and nominal capacity
- Power rating and heating values

Characteristics of Emissions

- Chemical composition (substance type) and emission rates (g/s)
- Stack parameters for stack sources including inside diameter (m), stack height (m), exit velocity (m/s) and stack temperature (K) or heat content (MJ/m3 and cal/s)
- Water content of effluent
- Stack type include if capped or horizontal
- Flaring pseudo-parameters
- Other parameters for non-point sources (vertical, horizontal dispersion, release height)
- Calculations or explanations on how emissions were calculated and the quality of these estimates
- Classification of how sources typically operate (continuous, intermittent, emergency/upset)

Time Variations (Short and Long-Term)

- Hours of operation, including seasonal variation
- Duration and frequency of upsets and non-routine events

Scenarios

Potential emissions scenarios using maximum emissions, typical emissions and infrequent events, including confirmation of whether or not maximum emissions rates are within 0.4 tonnes/day of typical emission rates.

Other Major Existing or Proposed Sources

- Identification of existing industrial sources within study area
- Identification of major proposed or approved (but not constructed) facilities within study area
- Facility type of industrial sources within study area
- Number, unique identifier and type of sources (stack, flare, etc.) for each facility
- Geographic locations of each source (UTM or Lat/Long NAD 83)
- Chemical composition (substance type) and emission rates (g/s)
- Data sources for other facility emission rates and identification of the quantification methods used (if known)

- Exit (stack) height above ground (m)
- Temperature (K) or heat content (MJ/m3 and cal/s)
- Exit velocity (m/s)
- Stack top inside diameter (m)

Topography

- Description and digital elevation map of modelling domain
- Elevation maxima and minima
- Vegetation cover/land use
- Receptor grid resolution and domain size
- Sensitive receptors
- Parks, campgrounds, and wilderness areas
- Population centres and public facilities
- Location of meteorological and air quality stations

General Climatology

- Temperature
- Precipitation
- Pressure
- Solar radiation
- Wind
- Cloud cover

Meteorology

- Sources of data
- Representativeness of measurements (time and space)
- Topographic influences
- **Wind**
  - Speed and direction distributions (roses)
  - Relation of short-term on-site to long-term off-site
  - Persistence
  - Diurnal and seasonal variations
  - Extreme values
  - Mean speed
  - Prevailing and resultant winds
  - Relation to visibility restrictions
  - Relation to topographic effects
- **Temperature**
  - Inversion heights, strengths, frequencies, and persistence
  - Mixing layer heights, diurnal and seasonal variation
  - Magnitude and behaviour, diurnal and seasonal variation
- **Turbulence**
  - Direct measurements - frequency distributions, diurnal and seasonal variations
  - Indirect determinations, definition of stability parameter (thermal/mechanical turbulence index) and description of inference scheme
  - Frequency distribution, diurnal and seasonal variations

Air Quality Modelling Summary

Air Quality Modelling Setup

- **Identification of the specific model version and switches used**. These must be provided in tabular form side-by-side with the default settings.
- All appropriate air quality model and data references

Air Quality Modelling Predictions

- Summary of baseline concentration data (station used, years considered, data completeness, statistics of data)
- Building downwash (include whether effects seen on or off facility property)
- Tabulated predicted ground level concentrations for all relevant averaging periods and relevant emission scenarios (maximum and typical emission scenarios, as required) from the assessment. These should include:
    - Maximum ground level concentrations at all sensitive receptors
    - Maximum ground level concentrations in modelling domain
    - Applicable AAAQO concentration values should be included for comparative purposes.
- Isopleths showing all predicted ground level concentrations for all substances of concern for all relevant averaging periods. Isopleth levels should be set from 10% to 90% in increments of 10% with additional isopleths if needed to highlight an impact. The isopleths should also clearly indicate:
    - the project boundaries
    - the location of any sensitive receptors and their predicted ground level concentrations
    - the location and value of the maximum model ground level concentration in the study area
- Predicted acid deposition and/or particulate deposition, as required
- Comparison with existing monitoring data (if applicable)
- A soft copy of dispersion model input and output files including any control files used in the assessment. These should also be provided in digital format (i.e., on CD) or electronic format
- Discussion regarding any topographic, meteorological or building effects germane to the project
- Any other relevant information that will assist the Director evaluate the environmental impact of the project

Special Topics

- Risks due to uncontrolled releases
- Unusual natural phenomena
- Atmospheric chemical transformations
- Chemical reactions between plumes containing different substances
- Synergistic effects of multiple-component emissions
- Icing caused by water vapour emissions
- Visibility

Conclusion

- Summary of impact on air quality (ambient concentrations, depositions, visibility, and odour) from assessment

Appendix C Competencies for Performing Air Quality Modelling

INTRODUCTION

Competencies are any attitude, skill, behavior, motive or other personal characteristic that are essential to perform a job, or more importantly, differentiate superior performers from solid performers.

