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GOVERNMENT NOTICE

DEPARTMENT OF ENVIRONMENTAL AFFAIRS

No. R. 533 **11 July 2014**

NATIONAL ENVIRONMENTAL MANAGEMENT: AIR QUALITY ACT, 2004 (ACT NO. 39 OF 2004)

REGULATIONS REGARDING AIR DISPERSION MODELLING

I, Bomo Edith Edna Molewa, Minister of Water and Environmental Affairs, hereby make the regulations regarding air dispersion modelling, in terms of section 53(f) of the National Environmental Management : Air Quality Act, 2004 (Act No. 39 of 2004), set out in the Schedule hereto.

BOMO EDITH EDNA MOLEWA
MINISTER OF WATER AND ENVIRONMENTAL AFFAIRS

SCHEDULE

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2. Purpose of regulations

3. Code of Practice for air dispersion modelling

4. Application of the Code of Practice for air dispersion modelling

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6. Short title and commencement

Definitions

1. In these regulations any word or expression to which a meaning has been assigned in the Act has that meaning, and unless the context indicates otherwise --

"air dispersion modelling" means a series of mathematical simulations of how air pollutants disperse in the ambient atmosphere and is performed with computer programs that solve the mathematical equations and algorithms which simulate the dispersion of pollutants;

"Code of Practice" means a supplement to the air dispersion modelling regulations providing technical standards on the application of air dispersion models as contained in Appendix A ;

"the Act" means the National Environmental Management: Air Quality Act, 2004 (Act No.39 of 2004); and

"relevant authority" means the authorities contemplated in section 19, 30 and 36 of the Act.

Purpose of regulations

2. The purpose of these regulations is to regulate air dispersion modelling.

Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa

3. The Code of Practice, contained in Appendix-A of the regulations, is prescribed as the technical Code of Practice for air dispersion modelling.

Application of Code of Practice for Air Dispersion Modelling

4. The Code of Practice for air dispersion modelling is applicable –

   (a) in the development of an air quality management plan, as contemplated in Chapter 3 of the Act;

   (b) in the development of a priority area air quality management plan, as contemplated in Section 19 of the Act;

   (c) in the development of an atmospheric impact report, as contemplated in Section 30 of the Act; and

   (d) in the development of a specialist air quality impact assessment study, as contemplated in Section 37(2)(b) of the Act.

Failure to comply with the Code of Practice for Air Dispersion Modelling

5. A relevant authority must refuse to accept air dispersion modelling results, if any person or organ of state fails to comply with the Code of Practice for Air Dispersion Modelling as contained in Appendix-A.

Short title and commencement

6. These regulations are called the Regulations Regarding Air Dispersion Modelling, 2014.

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

CODE OF PRACTICE FOR AIR DISPERSION MODELLING IN AIR QUALITY MANAGEMENT IN SOUTH AFRICA, 2014

APPENDIX A:

A supplement to the air dispersion modelling regulations providing technical standards on the application of air dispersion models.

EXECUTIVE SUMMARY – CODE OF PRACTICE FOR AIR DISPERSION MODELLING IN AIR QUALITY MANAGEMENT IN SOUTH AFRICA

Air quality management in South Africa has rapidly evolved from the control of a few contaminants emitted from industrial stacks to a complex network of management approaches in order to address a host of new, inter-related air quality issues. The National Environmental Management: Air Quality Act, Act 39 of 2004 (AQA) represents a distinct shift from exclusively source-based air pollution control to holistic and integrated effects based air quality management. In order to understand the complexities involved, decision makers are increasingly relying on atmospheric dispersion models as they provide a way to evaluate different emission control scenarios. Demonstrations of facilities compliance with the National Ambient Air Quality Standards (NAAQS) are frequently being based on dispersion modelling estimates rather than ambient air sampling results. Dispersion modelling is the only established tool for evaluating the impacts of future developments and quantitative answers to "what if" questions for environmentally sound, scientifically based as well as cost effective air quality management decisions.

Regulatory air dispersion modelling practices in South Africa have been operating in the absence of a standardised regulatory approach. This presents a number of challenges such as (1) air dispersion models are used by industry, consultancies and all levels of government at the discretion of modellers; (2) assessments to estimate the impacts of proposed or existing regulated industries on ambient air quality vary in terms of quality; (3) different regulatory authorities have different requirements in respect to estimating the impacts of proposed or existing regulated industries on ambient air quality and (4) the choice of methodology used to estimate the impacts of proposed or existing regulated industries on ambient air quality may be improperly influenced by the desired outcome of estimates.

In light of these challenges, the Department of Environmental Affairs (DEA) has developed these Air dispersion modelling regulations and **Code of Practice** for Air Dispersion Modelling in Air Quality Management in South Africa, hereafter called the **Code of Practice**. The **Code of Practice** is a supplement to the air dispersion modelling regulations providing technical standards on the application of air dispersion models. The regulations have been developed under paragraphs (f) of Section 53 of the AQA. They are applicable in the development of Air Quality Management Plans (AQMPs), as contemplated in Section 15 of the AQA; priority area AQMPs, as contemplated in Section 19 of AQA; atmospheric impact reports, as contemplated in Section 30 of the AQA and in an application for an atmospheric emission license (AEL) for such documentation and information as may be required by the licensing authority as contemplated in Section 37 (2)(b) of the AQA. The later would include documentation such as the specialist air quality impact assessment report as is prescribed in the National Framework for Air Quality Management in the Republic of South Africa.

The objectives of the air dispersion regulations are to standardise model applications for regulatory purposes and to make sure that dispersion modelling practices in South Africa are undertaken in a compatible form, thus ensuring that results from one dispersion modelling study can be compared directly to those from another. The regulations will ensure consistency and equity in the applications of models thereby creating confidence and transparency of appropriate model applications. They will provide the necessary procedures and protocols that will ensure standardisation and consistency in assessing discharges to the atmosphere when using air dispersion models so that, for example, all atmospheric emission licence applicants are treated equitably.

The **Code of Practice** recommends a suite of dispersion models to be applied for regulatory practices. It also provides guidance on modelling input requirements, protocols and procedures to be followed. The **Code of Practice** will assist dispersion modellers by providing a step-wise approach to good modelling practices when:

- Defining assessment objectives and scope of a modelling study.
- Selecting the most appropriate model for a task based on the required air quality assessment levels and criteria.
- Selecting the most appropriate data (emissions, meteorological and terrain data) to put into the model.
- Presenting modelling study reports with sufficient information for the regulatory authority to make an informed decision.

The **Code of Practice** is structured as follows:

- **Chapter 1** provides an overview of the purpose, legislative and policy context, and scope of the **Code of Practice.**
- **Chapter 2** presents the typical levels of assessments, technical summaries of the prescribed models (SCREEN3, AERSCREEN, AERMOD, SCIPUFF, and CALPUFF) and good practice steps to be taken in modelling applications.
- **Chapter 3** prescribes the source data input to be used in the models. This chapter provides guidance on how emission sources are to be defined (emission rates, source types) and how special sources such as flaring sources, fugitives and storage tanks are to be represented in air dispersion models.
- **Chapter 4** prescribes meteorological data input from onsite observations to simulated meteorological data. The chapter also gives information on how missing data and calm conditions are to be treated in modelling applications.
- **Chapter 5** provide guidance on geophysical data, model domain and coordinates system required in dispersion modelling.
- **Chapter 6** prescribes the general modelling parameterisations to be considered when carrying out regulatory modelling.
- **Chapter 7** outlines how the plan of study and modelling assessment reports are to be presented to authorities. This chapter also provides standard reporting checklists with the expected reporting requirements. The chapter gives guidance on information to be provided to the authorities to allow for a full understanding of the modelling results and how they were derived.

This **Code of Practice** is targeted at modellers undertaking atmospheric dispersion modelling for regulatory purposes in South Africa. The audience includes regulatory authorities, environmental consultancies, industrial companies, and academia and research institutes.

The **Code of Practice** is a live document, regularly subject to revisions to improve its content and to take account of emerging best practices, advancements in dispersion models, and improvements in input data as they emerge in future.

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ACRONYMS AND SYMBOLS

AQA	National Environmental Management: Air Quality Act, Act No 39 of 2004
AEL	Atmospheric Emission Licence
AERMOD	AMS/EPA Regulatory MODel
AERSCREEN	Screening-level version of AERMOD
AQMP	Air Quality Management Plan
BPIP	Building Profile Input File
CALMET	A diagnostic 3D wind filed program in the CALPUFF Model
CALPUFF	A non-steady state Gaussian puff model developed by the Sigma Research Corporation for the California Air Resources Board
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism (now DEA)
GEP	Good Engineering Practice
MetUM	United Kingdom Meteorological Office Unified Model
MM5	5th-generation Mesoscale Model – A prognostic meteorological model
NAAQS	National Ambient Air Quality Standard
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides ($NO_X = NO + NO_2$),
PM_{10}	Particulate matter with aerodynamic diameter equal or less than 10 μm
$PM_{2.5}$	Particulate matter with aerodynamic diameter equal or less than 2.5 μm
PRIME	Plume Rise Model Enhancements
SAWS	South African Weather Service
SCICHEM	A combined puff and gas-phase chemistry model for SCIPUFF
SCIGEO	A geophysical processor which prepares the terrain and land cover properties to be used by the meteorological processor SCIMET
SCIMET	A diagnostic 3D wind filed program in the SCIPUFF Model
SCIPUFF	Lagrangian puff dispersion model that uses a collection of Gaussian puffs to represent an arbitrary, three-dimensional, time-dependent concentration field
SCREEN3	An easy-to-use dispersion model for obtaining pollutant concentration estimates based on screening-level procedures
SO_4	Sulphate, a salt of sulphuric acid
SO_2	Sulphur dioxide
TAPM	The Air Pollution Model
US EPA	United States (of America) Environmental Protection Agency
UTM	Universal Transverse Mercator geographic grid
WRF	Weather Research and Forecasting – A prognostic meteorological model

1 INTRODUCTION

1.1 Background

Air quality management in South Africa has rapidly evolved from the control of a few contaminants emitted from industrial stacks to a complex network of management approaches to address a host of new, inter-related air quality issues. The National Environmental Management: Air Quality Act, Act No. 39 of 2004 (AQA) represents a distinct shift from exclusively source-based air pollution control to holistic and integrated effects based air quality management. It focuses on the adverse impacts of air pollution on the ambient environment and sets standards to control ambient air quality levels. At the same time, it sets emission standards to minimise the amount of pollution that enters the environment.

The objects of the AQA are as follows:

- To protect the environment by providing reasonable measures for -
    - the protection and enhancement of the quality of air in the Republic;
    - the prevention of air pollution and ecological degradation; and
    - securing ecologically sustainable development while promoting justifiable economic and social development; and
- Generally to give effect to Section 24(b) of the Constitution in order to enhance the quality of ambient air for the sake of securing an environment that is not harmful to the health and well-being of people.

Air pollution involves multiple contaminants emitted from a variety of sources over a range of spatial (local to global) and temporal scales (instantaneous to decades). In order to understand the complexities involved, decision makers are increasingly relying on dispersion models as they provide a way to evaluate different emission control policy scenarios that would be expensive, difficult, or destructive to do in the real world. Take for example, the regulatory process involving the permitting of sources of regulated pollutants; this process requires sources to demonstrate that National Ambient Air Quality Standards (NAAQS) of criteria pollutants are not exceeded as a result of released pollutants. The demonstration of the facility's compliance with the NAAQS is more frequently being based on dispersion modelling estimates rather than ambient air sampling results. For future developments, the only way to predict if regulations will be satisfied by a facility or modification that does not yet exist is to use dispersion models to simulate the impacts of the project. Dispersion models are often the only cost-effective method to understand the interaction of existing or future emission sources, with meteorology, topography, and existing air quality. The models generate quantitative answers to "what if" questions for environmentally sound, and scientifically based air management decisions.

Regulatory atmospheric dispersion modelling practices in South Africa have been operating in the absence of a standardised regulatory approach. This presents a number of challenges because:

- Air dispersion models are used by industry, consultancies and all levels of government at the discretion of modellers
- Assessments to estimate the impacts of proposed / existing regulated industries on ambient air quality vary in terms of quality
- Different regulatory authorities have different requirements in respect to estimating the impacts of proposed or existing regulated industries on ambient air quality and

- The choice of methodology used to estimate the impacts of proposed/existing regulated industries on ambient air quality may be improperly influenced by the desired outcome of estimates.

Due to these challenges;

- Regulatory decisions may be ill-informed and even misled by poor quality estimates of the impacts of proposed developments on ambient air quality
- Review of estimates of the impacts of proposed developments on ambient air quality by regulatory authorities can be problematic and
- Comparison of results, accuracy and quality etc, used to estimate the impacts of proposed developments on ambient air quality can be problematic.

All these factors result in inconsistent approaches in estimating proposed impacts. An inconsistent approach and / or poorly executed study can generate false predictions of the overall impact of an existing or planned facility or emission source. Without robust standards, regulatory modelling can become an "anything goes" process, whereby modelling options might be selected to achieve the desired outcome, rather than based on the best science.

In light of these challenges, the Department of Environmental Affairs (DEA) has developed these Air dispersion modelling regulations and **Code of Practice** for Air Dispersion Modelling in Air Quality Management in South Africa, hereafter called the **Code of Practice.** The **Code of Practice** is a supplement to the air dispersion modelling regulations providing technical standards on the application of air dispersion models. It provides the necessary procedures and protocols that will ensure standardisation and consistency in assessing discharges to the atmosphere when using air dispersion models so that, for example, all licence applicants are treated equitably.

1.2 Objectives of the Code of Practice

The principal objectives of this **Code of Practice** are to provide good modelling practice so as to:-

- Standardise model applications for regulatory purposes and to make sure that dispersion modelling practices in South Africa are undertaken in a compatible form, thus ensuring that results from one dispersion modelling study can be compared directly to those from another.
- Ensure consistency and equity in the applications of models from procedures, possibilities and limitations of models.
- Create confidence in and transparency of appropriate model applications.
- Encourage applications of the best available science in regulatory practices so that models are used as 'fit for purpose'.
- Allow regulators to interrogate results of dispersion modelling studies in an informed and standard method.

This **Code of Practice** is intended to assist dispersion modellers by providing a step-wise approach to good modelling practices when:

- Defining assessment objectives and scope of a modelling study.
- Selecting the most appropriate model for a task based on the required air quality assessment levels and criteria.
- Selecting the most appropriate data (emissions, meteorological and terrain data) to put into the model.

- Presenting modelling study reports with sufficient information for the regulatory authority to make an informed decision.