The following lists the tasks and knowledge required for competent air quality modelling. The introductory sections- Context, Core Knowledge and Abilities, and Quality Assurance- are integral to further understanding the Task and Knowledge and Experience requirements.

CONTEXT

The competencies must be interpreted within the following context:

- Communication with field workers, technicians, laboratories, engineers and scientists during the process is important to the success of the model, as well as
- Record keeping is important to support the accountability of the model.

CORE KNOWLEDGE AND ABILITIES

An air quality modeller must have the following core knowledge and abilities, in addition to specific technical knowledge, that includes:

- Knowledge of chemical and physical meteorology
- Understanding of the chemical and physical interactions of atmospheric substances
- Knowledge of primary substances, and their interaction with other substances (natural or industrial) to form secondary substances
- Knowledge of risks due to uncontrolled releases
- Knowledge of legislation, regulations and guidelines in regards to Ambient Air Quality Objectives (AAAQO) and limits
- Knowledge of information sources relevant to the model
- Ability to read and understand map information
- Ability to prepare reports and documents as necessary. Ability to review reports to ensure accuracy, clarity and completeness
- Communication skills
- Team skills.

QUALITY ASSURANCE

- Use of standard assessment and modelling protocol
- Selection of appropriate practitioners for the task. Referral to specialists when the situation requires specialized training

Tasks

- Obtain, review and interpret data from monitoring sites
- Obtain, review and interpret meteorological data
- Identify potential pollution (emission) sources and rates:
    - Gather information on sources such as mass flow rates (e.g., kg of SO_2/hr), stack top temperature, velocity (i.e., m/s) or volumetric flow rate (e.g., cubic meters/second), and stack height and diameter. Calculate emission rates based on collected information
- Identify land use (urban/rural)
- Identify land cover/terrain characteristics
- Identify the receptor grid/site
- Prepare and execute dispersion model
- Interpret results of model
- Prepare reports and recommend changes based on modelling results

- Determine if further assessment is necessary.

Knowledge and Experience

- Knowledge of chemical and physical meteorology:
  - Familiar with terminology, principles and interactions
  - Understanding of data collection methods and technologies
  - Ability to identify good and bad data points/sets
  - Understanding of how to deal with incomplete/missing meteorological data

- Knowledge of chemical and physical interactions of atmospheric substances:
  - Familiarity with fate and transport of substances in air
  - Understanding of meteorological impacts on substances
  - Knowledge of primary substances and the synergistic effects with other substances (natural or industrial) to form secondary substances

- Knowledge of surface characteristics:
  - Ability to identify and describe soil, water, drainage and terrain conditions
  - Understanding of their interaction
  - Familiarity with surface roughness

- Knowledge of pollution sources (point, line, area, volume):
  - Familiarity with emission control technologies
  - Knowledge of AAAQO
  - Understanding of baseline concentrations

- Understanding/ experience with computer modelling programs/ applications and limitations:
  - Selection of model which best meets needs of the task
  - Understanding of model input parameters
  - Understanding of modelling results

- Ability to read and understand map information:
  - Ability to create predicted concentration isopleths with model results

Appendix D Allowed Non-Default and/or Alternate Model Options for Air Quality Modelling

These switches represent allowed non-default AERMOD and CALPUFF modelling options to be used for screening and refined regulatory air quality modelling assessments. When not specified in the following table the default AERMOD and CALPUFF system values model options must be used. Deviation from these specified screening and refined modelling settings (the combination of allowed AEP settings and default model system settings) constitutes an advanced modelling assessment and requires additional modelling of a refined assessment.
Note: Administrative switches, .e.g., switches related to the type and style input/output data, grid domain, etc., may be changed as required for a particular regulatory application without additional modelling.

Table D 1 Allowed Non-Default and/or Alternate Model Options

Model	Allowed Non-Default/Alternate Model Options**	Comment
AERSCREEN		As required.
AERMET	Adjusted_U*	Preferred. Note: When using on site meteorology do not use this option.
AERMOD	Flat & Elevated Terrain	As required.
	Conversion of NOx to NO2 Total conversion ARM2 OLM or PVMRM	Total conversion of NO_x to NO_2 always required. Pay special attention to the use of the best available information for in-stack ratios (ISR) when using ARM2, OLM and PVMRM. Use OLMGROUP to simplify grouping of sources as appropriate when using OLM. Use Source Groups to simplify grouping sources as appropriate when using PVMRM. Use Regulatory provided O_3 concentrations (Appendix F) unless onsite data available.
	Capped and Horizontal Stack Releases	Allowed.
	Adjusted Friction Velocity (u*)	Preferred. This must be used with Adjusted_U* created by AERMET. Note: See AERMET comment. At this time, until the US EPA approves settings (not defaults) for wind speed options (LOW1, LOW2 and LOW3) these are <u>not</u> allowed to be used.
	Flaring (NOSTD)	See flaring guidance for pseudo-parameters and turn off NOSTD in AERSCREEN/AERMOD
CALMET	Input Group 2	
	ZFACE	ZFACE = 0.0, 20.0, 40.0, 80.0, 120.0, 280.0, 520.0, 880.0, 1320.0, 1820.0, 2380.0, 3000.0, 4000.0
	Input Group 4	
	MCLOUD	Use cloud cover derived from the AEP provided meteorological data (MCLOUD = 4 is preferred) unless complete set of surface observations are available (MCLOUD = 1). Provide explanation of choice.
	NOOBS	Use NOOBS = 0 for onsite meteorology. Use NOOBS = 1 when blending ground data into AEP provided meteorological data. NOOBS = 2 when using AEP meteorological data only.
	Input Group 5	
	IWFCOD	Set IWFCOD = 1.
	IEXTRP	Set IEXTRP = +/-1 when NOOBS = 2.

Model	Allowed Non-Default/Alternate Model Options**	Comment
	ITPROG	Set ITPROG = 0 or 1 for NOOBS = 0 or 1; ITPROG = 2 when NOOBS = 2.
	R1, R2	Set to one half the resolution of the AEP meteorological data set. These are only suggested values, variation from these values do not require additional modelling. Provide explanation of choice.
	RMAX1, RMAX2, RMAX3	Set to twice the resolution of AEP provided meteorological data set. These are only suggested values, variation from these values do not require additional modelling. Provide explanation of choice.
	TERRAD	Set TERRAD according to terrain features in modelling domain. Provide explanation.
	IPROG	Set IPROG = 14.
	Input Group 6	
	MNMDAV	Set MNMDAV = 10
	ITWPROG	Set as required when considering assessments over water.
	ILUOC3D	Set to Land Use category ocean to be consistent with prognostic dataset and ITWPROG, e.g., For MM5 v3.0 data ILUOC3D = 16.
	IRHPROG	Set IRHPROG = 1.
	TRADKM	Set TRADKM to twice the resolution of AEP provided meteorological data set.
CALPUFF	MBDW	Use the Prime algorithm for downwash (MBDW = 2) unless criteria for selecting ISC downwash (MBDW = 1) are met. See discussion on downwash (Section 5.2)
	MCHEM	MCHEM = 0 for modelling against AAAQOs. MCHEM = 6 (RIVAD/ISORROPIA) chemistry is preferred for modelling acid and secondary particulate deposition. All other chemical paths are considered alternate models.
	MAQCHEM	Set MAQCHEM = 1 given MCHEM = 6.
	MLWC	Set MLWC = 1 given MAQCHEM = 1.
	MOZ, MHN3, MH2O2	Set MOZ = 1 – use hourly O_3 data MHN3 = 0 – use monthly NH_3 data MH2O2 = 1 – use hourly H_2O_2 data Use on site values if available, otherwise use Regulator suggested monthly defaults (Appendix F).
	MNITRATE	Set MNITRATE = 1 given MCHEM = 6 to determine NO_3/HNO_3 partitioning using ALM method in POSTUTIL.
	MDISP	Set MDISP = 2.
	MPDF	Set MPDF to match the selected MDISP setting (MPDF = 1).
	MPARTLBA	Allow for partial penetration of plume (MPARTLBA = 1).
	MREG	Waive MREG check (MREG = 0).
	ZFACE	As for CALMET.