1.3 Legislative and Policy Context

The air dispersion modelling regulations have been developed under Section 53 (f) of AQA. They are applicable in the development of an Air Quality Management Plans (AQMPs), as contemplated in Section 15 of the AQA; priority area air quality management plans, as contemplated in Section 19 of AQA; atmospheric impact reports, as contemplated in Section 30 of the AQA and in the application for an atmospheric emission license (AEL) for such documentation and information as may be required by the licensing authority as contemplated in Section 37 (2)(b) of the AQA. Such documentation includes specialist air quality impact assessment report as is prescribed in the National Framework for Air Quality Management in the Republic of South Africa.

1.3.1 Air Quality Management Plans

Section 15(1) of AQA requires that each national department or province responsible for preparing the environmental implementation plan and the environmental management plan includes an AQMP as part of the plan. For local governments, Section 15(2) of the AQA requires each municipality to include an AQMP in its Integrated Development Plan (IDP) in terms of Chapter 5 of the Municipal Systems Act. Section 19 of the AQA requires that the competent authority prepare a priority area AQMP if the Minister/ MEC has declared an area as such. The national department has developed an AQMP manual with best practice guidelines on AQMP objectives, strategies, plans and procedures for each sphere of government, in order to meet the requirements of the AQA on good air quality management planning and reporting (DEAT 2008). This **Code of Practice** provides guidance on the use of air dispersion models within the AQMP processes and must be used in conjunction with the AQMP manual. Where more complex atmospheric processes are to be considered in AQMP modelling studies, for example the treatment of ozone and particulate matter formation, models recommended in this **Code of Practice** might not suffice. The modellers are encouraged to use photochemical grid models, such as Models-3 / Community Multi-scale Air Quality (CMAQ) modelling system, NAME (Numerical Atmospheric-dispersion Modelling Environment), WRF-CHEM, or CMAx (Comprehensive Air quality Model with extensions). However, even when complex models have been used in the development of an AQMP, reporting requirements prescribed in Chapter 7 of this **Code of Practice** will still apply.

1.3.2 Atmospheric Impact Reporting

According to Section 30 of the AQA, an air quality officer may require any person to submit to the air quality officer an atmospheric impact report in a prescribed form if:

a) the air quality officer reasonably suspects that the person has on one or more occasions contravened or failed to comply with AQA or any conditions of the licence and that such a contravention or failure has had, or may have detrimental effect on the environment, social conditions, economic conditions, ecological conditions or cultural heritage or has contributed to the degradation of ambient air quality; or
b) a review of a provincial atmospheric emission licence or an atmospheric emission licence is undertaken in terms of Section 45 of the AQA.

This **Code of Practice** provides guidance on the application of air dispersion models in the preparation of an atmospheric impact report.

1.3.3 Environmental Impact Management

Section 37 (1) and (2) of the AQA prescribes that:

(1) A person must apply for an atmospheric emission license by lodging with the licensing authority of the area in which the listed activity is or is to be carried out, an application in the form required by the licensing authority
(2) An application for an atmospheric emission license must be accompanied by –
    a. the prescribed processing fee
    b. such documentation and information as may be required by the licensing authority.

Listed activities authorisations are required to undertake an Environmental Impact Assessment (EIA), which, depending on the activity, might require a specialist air quality impact assessment study (DEA 2010). The National Framework for Air Quality Management (hereafter called the National Framework) describes the linkages between the EIA process and the AQA's atmospheric emission licensing (AEL) application process. This **Code of Practice** provides guidance on the applications of air quality models in undertaking air quality specialist impact studies as part of the environmental impact assessment. The key requirements of the specialist impact study must take into account, amongst others, the pollution being or likely to be caused by that activity and the effect on the environment, including health, economic conditions, cultural heritage and ambient air quality. The information must be available to inform the decision through the specialist air quality impact assessment report, which must be outlined as prescribed in Chapter 7 of this **Code of Practice**.

1.3.4 Other Applications

The **Code of Practice** may be used to establish point and non-point sources emission standards for a province/local municipality, or any geographical area within the province/local municipality, stricter than the national emission standards according to Section 10 and 11 of the AQA. This **Code of Practice** may be used in incident investigations, emergency planning and response and in designing ambient monitoring networks as appropriate. For specialised cases such as modelling emissions from highways, dense gas releases or cooling towers, special models not recommended in this **Code of Practice** must be considered, with the approval of the competent reviewing / licensing authority.

1.4 Audience

This **Code of Practice** is targeted at model users undertaking atmospheric dispersion modelling for regulatory purposes in South Africa. The audience includes regulatory authorities, government departments, environmental consultancies, industrial companies, and academia and research institutes.

1.5 Code of Practice Development and Review Process

The DEA has developed this **Code of Practice** in partnership with an Air Dispersion Modelling Working Group. The Working Group is a body of atmospheric-science and modelling experts set up in 2010 to support the DEA in providing air dispersion modelling guidance nationally. The group is comprised of professionals from the government and its agencies, industries, environmental consultancies, the academia and research institutes familiar with the South African regulatory processes. Participation in the Working Group is on a voluntary basis. The group is coordinated and chaired by the DEA's, Chief Directorate: Air Quality Management.

The DEA will continue to work with the Working Group and conduct workshops annually in order to maintain guidance on the use of dispersion models and will review and revise the **Code of Practice** when necessary. Feedback from these workshops will be presented to the **Code of Practice** users in line with the public participation process of the Air Quality Act. The DEA will also give feedback during the annual National Air Quality Governance Week in order to engage with a range of multistakeholders in attendance, namely the regulatory officials attending the Annual Air Quality Governance Lekgotla and academia, environmental consultancies and industries attending the National Association for Clear Air (NACA) annual conference.

The DEA will use these workshops to:

- Provide additional guidance or clarification in the application of recommended models.
- Solicit review of the modelling standards from the technical and user community for continuous improvement of the **Code of Practice** and;
- Identify any gaps in the standards and general applications of air dispersion models.

The **Code of Practice** is subject to revisions in order to correct errors, clarify guidance, and to reflect updates as new models, techniques and datasets become available. Comments or suggestions in this regard must be submitted to the National Air Quality Officer for consideration. The requests must be supported by peer-reviewed scientific journal articles as justification. In addition, since this **Code of Practice** is recommending US EPA regulatory models, reviewing of the **Code of Practice** shall also closely follow the US EPA guidelines or model developments unless otherwise specified by the DEA.

1.6 Scope and Structure of Code of Practice

The **Code of Practice** provides explicit recommendations when applying models in air quality management. It recommends a suite of dispersion models to be applied for regulatory practices and it provides guidance on modelling input requirements, protocols and procedures to be followed. However, it is impossible to provide detailed procedures for every situation given the diversity of the recommended models and their applications to different sources, topography and meteorological combinations. As such, professional judgment of technical experts conducting the modelling exercise, and those carrying out the regulatory tasks will always be required. The need for communication between persons conducting the modelling, reviewing the modelling results and decision-makers are always paramount. This **Code of Practice** cannot substitute training requirements in dispersion modelling. Individuals unfamiliar with dispersion modelling techniques/ applications are encouraged to pursue training courses offered by a range of institutes in South Africa.

The **Code of Practice** is structured as follows:

- **Chapter 1** provides an overview of the purpose, legislative and policy context, and scope of the **Code of Practice**.

- **Chapter 2** presents the typical levels of assessments, technical summaries of the prescribed models (SCREEN3, AERSCREEN, AERMOD, SCIPUFF, and CALPUFF) and good practice steps to be taken for modelling applications.
- **Chapter 3** prescribes the source data input to be used in the models. This chapter provides guidance on how emissions source are to be defined (emission rates, source types) and how special sources such as flaring sources, fugitives and storage tanks are to be represented in the air dispersion models.
- **Chapter 4** prescribes meteorological data input from onsite observations to simulated meteorological data. The chapter also gives information on how missing data and calm conditions are to be treated in modelling applications.
- **Chapter 5** outlines the geophysical data, model domain and coordinates system required in carrying out air dispersion modelling.
- **Chapter 6** prescribes the general modelling parameterisations to be considered when carrying out regulatory modelling.
- **Chapter 7** outlines how the plan of study and modelling assessment reports are to be presented to competent authorities. This chapter also provides standard reporting templates and checklists on reporting requirements. The chapter gives guidance on information to be provided to the authorities to allow for a full understanding of the modelling results and how they were derived.

2 MODEL APPLICATIONS AND RECOMMENDED MODELS

2.1 Levels of Assessment

This chapter borrows heavily from the British Columbia dispersion modelling guideline (British Columbia 2008). The purpose of the chapter is to provide guidance on the use of a tiered approach in defining the levels of assessment required in a modelling application. This **Code of Practice** recommends a number of dispersion models to be used in regulatory applications in South Africa. This requires a modeller to assess the application and identify which model would best provide the essential information to the regulatory authority with the detail and accuracy required in the application. Air quality assessments can vary in their level of detail and scope, which in turn is determined by the objectives of the modelling effort, technical factors and the level of risk associated with the project emissions.

A classical tiered approach in the selection of an air dispersion model is recommended, in which simpler screening models (**Level 1**) are first considered before moving to more advanced models if the situation requires (**Level 2 or 3**). The screening techniques must be used on relatively simple applications to provide conservative estimates of air quality impact using (preset) worst-case meteorological conditions. Otherwise, refined models must be applied where detailed treatment of physical and chemical atmospheric processes are required. The tiered approach minimises the cost and time required to do an assessment or licence application. It allows for flexibility in selecting a model that is most appropriate for a given application based on the assessment. Where a preliminary/conservative estimate is desired, acceptable screening techniques must be used, followed by the appropriate refined analysis.

The level of assessment must depend on the technical factors to be considered in the modelling exercise such as the geophysical, emissions and meteorological conditions. The assessment must also depend on the level of risk associated with the emissions and hence the level of detail and accuracy required from a model. The following factors can help a modeller distinguish between high and low level risk situations:

- Contaminant type.
- Amounts emitted.
- Current levels of air pollution in the area (pristine or already degraded).
- Sensitivity of the surrounding area (environmental and human).
- Geophysical setting (sheltered valley vs. open area).
- Environmental footprint of the facility.
- Future situation (land use, changes in sensitivity due to anticipated growth).
- Public interest or concern.
- Consequences of decisions that will be made based on model output.

2.1.1 Level 1 Assessment

Level 1 assessment provides an estimate of the worst-case air quality impacts. As such, screening models are sufficient for this level. Level 1 assessment must be used for:

- Licence / approval decisions for typically single sources.
- Preliminary identification of air quality issues associated with proposed new sources or modifications to existing sources.

- Identification of the need for more detailed modelling using Level 2 or 3 assessment approaches (if exceedances of short-term objectives are predicted) and;
- Confirmation of refined model results that might appear unusually high or low.

2.1.2 Level 2 Assessment

Level 2 assessment must be used for air quality impact assessment in standard / generic licence or amendment processes where:

- The distribution of pollutant concentrations and depositions are required in time and space.
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. Although more complicated processes may be occurring (i.e., curved plume trajectory), a more complicated model that explicitly treats these processes may not be necessary depending on the purposes of the modelling and the zone of interest. For example, if the area of interest is within 100 m, then curvature effects and chemical transformations may not be critical.
- Emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km) downwind.

2.1.3 Level 3 Assessment

Level 3 assessments require more sophisticated models and corresponding input data, resources and model operator expertise. These more powerful models require detailed meteorological, geophysical and source input that may include:

- One or more years of site-specific meteorological data (e.g., wind speed, wind direction, temperature, turbulence and mixing height) at a number of sites in the domain of interest.
- Detailed emission inventories for point, line, area and volume sources in an airshed with speciation, emissions and time variations of different contaminants.

Level 3 assessment is used in situations where:

- The purpose of the assessment requires a detailed understanding of the air quality impacts (time and space variation of the concentrations).
- It is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types and chemical transformations.

Level 3 assessments may be used in situations where there is need to:

- Evaluate air quality consequences under a permitting or environmental assessment process for large industrial developments that have considerable social, economic and environmental consequences.
- Evaluate consequences of air quality management approaches that involve multi-source, multi-sector contributions from permitted and non-permitted sources in an airshed.
- Assess contaminants resulting from non-linear processes where less refined models may only have crude treatments (e.g., deposition, ground-level ozone, particulate formation, visibility).
- Provide information to support environmental, human and economic effects studies
- Examine specific receptors that may be sensitive or of special interest such as residential areas and sensitive ecosystems.

- Assess contaminants in meteorologically complex situations such as mountain valley flows, reversals, sea breeze, and fumigation.
- Assist in understanding the underlying source and meteorological causes of episodes.

2.2 Recommended Regulatory Air Dispersion Models

For this first edition of the **Code of Practice** for Air Dispersion Modelling in South African, all models recommended are US EPA regulatory models. The models have been identified to adequately address the three assessment levels described above. Additionally, the models were selected based on a national baseline review conducted by the DEA in 2010. The purpose of the assessment was to recognise the common models that were being used nationally; the applications these models were being used for and the level of dispersion modelling expertise in the country. The information was collated through questionnaires that were distributed to a range a modellers in industry, government and environmental consultancies.

Models recommended here have gone through the US EPA processes of initial model formulation; developmental evaluation; internal peer review and beta testing; revised model formulation; performance evaluation and sensitivity testing; external peer review; and submission to US EPA's Office of Air Quality Planning and Standards (OAQPS) for consideration as regulatory models. The models are based on sound scientific principles, with established scientific merit, reviews, evaluations and documentation (US EPA 2005). These models are also used widely by a number of countries worldwide such as Australia, New Zealand and Canada (New Zealand EPA 2004; British Columbia 2008; Ontario Environment 2009).

The recommended model codes/ executables, supporting documentation and other useful information are available for downloading from the US EPA Support Centre for Regulatory Air Modelling (SCRAM) internet website, http://www.epa.gov./scram001. The model codes and supporting documents are not static but evolve to accommodate the best available science. Unless otherwise stated, the latest version of each model is the recommended version to be used in this **Code of Practice**. Modellers are encouraged to check this website regularly for updates to model codes and associated documents. The DEA will also provide updates regularly through the South African Air Quality Information System website (SAAQIS, http://saaqis.environment.gov.za). It is up to the users to decide on the model interface packages for visualisation, plotting and presentation of model outputs, as long as the model output is appropriately represented. Subsequent sections give technical summaries of the recommended regulatory models for South Africa, and users are encouraged to refer to the model technical guidelines for more details.

2.2.1 SCREEN3

SCREEN3 is the recommended tool to calculate screening-level impact estimates for stationary sources in simple terrain, i.e., Level 1 assessments. Simple terrain is defined as that in which terrain elevations are lower in elevation than the top of the stack height of the source being evaluated in the modelling analysis. SCREEN3 is a Gaussian plume model which provides maximum ground-level concentrations for point, area, flare, and volume sources (US EPA 1992). The model is a single source model and impacts from multiple SCREEN3 model runs can be summed to conservatively estimate the impact from several sources. SCREEN3 calculates 1-hour concentration estimates in simple terrain areas and 24-hour concentration estimates in complex terrain. These modelled estimates must be converted to the averaging period of each applicable national ambient air quality standards as detailed in Chapter 6.4.