Appendix E AEP Recommended Default Surface Characteristics

Table E 1 Surface Roughness Length (m) for Land Use by Season

Canada 2015: Land Use Cover FGP Code[1]	NLCD 2016[2]		Seasonal Surface Roughness			
		NLCD Code	Winter	Spring	Summer	Fall
Water	Open Water	11	**0.001**	**0.001**	**0.001**	**0.001**
Snow and Ice	Perennial Ice/Snow	12	**0.002**	**0.002**	**0.002**	**0.002**
	Developed, Open Space	21	0.020	0.030	0.040	0.030
	Developed, Low Intensity	22	0.050	0.090	0.100	0.090
Urban	Developed, Medium Intensity	23	**0.200**	**0.300**	**0.300**	**0.300**
	Developed, High Intensity	24	0.700	0.700	0.700	0.700
	Barren Land (Rock/Sand/Clay) (Arid Region)	31	NA	0.050	0.050	0.050
Barren	Barren Land (Rock/Sand/Clay) (Non-arid Region)		**0.010**	**0.050**	**0.050**	**0.050**
Sub-polar or polar barrenland-lichen-moss			0.010	0.050	0.050	0.050
	Unconsolidated Shore	32	0.010	0.050	0.050	0.050
Temperate or sub-polar broadleaf deciduous forest	Deciduous Forest	41	**0.500**	**1.000**	**1.300**	**1.300**
Temperate or sub-polar needleleaf forest	Evergreen Forest	42	**1.300**	**1.300**	**1.300**	**1.300**
Sub-polar taige needleleaf forest			1.300	1.300	1.300	1.300
Mixed Forest	Mixed Forest	43	**0.800**	**1.100**	**1.300**	**1.300**
Sub-polar or polar shrubland-lichen-moss	Dwarf Scrub (Arid Region)	51	NA	0.050	0.050	0.050
	Dwarf Scrub (Non-arid Region)		**0.050**	**0.100**	**0.100**	**0.100**
	Shrub/Scrub (Arid Region)	52	NA	0.150	0.150	0.150
Temperate of sub-polar shrubland	Shrub/Scrub (Non-arid Region)		**0.150**	**0.300**	**0.300**	**0.300**
Temperate or sub-polar grassland	Grasslands/Herbaceous	71	**0.005**	**0.050**	**0.100**	**0.100**
Sub-polar or polar grassland-lichen-moss			0.005	0.050	0.100	0.100
	Sedge/Herbaceous	72	0.005	0.050	0.100	0.100
	Lichens	73	0.005	0.050	0.050	0.050
	Moss	74	0.005	0.050	0.050	0.050
	Pasture/Hay	81	0.010	0.030	0.150	0.150
Cropland	Cultivated Crops	82	**0.014**	**0.040**	**0.200**	**0.200**
Wetland	Woody Wetlands	90	**0.300**	**0.500**	**0.500**	**0.500**
	Palustrine Forested Wetland	91	0.300	0.500	0.500	0.500
	Palustrine Scrub/Shrub Wetland	92	0.100	0.200	0.200	0.200
	Estuarine Forested Wetland	93	0.300	0.500	0.500	0.500
	Estuarine Scrub/Shrub Wetland	94	0.100	0.200	0.200	0.200
	Emergent Herbaceous Wetland	95	0.100	0.200	0.200	0.200
	Palustrine Emergent Wetland (Persistent)	96	0.100	0.200	0.200	0.200
	Estuarine Emergent Wetland	97	0.100	0.200	0.200	0.200
	Palustrine Aquatic Bed	98	0.050	0.050	0.050	0.050
	Estuarine Aquatic Bed	99	0.050	0.050	0.050	0.050

[1] Canada LUC 2015

[2] Table 6-5. Seasonal Values of Bowen Ratio for the NLCD 2001-2016

There are no arid areas in the province as per the NLCD definition.

Default surface values are indicated by the green shaded/bolded entries. Cream shaded boxes indicate interpolated values for this document.

Definition of Seasons:

"Spring" refers to periods when vegetation is emerging or partially green. This is a transitional situation that applies for 1–2 months after the last killing frost in spring.

"Summer" applies to the period when vegetation is lush and healthy, typical of midsummer, but also of other seasons where frost is less common.

"Autumn" refers to a period when freezing conditions are common, deciduous trees are leafless, crops are not yet planted or are already harvested (bare soil exposed), grass surfaces are brown, and no snow is present.

"Winter" conditions apply for snow-covered surfaces and subfreezing temperatures.

In Alberta the recommend defaults are:

Winter: Nov, Dec, Jan, Feb, Mar

Spring: Apr, May

Summer: June, July, August

Fall: Sep, Oct

Albedo and Bowen Ratio values can also be chosen to appropriately represent particular site conditions. Table E2 and Table E3 provide similar Albedo and Bowen Ratio values as a function of land use and season.

Table E 2 Albedo of Land Use Types by Season

Canada 2015: Land Use Cover FGP Code[1]	NLCD 2016[2]		Seasonal Albedo			
		NLCD Code	Winter	Spring	Summer	Fall
Water	Open Water	11	**0.1**	**0.1**	**0.1**	**0.1**
Snow and Ice	Perennial Ice/Snow	12	**0.7**	**0.6**	**0.6**	**0.6**
	Developed, Open Space	21	0.7	0.6	0.6	0.6
	Developed, Low Intensity	22	0.6	0.15	0.15	0.15
Urban	Developed, Medium Intensity	23	**0.45**	**0.16**	**0.16**	**0.16**
	Developed, High Intensity	24	0.18	0.18	0.18	0.18
	Barren Land (Rock/Sand/Clay) (Arid Region)	31	**0.25**	0.18	0.18	0.18
Barren	Barren Land (Rock/Sand/Clay) (Non-arid Region)		0.25	**0.2**	**0.2**	**0.2**
Sub-polar or polar barrenland-lichen-moss			0.25	0.2	0.2	0.2
	Unconsolidated Shore	32	0.3	0.14	0.14	0.14
Temperate or sub-polar boradleaf deciduous forest	Deciduous Forest	41	**0.5**	**0.16**	**0.16**	**0.16**
Temperate or sub-polar needleleaf forest	Evergreen Forest	42	**0.35**	**0.12**	**0.12**	**0.12**
Sub-polar taige needleleaf forest			**0.35**	**0.12**	**0.12**	**0.12**
Mixed Forest	Mixed Forest	43	**0.42**	**0.14**	**0.14**	**0.14**
	Dwarf Scrub (Arid Region)	51	NA	0.25	0.25	0.25
Sub-polar or polar shrubland-lichen-moss	Dwarf Scrub (Non-arid Region)		**0.5**	**0.18**	**0.18**	**0.18**
	Shrub/Scrub (Arid Region)	52	NA	0.25	0.25	0.25
Temperate of sub-polar shrubland	Shrub/Scrub (Non-arid Region)		**0.5**	**0.18**	**0.18**	**0.18**
Temperate or sub-polar grassland	Grasslands/Herbaceous	71	**0.6**	**0.18**	**0.18**	**0.18**
Sub-polar or polar grassland-lichen-moss			**0.6**	**0.18**	**0.18**	**0.18**
	Sedge/Herbaceous	72	0.6	0.18	0.18	0.18
	Lichens	73	0.6	0.18	0.18	0.18
	Moss	74	0.6	0.18	0.18	0.18
	Pasture/Hay	81	0.6	0.14	0.2	0.2
Cropland	Cultivated Crops	82	**0.6**	**0.14**	**0.2**	**0.2**
Wetland	Woody Wetlands	90	**0.3**	**0.14**	**0.14**	**0.14**
	Palustrine Forested Wetland	91	0.3	0.14	0.14	0.14
	Palustrine Scrub/Shrub Wetland	92	0.3	0.14	0.14	0.14
	Estuarine Forested Wetland	93	0.3	0.14	0.14	0.14
	Estuarine Scrub/Shrub Wetland	94	0.3	0.14	0.14	0.14
	Emergent Herbaceous Wetland	95	0.3	0.14	0.14	0.14
	Palustrine Emergent Wetland (Persistent)	96	0.3	0.14	0.14	0.14
	Estuarine Emergent Wetland	97	0.3	0.14	0.14	0.14
	Palustrine Aquatic Bed	98	0.3	0.14	0.14	0.14
	Estuarine Aquatic Bed	99	0.3	0.14	0.14	0.14

[1] Canada LUC 2015

[2] Table 6-5. Seasonal Values of Bowen Ratio for the NLCD 2001-2016

There are no arid areas in the province as per the NLCD definition.

Default surface values are indicated by the green shaded/bolded entries. Cream shaded boxes indicate interpolated values for this document.

Table E 3 Daytime Bowen Ratios for Land Use Types by Season (Average Moisture Conditions)