SCREEN3 incorporates source related factors and meteorological factors to estimate pollutant concentration from continuous sources. The model assumed that the pollutant does not undergo any chemical reactions, and that no other removal processes (wet or dry deposition) act on the plume during its transportation. SCREEN3 examines a range of stability classes and wind speeds to identify the combination of wind speed and stability that results in the maximum ground level concentrations – the "worst case" meteorological conditions. Except for those sources employing the Schulman-Scire downwash algorithm, stack tip downwash is estimated following Briggs equations. Building downwash effects are estimated for the cavity recirculation and wake (near and far) regions. Sources subject to aerodynamic turbulence induced by nearby buildings and structures must use the building downwash options. Dispersion coefficients are estimated from the Pasquill-Gifford (rural) and McElroy-Pooler (urban) methods based on the Industrial Source Complex (ISC3) formulations. The dispersion coefficients are adjusted to account for the effects of buoyancy induced dispersion. The model can also estimate maximum concentrations from inversion break-up and shoreline fumigations (US EPA 1992).

SCREEN3 is recommended for use on:

- Single point, area, volume sources.
- Single building effects on point source.
- Building wake cavity concentrations.
- Flare releases.
- Transport distances of less than 50 km in simple terrain.

2.2.2 AERSCREEN

AERSCREEN is a screening-level air quality model based on AERMOD (US EPA 2004) used for Level 1 assessments. The model consists of two main components: 1) the MAKEMET program which generates a site-specific matrix of meteorological conditions for input to the AERMOD model; and 2) the AERSCREEN command-prompt interface program. AERSCREEN interfaces with MAKEMET for generating the meteorological matrix, but also interfaces with AERMAP and BPIPPRM to automate the processing of terrain and building information respectively, and interfaces with the AERMOD model utilising the SCREEN option to perform the modelling runs. AERSCREEN interfaces with version 09292 and later versions of AERMOD and will not work with earlier versions of AERMOD. The AERSCREEN program also includes averaging time factors for worst-case 3-hr, 8-hr, 24-hr and annual averages. AERSCREEN is intended to produce concentration estimates that are equal to or greater to estimates produced by AERMOD with a fully developed set of meteorological and terrain data, but the degree of conservatism will vary depending on the application. Details on AERSCREEN can be found elsewhere (US EPA 2011).

AERSCREEN is recommended for use on:

- Single point, area, volume sources.
- Single building effects on point source.
- Building wake cavity concentrations.
- Flare releases.
- Transport distances of less than 50 km in simple terrain.

A number of regulatory guidelines in other countries are opting to use AERSCREEN instead of SCREEN3. However, for South Africa, AERSCREEN is still marginally used, while SCREEN3 is the most commonly used model in the country. As such, this Code of Practice is recommending both screening models to accommodate all users.

2.2.3 AERMOD

AERMOD (AERMOD Version 13350 or later version) is the recommended model for more sophisticated near-source applications in all terrain types (where near-source is defined as less than 50km from source). The model can mostly be applied to Level 2 assessments. A short overview of the AERMOD is given below, and full details can be found elsewhere (US EPA 2004).

AERMOD is a steady-state plume dispersion model for simulating transport and dispersion from point, area, or volume sources based on an up-to-date characterization of the atmospheric boundary layer. The model can be applied to rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources, including, point, area and volume sources. In the stable boundary layer (SBL), AERMOD assumes the concentration distribution to be Gaussian in both the vertical and horizontal. In the convective boundary layer (CBL), the horizontal distribution is also assumed to be Gaussian, but the vertical distribution is described by a bi-Gaussian probability density function (pdf) of the vertical velocity. The transport and dispersion of a plume in the CBL is characterised as the superposition of three modelled plumes; the direct plume (from the stack), the indirect plume, and the penetrated plume. The indirect plume accounts for the lofting of a buoyant plume near the top of the boundary layer, and the penetrated plume accounts for the portion of a plume that, due to its buoyancy, penetrates above. AERMOD is applicable to primary pollutants and continuous releases of toxic and hazardous waste pollutants. Chemical transformation of pollutants is treated by simple exponential decay.

This **Code of Practice** recommends meteorological fields generated by the meteorological pre-processor AERMET as the preferred mode of running AERMOD. AERMET uses standard meteorological measurements and surface parameters representative of the modelling domain to compute boundary layer parameters used to estimate profiles of wind, turbulence and temperature used by AERMOD.

AERMOD incorporates Plume Rise Model Enhancements (PRIME) building downwash algorithms which provide a more realistic handling of building downwash effects, see Chapter 6.4.2. PRIME algorithms were designed to address two fundamental features associated with building downwash; enhanced plume dispersion coefficients due to the turbulent wake; and to reduce plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake.

AERMOD is suitable for a wide range of near field applications in both simple and complex terrain. The evaluation results for AERMOD, particularly for complex terrain applications, suggest that the model represents significant improvements compared to previously recommended models, and has even outperformed the more complex CTDMPLUS model on several databases (US EPA 2005).

AERMOD has been designed to handle light wind conditions (wind speeds less than 1m/s) well, and also incorporates an approach for treatment of horizontal meander that can be significant under such conditions. The model can also accept multiple levels of site-specific wind measurements and will determine the transport direction for each source based on the wind direction from the vertical profile appropriate for the individual plume.

AERMOD is recommended for use on:

- Sources in an industrial complex (single or multiple point, area, line, volume sources) with no buildings or single or multiple buildings with building downwash.
- Gas and particle depositions.
- Constant or time-varying emissions.
- Rural or urban areas.

- Transport distances over which steady-state assumptions are appropriate, less than 50 km (depends on terrain).
- Concentration estimates for all terrain locations, except in lee areas.

A flow-chart for running AERMOD is given in the appendix.

2.2.4 CALPUFF

CALPUFF Version 6.42 is the recommended model for dispersion applications requiring detailed description of physical and chemical atmospheric processes, typically associated with Level 3 assessments for distances greater than 50 km. While the US EPA currently recommends CALPUFF v.5.8, we note that later versions are available, which correct well-known errors and shortcomings of the earlier versions. At the current time, we recommend either version 6.42. The continuing evolution of this model will necessitate updates to this **Code of Practice**. CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion modelling system that simulates the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. Full details on CALPUFF can be found elsewhere (Scire, Strimaitis et al. 2000). The model can simulate emissions at downward distances ranging from tens of metres up to 300 km for multiple point, volume, area and/or line sources with constant or variable emission rates. CALPUFF includes algorithms for near-field effects such as stack tip downwash, building downwash, transitional buoyant and momentum plume rise, rain cap effects and partial plume penetration into elevated temperature inversions. To solve the many computational difficulties in applying a puff model in the near-source-fields, CALPUFF includes two accurate and computationally efficient puff sampling routines. An elongated puff (slug) routine is applied in the near-field during rapidly varying meteorological conditions, otherwise an integrated puff approach is used. For building downwash effects, CALPUFF contains options for the user to specify the Huber-Snyder or Schulman-Scire routines for all stacks or on a stack-by-stack preference. The model includes algorithms, subgrid scale terrain and coastal interactions effects, and terrain impingement as well as longer range effects such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, vertical wind shear effects, overwater transport, plume fumigation, and visibility effects of particulate matter concentrations.

CALPUFF can use different forms of meteorological input data (surface, profile, or gridded); however, this **Code of Practice** recommends 3D meteorological fields generated by CALMET as the preferred mode of running CALPUFF. The meteorological input data must be fully characterised with time-and-space-varying three dimensional winds and meteorological conditions using CALMET. Data used by CALMET can be from single station surface and upper air observations, 3D prognostic model outputs (e.g. from models such as MM5, Eta TAPM, Unified Model, WRF). The prognostic model outputs can be used in combination with or without station observations.

Plume rise algorithms in CALPUFF model are generalised for a variety of source types. CALPUFF contains an option for puff splitting algorithm that allows vertical wind shear effects across individual puffs to be simulated. Estimates of horizontal plume dispersion are provided from turbulence-based dispersion coefficients based on measured or computed coefficients. The model provides several options for calculating these dispersion coefficients from the use of (i) turbulence measurements (σ_v and σ_w) (ii) similarity theory to estimate σ_v and σ_w, (iii) Pasquill-Gifford (rural) and McElroy-Pooler (urban) dispersion coefficients.

CALPUFF can fully treat stagnant conditions, wind reversals such as those experienced in land-sea breezes, mountain-valley breezes and in very rugged terrain. Water bodies and coastal lines present spatial changes to meteorological and dispersion conditions due to the abrupt change in surface properties between land and water bodies. CALMET contains overwater and overland boundary layer algorithms that allows for the effects on plume transportation, dispersion and deposition to be simulated in CALPUFF. The model includes a subgrid scale complex terrain algorithm for terrain impingement. Plume impingement on subgrid scale hills is evaluated using a dividing streamline to determine which material of the plume is deflected around the hills or advected over the hills.

CALPUFF treats primary pollutants and simulates secondary pollutant formation using a parameterised, quasi-linear chemical conversion mechanism based on five species. Pollutants treated include sulphur dioxide (SO_2), sulphates (SO_4^{2-}), nitrogen oxides (NO_x, nitrogen oxides = nitric oxide + nitrogen dioxide i.e., NO + NO_2), nitric acid (HNO_3), aerosol nitrates (NO_3^-), ammonia (NH_3), particulate matter (both PM_{10} and $PM_{2.5}$), toxic pollutants and others pollutant species that are either inert or subject to quasi-linear chemical reactions. A resistance-based dry deposition scheme is included for deposition of both gasses and particulate matter. Wet deposition is treated using a scavenging coefficient approach with removal rate as a function of precipitation type and intensity. CALPUFF Version 6.42 contains new options for gas-phase chemistry, aqueous phase chemistry and aerosol chemistry based on ISORROPIA chemical module used in models such as CMAQ. However, to these options have not been evaluated enough to be acceptable.

CALPUFF is currently the recommended model for most long-range (i.e. > 50 km) modelling applications. The model is used for major projects nationally, and it already has a measure of acceptance and public credibility worldwide. CALPUFF could have a distinct advantage over the use of a steady-state plume models such as AERMOD for near field impact analyses. One type of application where CALPUFF may be better than AERMOD is when there are strong localised influences on the wind field, such as valley channelling, upslope / downslope flows, and coastal areas. CALPUFF also has the ability to simulate spatial and temporal variations of concentration fields better than steady-state plume models like AERMOD. This may be an important advantage for risk-based assessments in which the accurate prediction of average exposure levels across the population in an area is more important than the prediction of the maximum concentration in any one location. The other type of application where CALPUFF could provide some advantage over the steady-state plume models is with stagnation conditions. Stagnation conditions may be especially important given the potential for a build-up of excessively high concentrations over time.

CALPUFF is recommended for use for:

- Long-range transport distances between 50 and 300 km.
- Complex, non-steady-state meteorological conditions where transport distances are less than 50 km, on a case-by-case basis including:
  - inhomogeneous winds
  - inversion breakup fumigation
  - shoreline fumigation
  - stagnation conditions.
- No buildings, single or multiple buildings.
- Availability of detailed meteorological and geophysical inputs.
- Deposition and light extinction where long-range transport distances are greater than 50 km.
- Secondary formation of particulate matter in long-range transport distances greater than 50 km.
- Multiple source (point, area, volume) and buildings.

2.2.5 SCIPUFF

Like CALPUFF, SCIPUFF is another recommended model for Level 3 assessments requiring detailed description of physical and chemical atmospheric processes, typically associated with Level 3 assessments. SCIPUFF is a Lagrangian puff dispersion model that uses a collection of Gaussian puffs to represent an arbitrary, three-dimensional, time-dependent concentration field. The turbulent diffusion parameterization is based on modern turbulence closure theory, specifically the second-order closure model of Donaldson (1973) and Lewellen (1977), which provides a direct relationship between the predicted dispersion rates and the measurable turbulent velocity statistics of the wind field. In addition to the average concentration value, the closure model also provides a prediction of the statistical variance in the concentration field resulting from the random fluctuations in the wind field. The closure approach also provides a direct representation for the effect of averaging time (Sykes and Gabruk 1997).

SCIPUFF is appropriate for modelling both short and long range (greater than 50km) transport, steady or non-steady state emissions of primary pollutants (gases or particles), buoyant or neutral sources using time-dependent meteorological data (surface, profile, or gridded). Shear distortion, complex terrain, linear chemical transformations, gravitational settling and deposition are treated. In addition to the mean concentration, dose and deposition, SCIPUFF provides an estimate of the probability levels of the predicted values. SCIPUFF has been extensively validated and compares favourably against comparison with CALPUFF and AERMOD (Lee, Peltier et al. 2009). These validation studies started as early as 1988 (Sykes, Lewellen et al. 1988) and (Sykes, Parker et al. 1993).

SCIPUFF contain pre-processors that work in similar manner to those used in the CALPUFF air dispersion modelling system. It contains a geophysical processor, named SCIGEO, which prepares the terrain and land cover properties to be used by the meteorological processor (SCIMET). One additional advantage of SCIMET is that unlike CALMET is does not require guessing "radius of influence" such as RMAX1, RMAX2, RMAX3, R1, R2, and TERRAD. Therefore, SCIMET facilitate the creation of the three-dimensional wind fields by the modeller and reduces uncertainties on the review process by the regulatory agency. The SCIPUFF modelling system input files were designed by SAGE and Lakes Environmental to be almost identical to the AERMOD modelling system. This way, SCIMET input files are almost identical to AERMET input formats, as well as the data format for SCIPUFF is almost identical to the ones for AERMOD (with all the keywords, including CO, SO, RE, and OU pathways).

Recent updates to SCIPUFF are currently being implemented in order to integrate SCICHEM and SCIPUFF into a single dispersion model with a more complex and realistic representation of gas, aqueous and aerosol chemistry and transformation. While this work is still in the testing stages at the time this **Code of Practice** are being finalized, this model holds promise for providing a superior treatment of pollutant concentrations when chemical transformations are important to characterize.

2.3 Good Modelling Practice Steps

Similar to Chapter 2.1, this section borrows largely from the British Columbia dispersion modelling guideline (British Columbia 2008). The purpose of this section is to provide general guidance on the steps involved in good modelling practice as illustrated in Figure 1. Although the level of detail in each of these steps will vary for different assessment levels and modelling studies, this flow chart provides a useful guide for every modelling application. (An additional flowchart for running AERMOD is included in Chapter 8). A discussion of each of these steps is provided below, with reference to the respective chapters in the **Code of Practice** for details. These modelling steps must be followed in conjunction with the relevant requirements for each regulatory application. For atmospheric emission licensing and EIA processes the EIA/AEL intergovernmental cooperation and coordination illustrated in the National Framework and subsequent EIA regulations must be followed; and for the AQMP development, the AQMP manual must be followed (DEAT 2008).

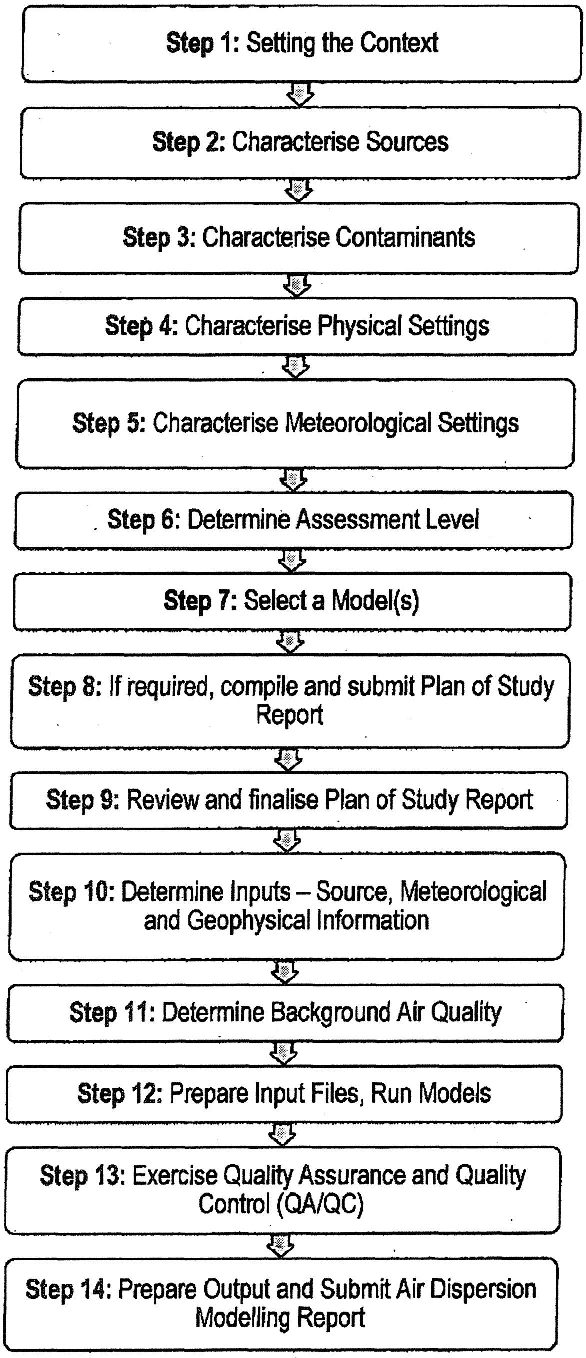

Figure 1. The 14 Steps to Good Modelling Practice (adapted from British Columbia 2008).

2.3.1 Step 1: Setting the Context

The modeller must explicitly define the purpose(s) and objectives of the air dispersion modelling under consideration. Objectives that are determined at an early stage will define the scope of the study and identify modelling requirements before allocating resources.

2.3.2 Step 2: Characterise Sources

The modeller must gather information on the sources of emissions to conduct the air dispersion modelling study based on the purpose and objectives of the study identified in Step 1. Chapter 3 provides detailed guidance that must be followed in characterising sources.

2.3.3 Step 3: Characterise Contaminants

Based on the sources identified in Step 2, the modeller must gather information on the type of contaminants to be considered, including methods to determine appropriate pollutants emission rates.

2.3.4 Step 4: Characterise Physical Setting

The modeller must identify the modelling domain required where air quality impacts will be assessed. The size of the modelling domain is dependent on the source of emissions and any overlapping effects from other sources. For screening purposes in a flat terrain, it may be sufficient to define the domain on the basis of the distance from the sources of concern to the receptors of interest. Refined modelling assessments normally use a grid of receptors over a wide domain. Guidance for determining the size of the modelling domain and the density of receptors are provided in Chapter 6.4. The geophysical characteristics (buildings, terrain and land use) in the model domain and the atmospheric behaviour (flow deflection, thermally driven flows, stagnations and wind direction variability) must be assessed in terms of how these characteristics affect flow complexity.

2.3.5 Step 5: Characterise Meteorological Setting

The modeller must confirm the availability and representativeness of meteorological data (surface and upper air observations or gridded data) appropriate for the modelling domain where air quality impacts will be assessed. The choice of meteorological data is determined by the level of assessment required. Chapter 4 provides detailed guidance on meteorological data required for modelling.

2.3.6 Step 6: Determine Assessment Level

Steps 1 to 3 are all information gathering procedures, which provide the modeller with an understanding on the assessment level required to meet the objectives of the modelling study. The considerations discussed in Chapter 2.1 (information requirements, technical factors, and level of risk) help determine the level of effort required and the corresponding level of assessment. An air quality assessment should answer two fundamental questions:

- Which model provides the necessary information for the decision maker to make an informed decision?
- What level of detail and accuracy is required for the analyses?

2.3.7 Step 7: Select Model(s)

After Steps 1 to 6, the modeller is in a position to select the model(s) by reviewing the technical capabilities of the models and their recommended use.

- If more than one model is appropriate, i.e., the models meet the technical requirements and provides the required information for the level of assessment, the modeller must select the model that is easiest to apply.
- If none of the models recommended in this **Code of Practice** are appropriate, the regulatory relevant authority must review the merit of using any other proposed model.

2.3.8 Step 8: Compile and Submit Plan of Study

For an detailed AEL or EIA/AEL application, a plan of study is required as part of the application process (DEAT 2009). The plan of study must provide a general overview of the intended modelling approach and will facilitate further discussions between the regulatory authority and those conducting the assessment. Recommendations on documentation requirements are presented in Chapter 7.2.1. The section also includes a standard reporting template for presenting air dispersion modelling reports.

2.3.9 Step 9: Review and Finalise Plan of Study Report

The responsible authority must review the plan of study report. The report must be amended as required before the comprehensive modelling study is initiated. This is especially important when an extensive air quality assessment is planned as considerable resources are required for collecting the input data, running the models, and organising the output in a way that will be meaningful to both the public and to decision makers.

2.3.10 Step 10: Determine Inputs – Source, Meteorological and Geophysical Data

Parameters for the different sources must be defined (point, area, line or volume), their locations and emission conditions must be determined for source data, and the emission rates need to be estimated, as described in Chapter 3. For meteorological data, the level of assessment and model selected determine the requirements for data. Level 1 assessment does not require representative or site-specific meteorological data, but use screening-level meteorological data. Level 2 assessments require hourly meteorological data that is "representative" of the site. The data may come from established sources such as the South African Weather Service (SAWS) meteorological stations, industrial operated meteorological stations or stations operated by other agencies. It may also be supplemented with mesoscale meteorological models. Chapter 4 provides guidance on measurements, parameters, data treatments and sources of meteorological data. The level of assessment and model selected also determine the requirements for geophysical data. Such data can include terrain information, building dimensions as well as surface conditions, roughness heights, albedo and Bowen ratios, and distinctions between rural and urban land use, Chapter 6.3. For Levels 2 and 3 assessments, the geophysical data requirements can be quite detailed and require some manipulation to prepare the data for the specific models. The data preparation process, as well as the sources of geophysical data is discussed in Chapter 5.

2.3.11 Step 11: Determine Background Air Quality

All levels of assessments must consider the background concentrations of air contaminants. The intent is to compare the ambient air quality to the cumulative impact of new emissions and existing baseline conditions. A process to quantify the background concentrations is provided in Chapter 6.1.

2.3.12 Step 12: Prepare Input Files and Run Models

In order to provide consistency in the application of models on specific features or treatments, recommended fundamental options are provided in Chapter 7.

2.3.13 Step 13: Exercise Quality Assurance and Quality Control (QA/QC)

For all levels of assessment, modellers must exercise quality control and quality assurance procedures to confirm the accuracy of the input source, receptor, and meteorological data and the proper behaviour of the models. A general approach on this is provided in Chapter 7.

2.3.14 Step 14: Prepare Output and Submit Air Dispersion Modelling Report

The model output must be presented and interpreted in a way that addresses the objectives and information needs of the modelling effort as identified in Step 1. In order for the regulatory officer or/and other interested parties to conduct a thorough review of the air quality assessment, various input and output files may be required. Recommendations on documentation requirements are presented in Chapter 7.2.2. The section also includes a standard reporting template for presenting air dispersion modelling reports.

3 MODEL INPUT – SOURCE CHARACTERISATION

All dispersion models require input data that describe how much pollutants are being released, details on how the pollutants are being released, and the environment into which the release occurs. The process of compiling a representative emission inventory is potentially a very time consuming and extensive. It is important to understand the characteristics/physical properties of the emissions in order to model the emissions as representative and accurate as possible. Before developing the representative emission inventory of the sources of interest within the modelling domain, the modeller must list and understand the different sources in the modelling domain and decide which "source types" would represent the sources accurately. Emission sources can be simplified into four types based on geometry: point, area, volume and line sources as shown in Figure 2 (figure from New Zealand EPA 2004).

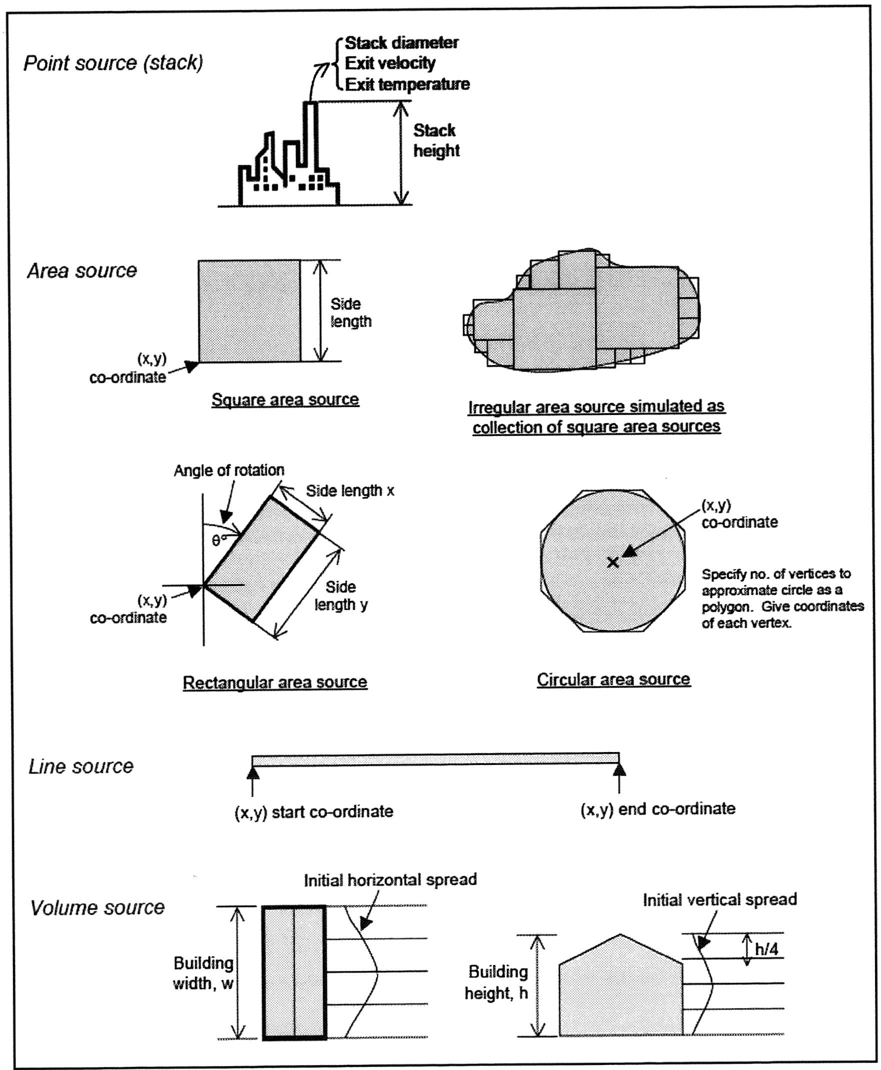

Figure 2. Types of sources used by dispersion models (New Zealand EPA 2004).

3.1 Source Types

3.1.1 Point Sources

Point sources are typically used to represent emission released to the atmosphere through well-defined stacks, chimneys or vents. The emissions are usually buoyant and have an upward velocity, unless the stack has a rain cap. A flare is considered to be a point source, but because of the buoyancy of the flue gases, special treatment is required in describing flare sources, see Chapter 3.2. Depending on the model used, the source parameters normally required for point sources include;

- **X coordinate:** *x* (east-west) coordinate for the source location (centre of the source).
- **Y coordinate:** *y* (north-south) coordinate for the source location (centre of the point source).
- **Base elevation:** Source base elevation. The model only uses the source base elevation if **Elevated** terrain is being used [m].
- **Release height above ground:** Source release height above ground (above ground) [m].
- **Emission rate:** Emission rate of the pollutant in grams per second [g/s].
- **Stack gas exit temperature:** Temperature of the released gas [°K].
- **Ambient air temperature: (screening applications),** the average atmospheric temperature in the vicinity of the source. If no ambient temperature data are available, assume a default value of 293 °K. For non-buoyant releases, the user must input the same value for the stack temperature and ambient temperature [°K].
- **Stack gas exit velocity:** Stack gas exit velocity [m/s].
- **Stack gas flow rate:** The stack gas flow rate [m^3/s].
- **Stack inside diameter:** Inner diameter of the stack [m].

Attention must be given to units of measure and ambient temperature inputs as these might differ between models. When building downwash effects are included in the modelling, parameters relating to neighbouring structures (height, width, length, and location with respect to the stack) will be needed. Building downwash for point sources that are within the **Area of Influence** of a building must be considered as discussed in Chapter 6.5.

3.1.2 Area Sources

Area sources are used to model low level or ground level releases where releases occur over an area. Typical examples of area sources include landfills, storage piles, slag dumps and lagoons. Urban regions consisting of multiple point sources can be combined to act as an area source. The dimensions of area sources can be represented by a combination of rectangles, circles or polygons. SCREEN3 allows definition of rectangular areas. AERMOD models accept rectangular areas that may also have a rotation angle specified relative to a north-south orientation, as well as a variety of other shapes. CALPUFF allows for all these representations as well as gridded emission data. Depending on the model, parameters normally required for area sources include:

- **Emission rate:** Emission rate of the pollutant [g/(s/m^2)].
- **Source release height:** Source release height above ground [m].