Canada 2015: Land Use Cover FGP Code[1]	NLCD 2016[2]	NLCD Code	Seasonal Bowen Ratio: Average				Seasonal Bowen Ratio: Wet				Seasonal Bowen Ratio: Dry			
			Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Water	Open Water	11	**0.10**	**0.10**	**0.10**	**0.10**	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Snow and Ice	Perennial Ice/Snow	12	**0.50**	**0.50**	**0.50**	**0.50**	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	Developed, Open Space	21	0.50	0.30	0.50	0.70	0.50	0.20	0.30	0.40	0.50	1.00	1.50	2.00
	Developed, Low Intensity	22	0.50	0.80	0.80	1.00	0.50	0.60	0.60	0.60	0.50	2.00	2.00	2.50
Urban	Developed, Medium Intensity	23	**0.50**	**1.10**	**1.10**	**1.20**	0.50	0.80	0.80	0.80	0.50	3.00	3.00	3.00
	Developed, High Intensity	24	0.50	1.50	1.50	1.50	0.50	1.00	1.00	1.00	0.50	3.00	3.00	3.00
	Barren Land (Rock/Sand/Clay) (Arid Region)	31	NA	3.00	4.00	6.00	NA	1.00	1.50	2.00	NA	5.00	6.00	10.00
Barren	Barren Land (Rock/Sand/Clay) (Non-arid Region)		**0.50**	**1.50**	**1.50**	**1.50**	0.50	1.00	1.00	1.00	0.50	3.00	3.00	3.00
Sub-polar or polar barrenland-lichen-moss			0.50	1.50	1.50	1.50	0.50	1.00	1.00	1.00	0.50	3.00	3.00	3.00
	Unconsolidated Shore	32	0.50	0.20	0.20	0.20	0.50	0.10	0.10	0.10	0.20	0.50	0.20	0.20
Temperate or sub-polar boradleaf deciduous forest	Deciduous Forest	41	**0.50**	**0.70**	**0.30**	**1.00**	0.50	0.30	0.20	0.40	0.50	1.50	0.60	2.00
Temperate or sub-polar needleleaf forest	Evergreen Forest	42	**0.50**	**0.70**	**0.30**	**0.80**	0.50	0.30	0.20	0.30	0.50	1.50	0.60	1.50
Sub-polar taige needleleaf forest			0.50	0.70	0.30	0.80	0.50	0.30	0.20	0.30	0.50	1.50	0.60	1.50
Mixed Forest	Mixed Forest	43	**0.50**	**0.70**	**0.30**	**0.90**	0.50	0.30	0.20	0.35	0.50	1.50	0.60	1.75
	Dwarf Scrub (Arid Region)	51	NA	2.00	3.00	4.00	NA	0.80	0.90	1.50	NA	4.00	6.00	7.00
Sub-polar or polar shrubland-lichen-moss	Dwarf Scrub (Non-arid Region)		**0.50**	**1.00**	**1.00**	**1.50**	0.50	0.80	0.80	1.00	0.50	2.50	2.50	3.00
	Shrub/Scrub (Arid Region)	52	NA	3.00	4.00	6.00	NA	1.00	1.50	2.00	NA	5.00	6.00	10.00
Temperate of sub-polar shrubland	Shrub/Scrub (Non-arid Region)		**0.50**	**1.00**	**1.00**	**1.50**	0.50	0.80	0.80	1.00	0.50	2.50	2.50	3.00
Temperate or sub-polar grassland	Grasslands/Herbaceous	71	**0.50**	**0.40**	**0.80**	**1.00**	0.50	0.30	0.40	0.50	0.50	1.00	2.00	2.00
Sub-polar or polar grassland-lichen-moss			0.50	0.40	0.80	1.00	0.50	0.30	0.40	0.50	0.50	1.00	2.00	2.00
	Sedge/Herbaceous	72	0.50	0.40	0.80	1.00	0.50	0.30	0.40	0.50	0.50	1.00	2.00	2.00
	Lichens	73	0.50	0.40	0.80	1.00	0.50	0.30	0.40	0.50	0.50	1.00	2.00	2.00
	Moss	74	0.50	0.40	0.80	1.00	0.50	0.30	0.40	0.50	0.50	1.00	2.00	2.00
	Pasture/Hay	81	0.50	0.30	0.50	0.70	0.50	0.20	0.30	0.40	0.50	1.00	1.50	2.00
Cropland	Cultivated Crops	82	**0.50**	**0.30**	**0.50**	**0.70**	0.50	0.20	0.30	0.40	0.50	1.00	1.50	2.00
Wetland	Woody Wetlands	90	**0.50**	**0.20**	**0.20**	**0.20**	0.50	0.10	0.10	0.10	0.50	0.20	0.20	0.20
	Palustrine Forested Wetland	91	0.50	0.20	0.20	0.20	0.50	0.10	0.10	0.10	0.50	0.20	0.20	0.20
	Palustrine Scrub/Shrub Wetland	92	0.50	0.20	0.20	0.20	0.50	0.10	0.10	0.10	0.50	0.20	0.20	0.20
	Estuarine Forested Wetland	93	0.50	0.20	0.20	0.20	0.50	0.10	0.10	0.10	0.50	0.20	0.20	0.20

	Estuarine Scrub/Shrub Wetland	94	0.50	0.20	0.20	0.20	0.50	0.10	0.10	0.10	0.50	0.20	0.20	0.20
	Emergent Herbaceous Wetland	95	0.50	0.10	0.10	0.10	0.50	0.10	0.10	0.10	0.50	0.20	0.20	0.20
	Palustrine Emergent Wetland (Persistent)	96	0.50	0.10	0.10	0.10	0.50	0.10	0.10	0.10	0.50	0.20	0.20	0.20
	Estuarine Emergent Wetland	97	0.50	0.10	0.10	0.10	0.50	0.10	0.10	0.10	0.50	0.20	0.20	0.20
	Palustrine Aquatic Bed	98	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	Estuarine Aquatic Bed	99	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

[1] Canada LUC 2015

[2] Table 6-5. Seasonal Values of Bowen Ratio for the NLCD 2001-2016

There are no arid areas in the province as per the NLCD definition.

Default surface values are indicated by the green shaded/bolded entries. Cream shaded boxes indicate interpolated values for this document.

* Winter Bowen ratios depend on wet or dry conditions as by comparison to the most recent 30 year climatological conditions. Precipitation 30% or less than the climatological average are dry. Precipitation 30% or more above the climatological average are wet. The default values are averages and should be applicable in most cases.