- **Larger side length of rectangular area:** The larger side of the rectangular source in meters (screening models) [m].
- **Smaller side length of rectangular area:** The smaller side of the rectangular source in meters (screening models) [m].
- **Receptor height above ground:** This may be used to model impacts at "flagpole" receptors [m].
- **X coordinate:** *x* (east-west) coordinate for the vertex (corner) of the area source that occurs in the southwest quadrant of the source [m].
- **Y coordinate:** *y* (north-south) coordinate for the vertex (corner) of the area source that occurs in the southwest quadrant of the source [m].
- **Base elevation:** Source base elevation. The model only uses the source base elevation if elevated terrain is being used [m].
- **Release height above ground:** The release height above ground in meters [m].
- **Options for defining rectangular area:** The maximum length / width aspect ratio for area sources is 10 to 1. If this is exceeded, then the area must be divided to achieve a 10 to 1 aspect ratio (or less) for all sub-areas.
- Area sources in some models require the initial vertical plume dispersion, denoted sigma-z.

3.1.3 Line Sources

A line source is a long, narrow source such as a roadway, conveyor belt, or roofline vent along a long, narrow building. Line sources are effectively represented as a string of volume sources or elongated area sources for modelling. The representation of line sources in models is detailed in Table 1.

3.1.4 Volume Sources

Volume sources are used to model releases from a variety of industrial sources, such as building roof monitors, fugitive leaks from an industrial facility, multiple vents, and conveyor belts. Depending on the model, source parameters normally required for volume sources include:

- **Emission rate:** The emission rate of the pollutant in grams per second [g/s].
- **Source release height:** The source release height above ground surface [m].
- **X coordinate:** The *x* (east-west) coordinate for the source location in meters. This location is the centre of the volume source.
- **Y coordinate:** The *y* (north-south) coordinate for the source location in meters. This location is the centre of the volume source.
- **Base elevation:** Refers to the base elevation of the source. The model only uses the source base elevation if **Elevated** terrain is being used [m].
- **Release height above ground:** The release height above ground surface in meters (centre of volume).
- **Length of side:** The length of the side of the volume source in meters. The volume source cannot be rotated and has the X side equal to the Y side (square) [m].
- **Building height (if on or adjacent to a building):** If the volume source is elevated and is on or adjacent to a building, then the building height must be specified. The building height can be used to calculate the Initial Vertical Dimension of the source. Note that if the source is surface-based, then this is not applicable [m].

- **Initial Lateral Dimension:** This parameter is calculated by choosing the appropriate condition in Table 1. This table provides guidance on determining initial dimensions [m].
- **Initial Vertical Dimension:** This parameter is calculated by choosing the appropriate condition in Table 1. This table provides guidance on determining initial dimensions [m].

Recommended procedures of obtaining the initial lateral and vertical dimensions for volume and line sources are listed in Table 1 (US EPA 1995).

Table 1. Summary of recommended procedures for estimating initial lateral dimension (σ_{yo}) and Initial vertical dimension (σ_{zo}) for volume and line sources.

Type of Source	Procedure for Obtaining Initial Dimension
Initial Lateral Dimension (σ_{yo})	
Single volume source	σ_{yo} = length of side divided by 4.3
Line source represented by adjacent volume sources	σ_{yo} = length of side divided by 2.15
Line source represented by separated volume sources	σ_{yo} = centre to centre distance divided by 2.15
Initial Vertical Dimension (σ_{zo})	
Surface-based source (h_e~0)	σ_{zo} = vertical dimension of source divided by 2.15
Elevated source (h_e>0) on or adjacent to a building	σ_{zo} = building height divided by 2.15
Elevated source (h_e>0) not on or adjacent to a building	σ_{zo} = vertical dimension of source divided by 4.3

If the facility under study has more than one source of the contaminant to be modelled, then it is a multi-source situation. To simplify the modelling when there are many release points, a modeller may conservatively combine the stacks/vents into a volume source, an area source or a single point source. The following factors shall be considered when selecting potential sources for combination into a single source:

- How similar are the source characteristics of the individual stacks or vents?
- Are the emission rates from the individual release points similar or are there one or two sources with significantly larger emission rates?
- Are the sources located over an area or volume that can be reasonably well defined?
- How far is the property line from the group of stacks/vents

The choices of size and location of volume or area sources or the stack parameters for a single stack representing a group shall be selected conservatively. For example, the parameters for the single stack shall not result in larger plume rise than would have occurred for the large majority of the stacks combined. The relative emission rates from the combined stacks may also be considered in selecting stack parameters.

3.2 Flaring Sources

This part of the **Code of Practice** borrows from the Ontario modelling guideline (Ontario Environment 2009). Flaring sources must be modelled as point sources, taking into account the buoyancy of the emissions due to heat loss, and a need to account for flame length in estimating plume height.

For SCREEN3, the following flare release input parameters must be included;

- **Emission rate:** The emission rate of the pollutant in grams per second [g/s].
- **Flare stack height:** The stack height above ground [m].
- **Total heat release rate:** The heat release rate in Joules per second for the flare [J/s].
- **Receptor height above ground:** This may be used to model impacts at "flagpole" receptors [m].

The SCREEN3 model calculates plume rise for flares based on an effective buoyancy flux parameter. An ambient temperature of 293°K is assumed in this calculation and therefore none is input by the user. It is assumed that 55% of the total heat is lost due to radiation. Plume rise is calculated from the top of the flame, assuming that the flame is bent 45° from the vertical. SCREEN3 calculates and prints out the effective release height for the flare. SCREEN3 provides the same options for flares as described earlier for point sources, including building downwash, complex and/or simple terrain, fumigation, and the automated and/or discrete distance. SCREEN3 model assumes a stack gas exit velocity (V_s) of 20 m/s, an effective stack gas exit temperature (T_s) of 1 273°K, and calculates an effective stack diameter based on the heat release rate (US EPA 1995).

For AERMOD and CALPUFF, input requirements are similar to those for a point source, except that the release height must be calculated as an effective release height and stack parameters need to be estimated to match the radiative loss reduced buoyancy flux. These pseudo-stack parameters are calculated to allow the model to simulate dispersion from flare stacks using conventional stack inputs.

The effective release height of the plume shall be calculated as

$$H_{sl} = H_s + 4.56 \times 10^{-3} \left(\frac{H_r}{4.1868} \right)^{0.478}$$

Where:

H_{sl} = effective flare height [m]
H_s = stack height above ground [m]
H_r = net heat release rate [Joules per second, J/s].

The net heat released is calculated as

$$H_r = 44.64 \times V \times \sum_{i=1}^{n} f_i H_i \times (1 - F_r)$$

V = volumetric flow rate (m³/s)
f_i = mole fraction or volume fraction of each gas component
H_i = net heating value of each component (J/g-mole)
F_r = fraction of radiative heat loss

The fraction of radiative heat loss depends on burning conditions of the flare. If there is information specific to the flare, then that fractional loss shall be used. As a default, a heat loss of 25% shall be used, as recommended by Ontario Environment. The stack parameters can be estimated by matching the buoyancy flux from the flare. The buoyancy flux from the flare is given by:

$$F = \frac{g \times H_r}{\pi \times \rho \times T \times C_p}$$

Where:

ρ = density of air [kg/m³]
T = air temperature [°K]
C_p = specific heat capacity of dry air [J/Kg °K].

Buoyancy flux for stack releases is:

$$F = g \times V_s \times r_s^2 \times \left(\frac{T_s - T}{T_s}\right)$$

Where:

V_s= exit velocity [m/s]
r_s = stack inner radius [m]
T_s = stack exit temperature [°K].

3.3 Emission Rates

Emission rates must be selected based on the purpose of the modelling exercise under consideration. For assessing air quality impacts of new or modified existing sources, the **maximum** allowed amount, volume, emission rates and concentration of pollutants that may be discharged to the atmosphere under (i) normal working conditions; and (ii) normal start-up, maintenance and shut-down conditions should be considered to demonstrate compliance with NAAQS (DEAT 2007). The emissions must include any other operating requirements relating to atmospheric discharges, including non-point source or fugitive emissions. The maximum emission rates must be based on emissions standards as stipulated in Section 21 of the AQA (DEA 2010). These emission standards are given in concentrations of pollutants per normalised cubic meter; hence, volumetric measurements must be reported in the modelling exercise to substantiate the emission rates used in the modelling. For proposed facilities, proposed emissions rates must be used, based in Section 21. For a facility with superior control pollution measures (hence emission rates more stringent than Section 21 emission standards), the modelled emission rates must be based on the emission rates to be stipulated in the licence.

Where no appropriate emission standards are available, representative emission rates from continuous stack monitoring, manufacturer specifications, published emission factors or estimated/calculated emissions must be used. Published emission factors are recommended for national consistency e.g., US EPA's AP-42 emission factors (US EPA 1995). Stack sampling survey data provide a snapshot in time of the emissions and is normally conducted for licence compliance reasons, rather than to characterise the emissions for modelling purposes. Unless sufficient survey data (based on expert judgement) is available to determine the uncertainty range of stack sampling, these measurements should only be used in situations where the air quality at the time of the survey is of interest or when there is no or little reliable data from other sources of information on emissions listed here.

Sources of emissions may emit only during certain periods of time. Model inputs for variable emissions rates can include the following time periods – seasonally, monthly, day-of-week, hourly or a combination of these periods. For non-continuous sources, variable emissions rates to be prescribed in the authorisation must be used in the modelling.

For assessing a past air quality event as required in Section 30 of the AQA (Chapter 1.3.2 of this **Code of Practice**), actual emissions estimated/calculated that correspond to that event must be used. Hourly emissions variations must be accounted for explicitly if the data is available.

If a source operates only during specified hours (batch processes), the emissions to be modelled must be restricted to the hours of operation. However, impacts must be assessed over the averaging periods of relevant pollutants as stipulated for the NAAQS. Background sources are discussed in Chapter 6.1. Table 2 summaries the emission rates to be used.

Table 2. Emission rate estimates for proposed / modified sources and nearby sources.

Averaging Time	Emission Limit	Operating Level	Operating factor
Proposed major new or modified source			
All respective NAAQS averaging periods	Maximum allowable emission limit or relevant enforceable licence limit.	Design capacity or relevant enforceable licence condition.	Continuous operation
Nearby sources			
Annual	Maximum allowable emission limit or relevant enforceable licence limit.	Actual or design capacity (whichever is greater), or the relevant enforceable licence condition.	Actual operating factor averaged over the most recent 2 years.
Short term periods (less than 24 hours)	Maximum allowable emission limit or relevant enforceable licence limit.	Actual or design capacity (whichever is greater), or the relevant enforceable licence condition.	Continuous operation

If the facility under consideration does not operate for all hours of the time period of consideration and the operational periods are reflected in the licence condition, an appropriate adjustment to the modelled emission rates must be made. For example, if operation is only from 08:00 to 16:00 each day, only these hours must be modelled with emissions from the source. Modelled emissions must NOT be averaged across non-operating time periods..

In cases where emissions estimates are derived from an emissions inventory model, sufficient information must be provided to support how the estimates were derived. The information must include estimation methodology applied, uncertainly ranges and the assumptions made.

3.4 Special Conditions

3.4.1 Storage Tanks

Storage tanks are generally of two types – fixed roof tanks and floating roof tanks. In the case of fixed roof tanks, most of the contaminant emissions occur from a vent, with some additional contribution from hatches and other fittings. Fixed roof tanks must be modelled as a point source with the vent at the centre of the tank. The tank itself must be represented as a building for downwash calculations. In the case of floating roof tanks, most of the contaminant emissions occur through the seals between the roof and the wall and between the deck and the wall, with some additional emissions from fittings such as ports and hatches. The floating roof tanks must be modelled as a circle of eight (or more) point sources, representing the tank itself as a building for downwash calculations. The total emissions must be distributed equally among the circle of point sources. There is virtually no plume rise from tanks and the stack temperature must be set equal to the ambient temperature. The stack parameters representing the emissions must be set to near zero with stack gas exit velocity = 0.001 m/s, and stack diameter = 0.001 m.

This **Code of Practice** also recommends the use of TANKS model to estimate emissions from petroleum storage facilities (US EPA 1999). TANKS is a Windows-based computer software program that estimates volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions from fixed- and floating-roof storage tanks. The model is based on the emission estimation procedures from EPA's AP-42. TANKS uses chemical, meteorological, roof fitting and rim seal data to generate emissions estimates for several types of storage tanks, including:

- vertical and horizontal fixed roof tanks
- internal and external floating roof tanks
- domed external floating roof tanks
- underground tanks.

TANKS is capable of calculating individual component emissions from known mixtures and estimating emissions from crude oils and selected refined petroleum products using liquid concentration HAP profiles supplied with the program. Whenever TANKS is used to estimate emissions, full details on the type of fuel, type of storage tanks, roof fittings and meteorological data used to estimate the emissions must be included in the modelling report.

3.4.2 Fugitive sources

Fugitive emissions include the emissions resulting from industrial processes that are not captured and vented through a stack but may be released from various locations within the complex. It also includes dust put into the atmosphere by the wind blowing over ploughed fields, mind dumps, desert or sandy areas with little or no vegetation and re-entrained dust from vehicles travelling on dirt roads. For industrial processes, fugitive dust from loading material to and from stock piles must be modelled as volume sources representative of the loading or unloading operation. Emissions coming from equipment such as crushers, screens, or material transfer points and haul roads must also be modelled as elongated sources. Traffic carrying materials mined or processed at the facility must be modelled as part of the facility. The roads must include portion of the roads that are not publicly accessible. Elongated sources may be modelled as volume or rectangular area sources in some models, including CALPUFF and AERMOD. In some cases, the rectangular area sources may be a more accurate way to model such sources but would require much longer computer processing time.

Emissions estimates for fugitive sources are frequently based on US EPA AP-42 emission factors, which in turn have a large uncertainty, i.e., a rating of E representing poor. It is therefore recommended that fugitive sources results must be reported with other sources where there is greater certainty in the emissions, like point sources as well as separately from point sources (British Columbia 2008). This means that the modeller must report the impacts from all sources as well as the impacts from fugitive sources of the facility under consideration. Separating the results would assist in allocating the facility impacts rightfully and defining mitigation measures appropriately. In addition, detailed information about the emission factors used to estimate the fugitive emissions must be reported.

3.5 Structures around Sources

The layout of the facility e.g., connection schemes between stacks and other building, and the distance and direction between stacks, building parameters (length, width, height, location and orientation relative to stacks) for plant structures, control equipment, and surrounding buildings must be included in the modelling. For point sources, the buildings that are within the **Area of Influence** of a building must be considered for building downwash effects i.e., approximately five stack heights (see Chapter 6.5).

4 MODEL INPUT – METEOROLOGICAL DATA

Meteorology is the principal factor affecting the dilution and dispersion of pollutants in the atmosphere. Ground-level concentrations of emissions released from one or more sources are primarily controlled by two meteorological attributes affecting transport – dispersion and dilution. Wind direction and speed are important in the horizontal plane while turbulence and the mixing height of the lower boundary layer are important in the vertical. Accurate characterisation of the surface and boundary layer meteorology is therefore important when modelling ground-level concentrations of pollutants.

The meteorological data requirements for steady-state Gaussian-plume models and advanced dispersion models vary considerably. The former require meteorological data from a single surface station and assume that the data are applicable throughout the modelling domain, to the top of the boundary layer and that there is no variation with height. Advanced dispersion models allow meteorological conditions to vary across the modelling domain and vertically through the atmosphere. This complex approach requires significantly more detailed meteorological data.

Because meteorological data requirements vary greatly between these two model types, the choice of which dispersion model to use may depend on the expected meteorological condition, or in turn, the available meteorological data in the area of interest. Influencing factors to consider include possible variation in the boundary layer structure, atmospheric turbulence, topographical variation and the associated mesoscale effects on the boundary layer and near surface winds. When selecting a dispersion model, it is therefore important to:

- Understand the modelling objectives and whether meteorology is expected to vary across the modelling domain.
- Determine whether diurnal, seasonal and inter-annual variations in meteorology need to be considered.

AERMOD, SCIPUFF, and CALPUFF can use different forms of meteorological input data. However, this **Code of Practice** recommends 3D meteorological fields generated by AERMET / CALMET / SCIMET as the regulatory mode of running the respective models.

4.1 Meteorological Data and the Modelling Objective

4.1.1 Reasonable Worst-Case Events, Initial or Basic Assessment

If worst-case events are of primary concern or the modelling objective requires an initial assessment or a basic assessment, SCREEN3 or AERSCREEN models are recommended. In this case the standard screening meteorological datasets that comes with the models are used. They have been developed using standard combinations of wind speed, stability class and mixing heights, which are expected to mimic the range of atmospheric conditions that are likely to occur in any given location. They provide a simple option to run the air dispersion model and can be applied in most locations. The maximum ground level concentration predicted using a screening data set is normally regarded as conservative – often termed 'worst-case scenario' impacts. This means that it is likely that the model over-predicts concentrations expected to occur in reality, assuming that other input data (emissions and source parameters) are representative. Screening model requirements are less demanding than refined models. SCREEN3 provides three methods of defining meteorological conditions: full meteorology, single stability class and single stability class, and wind speed. The full meteorology conditions are recommended for regulatory applications in this **Code of Practice**. In this case, the model will examine all six stability classes (five for urban sources), their associated wind speeds for a range of stability classes and wind speeds to identify the "worst case" meteorological conditions, i.e., the combination of wind speed and stability that results in the maximum ground level concentrations.

4.1.2 Detailed Assessment

If, in order to meet the modelling objectives a detailed assessment (Level 2 or 3) is required, a Gaussian-plume (AERMOD) or advanced puff dispersion models (CALPUFF or SCIPUFF) must be used. In selecting between a Gaussian-plume model and an advanced dispersion model, the meteorological short-comings of the Gaussian-plume models need to be considered, i.e. the inability to simulate dispersion in calm or light wind conditions and the inability to account for inversions and inversion break-up, and the existence of complex terrain. Similarly, advanced dispersion models provide a more representative simulation of mesoscale winds.

For both Gaussian-plume and advanced dispersion models, surface and upper air meteorological data are required from at least one monitoring station in the modelling domain.

The hourly sequential surface data must include:

- Temperature
- Relative humidity
- Wind speed
- Wind direction
- Solar radiation
- Cloud height
- Cloud cover

The upper air profile data must comprise at least two daily soundings, including:

- Temperature
- Relative humidity
- Wind speed
- Wind direction

4.2 Availability of Data and Data Representativeness

Meteorology has a significant impact on the transport and dispersion of pollutants in the boundary layer. Therefore, uncertainties in the representativeness of meteorological data could lead to inaccurate air dispersion model predictions, which in turn could lead to misinformed decision-making with significant human health, environmental, and financial consequences. The meteorological data that is input to a model must be selected based on its appropriateness for the modelling project. More specifically, the meteorological data must be representative of the wind flow in the area being modelled, so that it can properly represent the transport and diffusion of the pollutants being modelled. There are four factors that affect the representativeness of the meteorological data. These are the:

- Proximity of the meteorological site to the area being modelled.

- Complexity of the terrain.
- Exposure of the meteorological measurement site.
- Time period of the data collection.

It must be emphasised that **representativeness** (both spatial and temporal) of the data is the key requirement. One factor alone should not be the basis for deciding the representativeness of the data.

4.2.1 Site-Specific Meteorological Data

As a rule, site-specific meteorological data are always preferred when developing a meteorological data profile for a specific modelling objective. The term "site-specific" refers to measurements that represent the meteorological conditions at the source being modelled. The site may or may not be within the legal boundary of the facility. The meteorological station must be located away from the influences of obstructions such as buildings and trees to ensure that the general state of the environment (wind direction, speed and temperature) is best represented. It is recommended that the anemometer is located at 10 m above ground level to measure wind direction, speed and temperature differentials. For major industrial sources with tall stacks, or a site within a complex terrain environment, higher monitoring masts are recommended to adequately monitor lower boundary-layer wind and temperature profiles.

To develop a meteorological data set for dispersion modelling the minimum requirement includes the following parameters:

- Temperature
- Temperature difference (between 1.5 m and 10 m or higher)
- Relative humidity
- Wind speed
- Wind direction
- Standard deviation of horizontal wind direction
- Solar radiation

Measured data must be reduced to hourly averages for all parameters. The data must be supplemented with the following off-site data from the nearest SAWS climate station:

- Hourly cloud cover and height for the region
- Twice-daily upper air temperature, relative humidity, and wind speed and direction from the closest upper air radiosonde station, or a stability measurement to calculate mixing height.

The representativeness of the data set for the specific modelling objective must be assessed and demonstrated in terms of climatic means and extremes. This can be achieved by establishing correlations between long-term on-site data records or with climatic averages and regional extremes. Average climatic conditions for the region can be obtained at a representative station from SAWS (http://www.weathersa.co.za).

4.2.2 Meteorological Data from another Location

Site-specific data or representative data may not be available in the area of interest, but suitable surface meteorological data from other local sources may be available. For simple single-station plume modelling, off-site data should only be used if the nearby site has similar topographic characteristics which are likely to result in similar meteorological conditions for the site concerned, e.g. both sites are located in the same valley system, or in close proximity along a coastline. The representativeness of off-site data must be established by the modeller before being used in any dispersion study.

It must be noted that certain meteorological variables may not be considered to be representative of another site (i.e., wind direction, wind speed), while other variables may be representative (temperature, cloud cover). However, before meteorological data from another site is used, the following must be established:

- Whether the data collected at the alternate site characterises the meteorological conditions at the site of interest.
- Whether the geophysical situation at the alternative site characterises the geophysical conditions at the site of interest, including:
    - Aspect ratio of terrain.
    - Slope of terrain.
    - Ratio of terrain height to stack and/or plume height.
- Maximum distance from source of up to 50 km for Level 2 assessments
- Orientation of the terrain feature to prevailing meteorological conditions.
- The purpose of the alternate site collection programme and the measured parameters.
- The type of instrumentation and data collection, and the height of the measurements as certain parameters might be missing or not suitable for modelling.
- The instrument specifications, siting criteria and data treatment (response thresholds, data collection and handling protocols and special data entry flags). This will indicate the limitations and quality of the data.
- The critical nature of the air quality assessment as part of the decision-making process.

Approval decisions that have large societal and environmental consequences require a high degree of confidence in the meteorological data used in the dispersion model.

4.3 Sources of Meteorological Data

4.3.1 South African Weather Service (SAWS)

The SAWS is the main source of both observed surface and upper-air meteorological data as well as specific model-generated data in South Africa. SAWS maintains the longest historical records of meteorological data in South Africa, and one of the major advantages of SAWS data is that it has been collected in accordance with the requirements established by the World Meteorological Organisation (WMO). In other words, instrumentation and siting criteria meet the WMO standards. SAWS data is suitable for long-term trend analysis that covers a significant number of decades. The cost of the data is related to:

- The number of sites requested.
- Whether the data is measured or modelled.
- The number of parameters and vertical levels requested; and
- The total time period which the data represents.

SAWS observation stations are meant to provide coverage to meet its meteorological obligations. However, this is inadequate to meet the requirements for robust atmospheric modelling in the country as:

- The spatial distribution of observation stations is not sufficient to address dispersion modelling data requirements. There are only seven upper air stations operated by SAWS across the entire country.
- Not all of SAWS observation stations measure all the parameters required for air dispersion modelling, e.g., some stations only monitor rainfall.
- Data are not necessarily in formats compatible with the air dispersion models recommended in this **Code of Practice**.
- As with all databases, some of the observation stations experience data loss. As a result, these data either need to be rejected/interpolated using mathematical techniques or professional judgement.

To address the challenges relating to data scarcity, dispersion modellers are encouraged to use mesoscale meteorological data to supplement/characterise meteorology in areas with limited observations.

4.3.2 Mesoscale Meteorological Modelled Data

Mesoscale models use gridded meteorological data and sophisticated physics algorithms to produce meteorological fields at defined horizontal grid resolutions and in multiple vertical levels over a large domain. They therefore offer an alternative to meteorological measurements as input for Gaussian-plume models and advanced dispersion models. Providing actual surface observations to mesoscale meteorological model simulations produce more accurate meteorological fields as the actual observations are used to "nudge" the model in its solutions.

A number of meteorological model datasets covering South Africa are available from a number of vendors. This **Code of Practice** will refrain from recommending specific datasets, but encourage modellers to use data from the United Kingdom Meteorological Office Unified Model (MetUM), Weather Research and Forecasting (WRF), The Air Pollution Model (TAPM) and the 5th-generation Mesoscale Model (MM5). MetUM and WRF are the current operational models at SAWS, hence there are archived datasets available for long term periods.

The advantages of the mesoscale model approach are that:

- They provide surface and upper air data for any location, thus avoiding the cost of setting up a new meteorological station and providing information at locations where data is not available.
- It takes less time to generate a data set than collecting data in an observational program
- The approach avoids subjective decisions regarding the use of quasi-representative meteorological data (e.g. judgment required to adjust or rotate winds from a remote site to account for different terrain orientations at the modelling site).
- The approach avoids subjective decisions regarding the interpolation for missing data.
- They provide details of the space and time variability of the meteorology in three dimensions within the modelling domain, which is especially important in complex terrain.

Conversely, mesoscale meteorological models require considerable expertise and computational resources (processing time, storage) which escalate rapidly with increasing domain size, fine grid resolution and the modelling period. Thus, it may be impractical to apply mesoscale meteorological models for dispersion modelling at a fine grid scale in situations where it is required to simulate multiple years of hourly meteorology or to resolve the effects of small-scale terrain features. In these situations, an appropriate balance is needed and the implications of the selected approach must be understood.

4.4 Meteorological Data Assessment and Quality

4.4.1 Treatment of Calm Conditions

"Calm" conditions are defined as the periods where the wind speed is recorded as zero. The zero values can be due to:

- "Meteorological" calm which refers to a condition of no movement of air (no wind).
- An "instrument" calm, where there may be wind, but it is below the anemometer starting threshold (AST).

The threshold wind speed is typically the threshold of the instrument used to collect the wind speed data. SAWS Automatic Weather Stations (AWS) wind sensors have lower threshold of 1.0 m/s. The frequency of calms is instrument dependent as it depends on the threshold. Caution must therefore be taken when defining and reporting the percentages of calm conditions. Percentages of calms must be reported together with the instrument AST.

AERMOD and CALPUFF use different methodologies to identify and treat calm conditions. Gaussian-plume models assume that concentrations of pollutants are inversely proportional to wind speed. Therefore, concentrations can become unrealistically large as wind speeds approach calm conditions. Procedures have been developed to prevent the occurrence of overly conservative concentration estimates during periods of calms in AERMOD. These procedures acknowledge the shortfall of Gaussian models in treating calm conditions, and therefore disregard the hours identified as calm. In AERMET pre-processing of meteorological data, the calm conditions are treated as missing values and the concentrations are disregarded. The hours with the missing values must be treated in the convention for handling missing hours as recommended in Chapter 4.4.2. The AERMET pre-processor calculates several parameters that require wind speed. In calm conditions, these parameters become undefined, and, thus, will be missing in the surface file that is output from AERMET. These parameters are the friction velocity, mechanical mixing height, Monin-Obukhov length, heat flux (night only), convective velocity scale (daytime only), lapse rate at the mixing height (daytime only) and convective mixing height (daytime only). To avoid unrealistically high concentration estimates at low wind speeds, it is recommended that wind speeds less than 1 m/s (but above the instrument threshold for observations) be reset to 1 m/s in AERMOD (US EPA 2000). The number of calms and adjusted wind speed data points must be quantified when presenting the modelling results and the potential implications of the data adjustment must be assessed.

AERMOD uses the following procedure, as specified in the US EPA guideline (US EPA 2005); when calculating an n-hour average concentration, if more than 75% of the hourly concentrations are valid (i.e., no more than 25% of the hours are calm or contain missing then the average is calculated by summing the concentrations and dividing by the number of valid hours. If less than 75% of the hourly concentrations are valid (i.e., more than 25% of the hours are calm or missing), then the average is calculated by summing the concentrations and dividing by the lowest number that is at least as large as 75% of n. For example, if a 24-hour period contains two hours that are calm or contain missing data, then the average will be taken of the remaining 22 hours (the sum of the concentrations divided by 22). If a 24-hour period contains six hours that are calm or contain missing data, then the 24-hour average will be taken of the remaining 18 hours. However, if 24-hour period contains eight hours that are calm or have missing data, the average will be obtained by summing the concentrations and divided by 18, not 16. Similarly, if the number of valid hours for an 8-hour average is less than six, the 8-hour average is obtained by summing the concentrations and dividing by six. Also, if the number of valid hours for a 3-hour average is less than three, the three-hour average is obtained by summing the concentrations and dividing by three.

The potential effect of low wind speeds on assessments using Gaussian-plume models depends strongly on the nature of local wind flow and the accuracy of the hourly average wind direction. If the wind direction is relatively steady at low wind speeds, prediction from the Gaussian-plume model may be reasonable. However, if on a specific modelling objective, calm conditions are recognised as a potential concern, CALPUFF must be used for assessment as the model can fully treat stagnant conditions. No special calms treatment is required in CALPUFF as wind speeds = 0.0 m/s are handled.

4.4.2 Missing Data

Dispersion models require sequential hourly data. Missing data must therefore be replaced with synthesised data or missing data indicators (flagging) to ensure that the air dispersion models can run successfully. Missing data at the very beginning and at the very end of the data set must be left as "missing" (no extrapolation is applied). The following approaches are recommended:

- Where only one or two hours of missing data occur, linear interpolation of the data is acceptable. Caution is needed for transition periods such as sunrise and sunset.
- Where data is missing for periods of up to seven days, synthesised averages from a longer-term record of the station may be substituted into the data set, or data from a nearby representative site can be used. Alternatively, missing data indicators can be applied to flag the missing data.
- For continuous periods of longer than seven days, synthesised data must not be used and the length of the data set must be reduced by the length of the missing data. For example, with three weeks of continuous missing data, the total length of an annual dataset would cover 49 weeks instead of a standard 52 weeks. It is important, however, to ensure that an adequate coverage of all seasons is obtained within the data.