Appendix F AEP Recommended Ozone Levels

Based on ambient air quality monitoring data in Alberta from 2000 to 2010 (Urban: Calgary North, Calgary Central, Calgary East, Edmonton South, Edmonton Central, Edmonton East, Fort Saskatchewan – 92nd Street and 96th Avenue, Lethbridge, Red Deer – Riverside; Rural: Anzac, Beaverlodge, Caroline, Elk Island, Fort Chipewyan, Genesee, Tomahawk, Violet Grove).

Table F 1 AEP Recommended Ozone Levels

Urban (ppm)

Hour	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.013	0.015	0.021	0.026	0.026	0.022	0.018	0.016	0.013	0.014	0.013	0.012
2	0.013	0.016	0.021	0.025	0.025	0.021	0.018	0.016	0.013	0.014	0.014	0.013
3	0.013	0.016	0.021	0.025	0.023	0.020	0.017	0.015	0.013	0.014	0.014	0.013
4	0.013	0.016	0.021	0.024	0.022	0.019	0.016	0.014	0.012	0.013	0.014	0.013
5	0.013	0.015	0.020	0.021	0.020	0.016	0.014	0.012	0.011	0.012	0.014	0.013
6	0.012	0.014	0.018	0.018	0.018	0.015	0.012	0.010	0.009	0.010	0.013	0.012
7	0.011	0.012	0.016	0.017	0.018	0.016	0.013	0.009	0.007	0.008	0.011	0.011
8	0.010	0.011	0.016	0.020	0.022	0.019	0.016	0.011	0.008	0.008	0.009	0.009
9	0.009	0.011	0.019	0.026	0.027	0.024	0.021	0.016	0.011	0.010	0.009	0.009
10	0.011	0.015	0.024	0.031	0.033	0.029	0.026	0.021	0.015	0.013	0.012	0.011
11	0.013	0.019	0.029	0.035	0.037	0.033	0.031	0.026	0.020	0.017	0.015	0.013
12	0.016	0.022	0.032	0.038	0.039	0.036	0.034	0.030	0.024	0.020	0.017	0.015
13	0.018	0.025	0.034	0.040	0.041	0.038	0.036	0.033	0.027	0.023	0.020	0.017
14	0.019	0.026	0.036	0.041	0.042	0.039	0.037	0.035	0.028	0.025	0.021	0.018
15	0.019	0.027	0.036	0.042	0.042	0.039	0.038	0.036	0.029	0.025	0.020	0.017
16	0.017	0.026	0.036	0.042	0.042	0.038	0.037	0.035	0.029	0.024	0.018	0.014
17	0.013	0.022	0.034	0.042	0.042	0.038	0.037	0.035	0.028	0.022	0.013	0.010
18	0.010	0.017	0.032	0.041	0.042	0.038	0.037	0.034	0.026	0.017	0.010	0.009
19	0.010	0.014	0.027	0.039	0.041	0.037	0.035	0.031	0.021	0.014	0.010	0.009
20	0.011	0.014	0.024	0.035	0.038	0.035	0.032	0.026	0.016	0.013	0.011	0.010
21	0.011	0.014	0.022	0.030	0.032	0.030	0.026	0.020	0.014	0.013	0.011	0.011
22	0.011	0.014	0.021	0.028	0.029	0.025	0.021	0.018	0.013	0.013	0.011	0.011
23	0.012	0.014	0.021	0.027	0.027	0.023	0.019	0.017	0.013	0.013	0.012	0.011
24	0.012	0.015	0.021	0.026	0.022	0.022	0.018	0.017	0.013	0.014	0.013	0.011

Rural (ppm)