All missing or synthesised meteorological data must be clearly documented and discussed in the method.

4.4.3 Data Period

A minimum of 1-year on-site specific data or at least three years of appropriate off-site data must be used for Level 2 assessments. For Level 3 assessments, meteorological data from a minimum of three consecutive years is required. The meteorological data must be from a period no older than five years to the year of assessment. All data must be subjected to quality assurance procedures, and documented in the modelling study report.

5 MODEL INPUT – GEOGRAPHICAL INFORMATION

5.1 Geophysical Data

Meteorological conditions can vary dramatically over short distances in areas of undulating or complex terrain, near coastal boundaries or between urban and rural areas. Geophysical data that includes terrain height and land use is therefore important for dispersion modelling studies in these locations. It can range from a simple choice between selecting the surrounding area as urban or rural, or providing detailed topographical and land use information with corresponding values of surface roughness, albedo and Bowen ratios (see Chapters 6.3).

When using a screen model for a basic assessment or worst-case modelling study, the dispersion modeller has the option to apply terrain effects. The option is exercised based on the height of the stacks relative to the surrounding topography.

Grid-based terrain height and land use data throughout the modelling domain are primarily input requirement for Gaussian-plume and advanced dispersion models. These data may be extracted and prepared for input to these models from maps or various data bases. Advanced dispersion models can simulate the effects on pollutant transport and dispersion in a more realistic manner than a Gaussian-plume model, which assumes spatial uniformity in meteorology. This means that advanced dispersion models require more detailed meteorological input data to accurately emulate the complex dispersion effects associated with the terrain.

Digital elevation model (DEM) data are available from South African vendors and the US Geological Survey in several different formats. DEM data covering South Africa are also available free of charge from WebGIS™ (http://www.WebGIS.com). Note that the WebGIS™ site contains a more up-to-date version of the DEM, which was converted from the newer NASA Shuttle Radar Topography Mission (SRTM) terrain elevations.

Land use maps are also available from South African vendors and the US Geological Survey in several different formats. These maps can provide information on the nine major land use types within an area of study, such as industrial, agricultural, forested and others. Caution must be taken with the land-use maps to account for the rapid urbanisation in some parts of the country. Manual extraction of land use classification data from land use maps is a method of preparing the land use input file. Data may be extracted from GIS data files at the required dispersion model resolution, although the resulting precision and digital reproduction might not be particularly accurate.

5.2 Model Domain and Coordinates System

The model domain is the area within which model predictions are made. The size and extend of the model domain is influenced by a number of factors such as source buoyancy, terrain features (valleys, mountains) and the location of contributing sources. The domain will generally be greater for large buoyant sources where a domain of 50 by 50 km centred on the stack may be required for a flat terrain area. For shorter stacks, a smaller domain may be appropriate (e.g., 10 km by 10 km). When using AERMOD in complex terrain, the domain might need to be elongated to capture flows in the valleys, or truncated across the mountain ridges since the model is unable to accurately predict pollutant concentrations in the lee of mountains (lee side of a mountain / building is the side that is sheltered from the wind). The model domain must also be sufficiently large to capture those sources that might impact significantly the background concentrations of the facility under consideration.

This **Code of Practice** recommends the use of the Universal Transverse Mercator (UTM) coordinate system for the air dispersion models. The UTM system uses meters as its basic unit of measurement and allows for a more clear definition of specific locations than latitude/longitude. The modeller must ensure that all model objects (sources, buildings, receptors) are defined in the same horizontal datum. All coordinates must be defined on the **World Geodetic System** 84, WGS-84 system. Defining some objects based on one datum system while defining others within another system can lead to significant errors in relative locations.

Close to the facility under consideration, ambient air quality objectives are applied to areas where there is public access outside the facility fenceline (i.e., beyond the facility boundary). Within the facility boundary, environmental conditions are prescribed by occupational health and safety criteria. In this **Code of Practice**, the facility boundary is defined based on these criteria:

- The facility fenceline or the perimeter where public access is restricted.
- If a facility is located within another larger facility boundary, the facility boundary is the boundary of the encompassing facility.
- If a public access road passes through the plant, the plant boundary is the perimeter along the road allowance.

6 GENERAL MODELLING CONSIDERATIONS

This chapter provides guidance and recommendations on the technical options to be applied in regulatory modelling for different modelling conditions, in order to maintain consistency when using these models. Most of the general modelling considerations are intricately built into the recommended models algorithms and should be selected for use in regulatory applications. The majority of these considerations are based on the US EPA modelling guidelines, and are the default options in the models. In those extreme cases when deviations from these options should be considered, the deviations must be carried out in consultation with the competent regulatory authorities.

6.1 Ambient Background Concentrations

The background concentration is the portion of the ambient concentration due to sources, both natural and anthropogenic, other than the source(s) being evaluated. Often background concentrations include two components:

- Local background consisting of significant nearby sources (other than the source being evaluated).
- Regional background, consisting of natural sources, distant anthropogenic sources and other minor sources.

The background concentrations can be obtained from a network of long-term ambient monitoring stations near the source under study, long-term ambient monitoring at a different location that is adequately representative or modelled background from significant background sources. Owing to the limited number of ambient monitoring stations across the country, quantification of background levels must be carefully calculated, fully documented and approved by the appropriate reviewing/licensing authority. The following method is recommended to quantify background data:

- Generally, at least one year of monitoring data is necessary, as there are usually significant seasonal differences in ambient concentrations. This can be due to atmospheric differences or the seasonal nature of some operations.
- All monitoring data must be subjected to validation and quality control to ensure its accuracy.

In most cases, the background concentrations are given for long term averaging times (usually annual). The short term background levels must be adjusted for the appropriate averaging times as recommended in 6.4.1.

6.1.1 Estimating Background Concentrations in Isolated Areas

For isolated facilities, background concentration may only consist of the regional background. The background levels might be negligible for many pollutants, except for PM_{10} levels. Assessment for compliance with NAAQS for an isolated source must follow the procedures in Table 3. Where ambient monitoring data exist, the monitoring network used for background determinations must conform to the appropriate quality assurance requirements. Appropriate data validation procedures must be applied to the data prior to use. Once again, the quantification of background levels must be used with professional judgment by the appropriate reviewing/licensing authority.

6.1.2 Estimating Background Concentrations in Multi-Source Areas

The National Framework calls for air quality assessment not only in terms of the individual facility contribution, but in terms of its additive contribution to baseline ambient air quality i.e. cumulative effects must be considered (DEAT 2007). As such, all sources expected to cause a significant concentration gradient in the vicinity of the source or sources under consideration must be explicitly modelled. Owing to both the uniqueness of each modelling situation and the large number of variables involved in identifying nearby sources, no attempt is made here to comprehensively define this term. Rather, identification of nearby sources calls for the exercise of professional judgment by the appropriate reviewing/licensing authority.

For short-term average analyses, background sources must be modelled using maximum allowable emissions. For annual average analyses, background sources must be modelled using annual average emissions averaged over the last two years, see Table 2. It is the responsibility of the licence applicant to sufficiently document what the maximum physical capacities to emit are for such nearby sources.

Where a primary source proponent believes that a nearby source does not, by its nature, operate at the same time as the primary source being modelled, the burden is on the proponent to demonstrate to the satisfaction of the appropriate reviewing licensing authority that this is, in fact, the case. Whether or not the primary source proponent has adequately demonstrated that fact is a matter of professional judgment left to the discretion of the appropriate reviewing/licensing authority.

The impact of the nearby sources must be examined at locations where interactions between the plume of the facility under consideration and those of nearby sources (plus natural background) can occur. Significant locations include areas of maximum impact of:

- Source(s) under consideration.
- Nearby sources.
- All sources combined.

These locations may be identified through trial and error analyses.

6.2 NAAQS Analyses for New or Modified Sources

Compliance with NAAQS must be defined such that all significant local and regional contributions to the background concentrations are accounted for. For each averaging time, the sum of the (model) predicted concentration (C_P) and the background concentration (C_B) applicable must be compared to the NAAQS. The background concentrations C_B, must be the sum of contributions from non-modelled local sources and regional background. If the sum of background and predicted concentrations are ($C_B + C_P$) is more than the NAAQS, the applicant must review the design of the facility (including pollution control equipment) to ensure compliance with NAAQS. Compliance assessments must provide room for future permits to new emissions sources, while maintaining overall compliance with NAAQS. For the different facility locations and averaging times, the comparisons with NAAQS must be based on recommendations in Table 3.

Table 3. Summary of recommended procedures for assessing compliance with NAAQS.

Facility location	Annual NAAQS	Short-term NAAQS (24 hours or less)
Isolated facility not influenced by other sources, C_B insignificant*.	Highest C_P must be less than the NAAQS, no exceedances allowed.	99th percentile concentrations must be less than the NAAQS. Wherever one year is modelled, the highest concentrations shall be considered.
Facilities influenced by background sources e.g., in urban areas and priority areas.	Sum of the highest C_P and background C_B must be less than the NAAQS, no exceedances allowed.	Sum of the 99th percentile concentrations and background C_B must be less than the NAAQS. Wherever one year is modelled, the highest concentrations shall be considered.
*For an isolated facility influenced by regional background pollution C_B must be considered.		

The 99th percentile concentrations are recommended for short-term assessment with the NAAQS since the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. This might cause exceptionally high concentrations that the facility may never actually exceed in its lifetime.

6.3 Land Use Classification

For most applications, this **Code of Practice** recommends the Land Use Procedure as sufficient for determining the urban/rural status of a modelling domain. The alternative approach on urban/rural classification using the Population Density Procedure is not encouraged in this **Code of Practice** as the approach can be rather subjective.

The classification of a site as urban or rural must be based on the Auer method specified in the US EPA guideline on air dispersion models (US EPA 2005).

From the Auer's method, areas typically defined as Rural include:

- Residences with grass lawns and trees.
- Large estates.
- Metropolitan parks and golf courses.
- Agricultural areas.
- Undeveloped land.
- Water surfaces.

An area is defined as Urban if it has less than 35% vegetation coverage or the area falls into one of the following use types:

Table 4. Land types, use and structures and vegetation cover.

Urban Land Use		
Type	**Use and Structures**	**Vegetation**
I1	Heavy industrial	Less than 5 %
I2	Light/moderate industrial	Less than 5 %
C1	Commercial	Less than 15 %
R2	Dense single / multi-family	Less than 30 %
R3	Multi-family, two-story	Less than 35 %

The classification of a site as urban or rural must be based on the method specified in the US EPA guideline following these steps:

- **Step 1:** Draw a circle with a radius of 3 km from the centre of the stack or centroid of the polygon formed by the facility stacks. Classify the land use within the 3-km radius of the source.
- **Step 2:** If land use types I1, I2, C1, R2, and R3 account for 50 % or more of the area within the circle, then the area is classified as **Urban**, otherwise the area is classified as **Rural**.

AERMET uses land use to distinguish between urban and rural and to estimate parameters that are used to calculate stability parameters (US EPA 2004). AERMET also provides the ability to specify land characteristics for up to 12 different contiguous, non-overlapping wind direction sectors that define unique upwind surface characteristics. The following properties of wind sectors must be true:

- The sectors are defined clockwise as the direction *from which the wind is blowing*, with north at 360°.
- The sectors must cover the full circle so that the end value of one sector matches the beginning of the next sector.
- The beginning direction is considered part of the sector, while the ending direction is not.

Each wind sector can have a unique albedo, Bowen ratio, and surface roughness, although normally only the surface roughness variation by wind sector is important. Sector widths must be no smaller than 30 degrees. Furthermore, these surface characteristics can be specified annually, seasonally, or monthly to better reflect site conditions.

6.3.1 Surface Roughness

The surface roughness length is not a physical height, but a theoretical one based on the wind profile. It is the height at which the mean horizontal wind speed approaches zero. For many modelling applications, the surface roughness length is typically about an order of magnitude (factor of 10 or so) smaller than the average heights of the roughness elements. The surface roughness length can be adequately estimated from the land use categories as a function of the season. Table 5 lists recommended values for a range of land-use types for the different seasons.

Table 5. Surface roughness lengths (m), for typical land use types and seasons.

Land Use Type	Seasons				
	Spring	Summer	Autumn	Winter*	Average
Water (fresh water and sea water)	0.0001	0.0001	0.0001	0.0001	0.0001
Deciduous Forest	1.00	1.30	0.80	0.50	1.03
Coniferous Forest	1.30	1.30	1.30	1.30	1.30
Swamp	0.20	0.20	0.20	0.05	0.20
Cultivated land	0.03	0.20	0.05	0.01	0.093
Grassland	0.05	0.10	0.01	0.001	0.053
Urban	1.00	1.00	1.00	1.00	1.00
Desert shrub land	0.30	0.30	0.30	0.15	0.30

*"Winter" applies to snow covered areas. This will rarely, if ever, be applicable to South Africa. For this reason, the "Average" column is calculated without the "Winter" figures.

6.3.2 Albedo

Noon-time albedo is the fraction of the incoming solar radiation that is reflected from the ground when the sun is directly overhead. Table 6 lists typical albedo values as a function of several land use types and seasons. For practical purposes, the selection of a single value for noon-time albedo to process a complete year of meteorological data is desirable. If other conditions are used, the regulatory agency must review the proposed noon-time albedo values used to pre-process the meteorological data.

Table 6. Albedo values for typical land use types and seasons.

Land Use Type	Seasons				
	Spring	Summer	Autumn	Winter	Average
Water (fresh water and sea water)	0.12	0.1	0.14	0.20	0.12
Deciduous Forest	0.12	0.12	0.12	0.50	0.12
Coniferous Forest	0.12	0.12	0.12	0.35	0.12
Swamp	0.12	0.14	0.16	0.30	0.14
Cultivated land	0.14	0.20	0.18	0.60	0.17
Grassland	0.18	0.18	0.20	0.60	0.19
Urban	0.14	0.16	0.18	0.35	0.16
Desert shrub land	0.30	0.28	0.28	0.45	0.29

6.3.3 Bowen Ratio

The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux (US EPA 1990). The presence of moisture at the Earth's surface alters the energy balance, which in turn alters the sensible heat flux and Monin-Obukhov length. Table 7 lists Bowen ratio values as a function of land-use types, seasons and moisture conditions for average moisture conditions. Bowen ratio values vary depending on the surface wetness. The average moisture conditions must be used normally, and the regulatory agency should review any other proposed Bowen ratio values used to pre-process the meteorological data.