Hour	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.024	0.029	0.035	0.037	0.033	0.027	0.022	0.020	0.019	0.022	0.022	0.022
2	0.026	0.030	0.035	0.038	0.034	0.028	0.022	0.020	0.019	0.022	0.024	0.023
3	0.024	0.029	0.034	0.036	0.031	0.025	0.020	0.018	0.018	0.022	0.022	0.021
4	0.023	0.028	0.033	0.034	0.029	0.023	0.018	0.016	0.016	0.021	0.022	0.022
5	0.023	0.028	0.033	0.033	0.028	0.022	0.017	0.016	0.016	0.020	0.022	0.022
6	0.023	0.027	0.032	0.033	0.027	0.021	0.016	0.015	0.015	0.020	0.022	0.022
7	0.023	0.027	0.031	0.032	0.028	0.022	0.017	0.015	0.015	0.019	0.021	0.022
8	0.023	0.026	0.032	0.033	0.031	0.025	0.020	0.016	0.015	0.019	0.021	0.022
9	0.023	0.027	0.033	0.036	0.034	0.029	0.023	0.019	0.017	0.019	0.021	0.021
10	0.023	0.028	0.035	0.039	0.037	0.032	0.027	0.023	0.020	0.021	0.022	0.021
11	0.024	0.030	0.037	0.041	0.039	0.035	0.030	0.027	0.023	0.023	0.023	0.023
12	0.026	0.031	0.038	0.043	0.041	0.037	0.032	0.030	0.026	0.026	0.025	0.024
13	0.027	0.033	0.040	0.045	0.042	0.039	0.034	0.031	0.028	0.028	0.026	0.025
14	0.027	0.034	0.041	0.046	0.043	0.040	0.035	0.033	0.029	0.029	0.027	0.026
15	0.028	0.035	0.042	0.047	0.044	0.040	0.036	0.034	0.030	0.029	0.027	0.026
16	0.027	0.035	0.042	0.047	0.044	0.041	0.036	0.034	0.031	0.029	0.026	0.025
17	0.026	0.034	0.042	0.047	0.045	0.040	0.036	0.034	0.030	0.028	0.025	0.024
18	0.025	0.033	0.041	0.047	0.044	0.040	0.035	0.033	0.029	0.027	0.024	0.023
19	0.025	0.032	0.040	0.046	0.043	0.039	0.034	0.031	0.027	0.026	0.024	0.023
20	0.024	0.031	0.039	0.044	0.042	0.037	0.032	0.028	0.025	0.025	0.023	0.022
21	0.024	0.031	0.038	0.042	0.039	0.034	0.028	0.025	0.023	0.024	0.023	0.022
22	0.024	0.030	0.037	0.041	0.037	0.032	0.026	0.024	0.022	0.023	0.023	0.022
23	0.024	0.030	0.036	0.039	0.036	0.030	0.025	0.022	0.021	0.023	0.022	0.022
24	0.024	0.029	0.036	0.038	0.034	0.028	0.023	0.021	0.020	0.022	0.022	0.022

Appendix G AEP Recommended NH_3 and H_2O_2 Levels

For CALPUFF deposition and secondary particulate matter studies, it is important to set representative NH_3 and H_2O_2 levels. If onsite NH_3 and H_2O_2 data is available it must be used, particularly in areas where there are known sources of NH_3 (e.g., agricultural operations), otherwise use the default values.

Table G 1 Recommended Default NH_3 Monthly Levels

NH_3 [ppb]*											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.5	1.5	1.5	2.5	2.8	3.2	3.2	3.0	2.5	2.0	1.5	1.5

* Adapted from Warner et al., 2017 assuming Alberta's seasonal variability.

Table G 2 H_2O_2 Hourly Levels by Season

H_2O_2 [ppb]**						
	Urban/Industrial			Rural		
Hour	Winter	Summer	Spring/Fall	Winter	Summer	Spring/Fall
0:00	0.30	0.50	0.40	0.54	0.43	0.48
1:00	0.35	0.60	0.48	0.56	0.41	0.49
2:00	0.40	0.70	0.55	0.59	0.39	0.49
3:00	0.44	0.74	0.55	0.60	0.38	0.49
4:00	0.48	0.78	0.63	0.60	0.36	0.48
5:00	0.50	0.80	0.65	0.56	0.35	0.45
6:00	0.49	0.75	0.62	0.52	0.31	0.42
7:00	0.47	0.62	0.55	0.46	0.32	0.39
8:00	0.48	0.64	0.56	0.47	0.33	0.40
9:00	0.55	0.72	0.64	0.54	0.39	0.47
10:00	0.63	0.90	0.77	0.62	0.48	0.55
11:00	0.76	1.16	0.96	0.71	0.59	0.65
12:00	0.83	1.29	1.06	0.81	0.66	0.74
13:00	0.92	1.47	1.20	0.85	0.71	0.78
14:00	0.97	1.53	1.25	0.85	0.76	0.81
15:00	0.99	1.54	1.26	0.77	0.85	0.81
16:00	1.00	1.48	1.24	0.73	0.86	0.79
17:00	1.00	1.40	1.20	0.63	0.84	0.74
18:00	0.90	1.28	1.09	0.60	0.81	0.71
19:00	0.77	1.10	0.94	0.61	0.74	0.67
20:00	0.60	0.75	0.68	0.61	0.68	0.64
21:00	0.40	0.50	0.45	0.62	0.61	0.61
22:00	0.30	0.38	0.34	0.59	0.58	0.58
23:00	0.30	0.36	0.33	0.57	0.50	0.54

**Average values adapted from Das and Aneja 1994, Grossmann et al., 2003, Hua et al. 2008, Gillett 2014, and Zhang et al. 2012. Note that the September 1999 and May 2000 data from Gillett were designated as outliers for this work and have not been included. The average values have been smoothed to capture the essential seasonal and diurnal variability.