Table 7. Bowen ratios for typical land use types, seasons and average moisture conditions.

Land Use Type	Seasons				
	Spring	**Summer**	**Autumn**	**Winter**	**Average**
Water (fresh water and sea water)	0.1	0.1	0.1	1.5	0.10
Deciduous Forest	0.7	0.3	1.0	1.5	0.67
Coniferous Forest	0.7	0.3	0.8	1.5	0.60
Swamp	0.1	0.1	0.1	1.5	0.10
Cultivated land	0.3	0.5	0.7	1.5	0.50
Grassland	0.4	0.8	1.0	1.5	0.73
Urban	1.0	2.0	2.0	1.5	1.7
Desert shrub land	3.0	4.0	6.0	6.0	4.3

6.4 Temporal and Spatial Resolutions

6.4.1 Temporal Resolutions for Screening Models

SCREEN3 applications typically calculate maximum 1-hour average concentrations. The use of conversion factors is a functional way to estimate concentrations for other averaging times including longer averaging times, such as 24 hours, or shorter averaging times such as the 10-minute standard conversion for SO_2. AERSCREEN automatically provides impacts for other averaging periods using the scaling ratios in Table 8.

For screening purposes, the hourly average concentrations must be converted by the factors listed in Table 8.

Table 8. Averaging time conversion factors (US EPA 1995)

Averaging Time	**Multiplying Factor** (1 hour average x the multiplying factor)
8 hours	0.7 (±0.2)
24 hours	0.4 (±0.2)
Annual	0.08 (±0.02)

For AERMOD and CALPUFF, the following equation is recommended to convert concentrations from one hour to the desired minutes:

$$C_P = C_M * (T_M / T_P)^P$$

Where

C_P = Peak concentration, expressed on the new averaging time [µ/m³].
C_M = Mean concentration on one hour averaging time [µ/m³].
T_M = Averaging time for mean hour [60 minutes].
T_P = New averaging time [minutes].
P = Decay value = 0.2 [non-dimensional].

Note that all the averaging time to which the conversion is to be made is defined in minutes. This **Guideline** recommends the use the decay factor P = 0.2 for AERMOD and CALPUFF for consistency with the US EPA guidelines.

6.4.2 Receptors and Spatial Resolutions

Specific sets of receptor spacing are required to assure that maximum impacts from sources are captured in the model. However, each receptor point requires computational time. Consequently, it is not optimal to specify a dense network of receptors over a large modelling area; the computational time would negatively impact productivity and available time for proper analysis of results. A multi-tier grid approach that combines aspects of coarse grids and refined grids in a modelling application is recommended when specifying receptor locations. The multi-tier grid approach strives to achieve proper spatial definition of points of maximum impact while maintaining reasonable computation times without sacrificing sufficient resolution.

The Cartesian grid must be used to define the receptor grids with the facility under consideration as close to the centre of the grids as possible. Polar grids are not recommended for regulatory air dispersion modelling. This is because polar receptor spacing from the facility under consideration becomes too large too quickly as the distance increases, making interpretation of results difficult.

The multi-tier Cartesian grid with pre-defined grid spacing as defined in Table 9 is recommended for modelling applications. If necessary, a separate refined grid or discrete receptors should be placed in areas of concern wherever circumstances require further characterisation. Such circumstances include the presence of hotspots and sensitive receptors within the modelling domain, e.g., schools, residential zones or hospitals. It is standard practice that assessments of pollutant concentrations are conducted at ground level. For the sake of consistency it is recommended that unless specific circumstances require otherwise, assessments must be conducted at ground level, hence flagpole height of 0.0 m. For specific requirements such as concentrations at the height of a person, a flagpole height of 1.5 m must be used.

Table 9. Recommended grid spacing for receptor grids.

Resolution	Receptor spacing
50 m	General area of maximum impact, property boundary and over steep terrain
100 m	5 km from the facility of interest
250 m	10 km from the facility of interest
1 000 m	Beyond 10 km from the facility of interest

6.5 Building Downwash Effects

The trajectory of a plume from a stack may be modified by the presence of building structures (including that of the stack). Buildings in the vicinity of the stack may act as barriers to stream flow. Depending on the ambient wind profile and exit velocity, parts of the plume may be drawn down into the building cavity, a low pressure region in the near-wake of a building. This phenomenon is called building downwash and is caused by turbulence created by air movement around building obstacles. Buildings and other structures near a relatively short stack can have a substantial effect on plume transport and dispersion, and on the resulting ground-level concentrations that are observed. In certain meteorological conditions, building downwash effects may trigger pollutant accumulation and increased ground pollutant concentrations far beyond air quality standards near the sources.

In the pre-2011 versions of AERMOD, the effects of building downwash were "turned-off" for plumes released from stacks higher than the US EPA's formula for determining Good Engineering Practice (GEP) stack height (US EPA 2005). Thus, facilities received a benefit by raising their stacks to the GEP stack height to avoid accounting for downwash effects. In the absence of improved dispersion techniques or other limitations, raising a stack height to the formula height was an acceptable means of demonstrating compliance in air dispersion modelling analyses. However, turning off of downwash at the GEP formula height introduced a discontinuity in the dispersion profile (i.e., a stepwise decrease in concentration for stacks just above or just below the formula height). In the post-2011 AERMOD version (AERMOD Version 11353), the US EPA has implemented a change to the way that building downwash is considered for stacks at or above the GEP formula height (US EPA 2011). Specifically, AERMOD no longer turns off downwash above the GEP formula height. Rather, the determination of whether building downwash effects apply is based on the criterion implemented within the Plume Rise Model Enhancement (PRIME) downwash algorithm. PRIME provides a more realistic handling of downwash and is incorporated in both AERMOD and CALPUFF models.

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

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

For point sources within the **Area of Influence,** building downwash information (direction-specific building heights and widths) must be included in the modelling project. These direction-specific building heights and widths can be computed using the Building Profile Input Program (BPIP).

Structure Influence Zone (SIZ): For downwash analyses with direction-specific building dimensions, wake effects are assumed to occur if the stack is within a rectangle composed of two lines perpendicular to the wind direction, one at **5L** downwind of the building and the other at **2L** upwind of the building, and by two lines parallel to the wind direction, each at **0.5L** away from each side of the building, as shown in Figure 3. **L** is the lesser of the building height or projected building width (PBW). This rectangular area has been termed a **Structure Influence Zone (SIZ).** Any stack within the SIZ for any wind direction is potentially affected by GEP wake effects for some wind direction or range of wind directions.

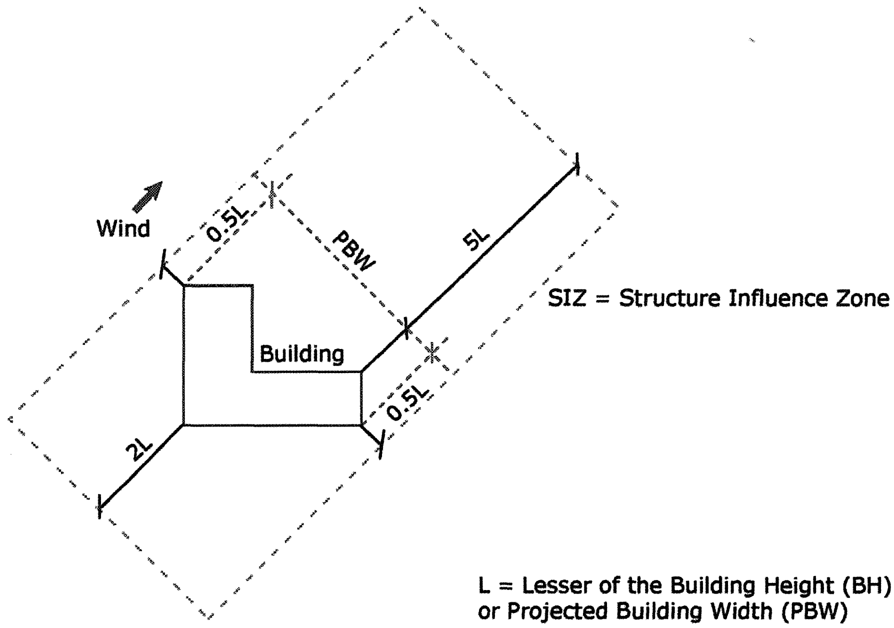

Figure 3. Structure influence zone for downwash analyses

Direction-specific building parameters within the area of influence and structure influence zone can be tedious to determine by hand for complicated building structures (for example, *"L"* shaped buildings with multiple tiers). Such efforts can be avoided through the use of the Building Profile Input Program Plume Rise Model Enhancements BPIP-PRIME (referred to as BPIP) building pre-processor, a US EPA utility program. Based on building and stack information, BPIP accounts for multiple buildings of various shapes, calculates the relevant scaling parameters that are required as model input and identifies those sources affected by buildings for all wind directions.

PRIME was designed to include the latest scientific algorithms for evaluating building downwash and is the algorithm recommended estimating building downwash in AERMOD and CALPUFF. Building downwash analyses should be performed first using BPIP-PRIME. The results from BPIP-PRIME can then be incorporated into the modelling studies for consideration of downwash effects. BPIP user's Guide (US EPA 1995) provides details on how to input building and stack data to the program.

PRIME incorporates two fundamental features associated with building downwash:

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

PRIME algorithms account for:

- The location of the stack relative to the building.
- The deflection of streamlines up over the building and down the other side.
- The effects of the wind profile at the plume location for calculating plume rise.
- Pollutants captured in the recirculation cavity to be transported to the far wake downwind.
- Discontinuities in the treatment of different stack heights.

6.6 Chemical Transformations of NO_x and SO_2

6.6.1 Estimating NO_2 Concentrations

Combustion processes emit nitrogen oxides in the form of nitric oxide (NO) and nitrogen dioxide (NO_2). The South African NAAQS stipulates the regulation of NO_2; however, emissions of nitrogen oxides must be modelled in order to estimate total NO_2 concentrations. Total oxides of nitrogen (NO_x) are comprised of nitric oxide and nitrogen dioxide ($NO_x = NO + NO_2$). The concentration of NO_2 in the exhaust of typical combustion sources is generally in the order of five to 10% of the NO_x concentration. As the plume travels away from the stack, it can react with background ozone in the plume, rapidly transforming NO, eventually resulting in close to total conversion of NO to NO_2.

Dispersion models in this **Code of Practice** do not have sufficiently detailed descriptions of atmospheric chemistry to robustly account for NO to NO_2 conversion and thus the predicted NO_x concentration must be equated into NO_2 using a conversion factor. A tiered screening approach is recommended to obtain annual average estimates of NO_2 from point sources as stipulated by the US EPA and other guidelines.

Tier 1: Total Conversion Method

Use any of the appropriate models recommended to estimate the maximum annual average NO_2 concentrations by assuming a total conversion of NO to NO_2. If the maximum NO_x concentrations are less than the NAAQS for NO_2, then no further refinement of the conversion factor is required. If the maximum NO_x concentrations are greater than the NAAQS for NO_2, or if a more "realistic" estimate of NO_2 is desired, proceed to the second tier level.

Tier 2: Ambient Ratio Method (ARM) – Multiply NO_x by a national ratio of $NO_2/NO_x = 0.80$

Assume a wide area quasi-equilibrium state and multiply the Tier 1 empirical estimate NO_x by a ratio of $NO_2/NO_x = 0.80$. The ratio is recommended for South Africa as the conservative ration based on a review of ambient air quality monitoring data from the country. If representative ambient NO and NO_2 monitoring data is available (for at least one year of monitoring), and the data is considered to represent a quasi-equilibrium condition where further significant changes of the NO/NO_2 ratio is not expected, then the NO/NO_2 ratio based on the monitoring data can be applied to derive NO_2 as an alternative to the national ratio of 0.80.

6.6.2 Estimating SO_2 Concentrations

Transformation of SO_2 emitted from point sources / single industrial plants in rural areas is assumed to be relatively unimportant to the estimation of maximum concentrations for periods of a couple of hours. In urban areas SO_2 transformation cannot be ignored hence:

- A half-life of **4 hours** must be applied to the analysis of SO_2 emissions
- Transformation coefficients from site specific studies must be accompanied by peer-reviewed documentation. However, transformation coefficients should not be applied in screening applications.

The oxidation of SO_2 in the atmosphere is a highly complex process which is influence by many factors, including relative humidity, pH, concentrations of catalysts and other reactive species. In the absence of highly detailed description of atmospheric chemistry, a half-life of 4 hours is consistent with a large number of studies in the literature, and is an accepted value in most modelling guidelines. We therefore recommend a half-life of 4 hours for SO_2 in dispersion modelling applications."

It should be noted that not all chemical reactions result in the destruction of pollutants or in reaction products that are of less concern than the pollutants from which they derive. In some cases, the immediate reaction products result in products that are more toxic and / or more persistent than the chemicals that were originally released into the atmosphere. Examples of large-scale chemical reactions that result in products that can be hazardous to health include the generation of acid particulates through photo-oxidation after the release of sulphur dioxide (SO_2) and NO_x from combustion sources (i.e., to make sulphuric acid and nitric acid), the formation of highly oxidized secondary organic particulate matter, degradation of VOCs to form aldehydes, and the formation of ozone in areas with high levels of NOx and volatile organic emissions (USEPA, 2004).

6.7 Deposition

Wet deposition are natural processes by which pollutants (gases or particles) are removed from the atmosphere by hydrometeors (such as cloud and fog droplets, rain, snow) and consequently delivered to the Earth's surface. Dry deposition is the transportation of pollutants from the atmosphere onto surfaces in the absence of precipitation. Deposition processes are the ultimate pathways by which pollutants are removed from the atmosphere. Dry or wet deposition can be important whenever the source discharges significant amounts of large particles or certain other contaminants (e.g., heavy metals and dioxins).

AERMOD, CALPUFF and SCIPUFF include algorithms for modelling the settling and removal of large particulates (dry deposition) as well as algorithms to determine wet deposition of gases and particulates. These deposition processes deplete the plume material as it is deposited on the surface. Unless deposition fluxes are of importance to the modelling study, pollutant deposition must not be modelled in licensing applications. Where fugitive dust deposition fluxes are to be accounted for, particle-size distributions and settling velocities must be carefully selected to be representative of the fugitive emissions. As indicated in Chapter 3.3, modelling results of fugitive sources must be reported separately from the modelling results associated with sources where there is greater certainty in the emissions (like point sources).

7 GENERAL REPORTING REQUIREMENTS

7.1 Model Accuracy and Uncertainty

Air quality models attempt to predict concentrations at a specific point and time based on "known" or measured values of various parameters input into the model, such as wind speed, temperature profiles, solar radiation. There are however, variations in the "unknown" parameters that are not measured as well as unresolved details of atmospheric turbulent flow. Other input parameters, such as intermittent background sources, may be highly uncertain and difficult to characterize. Variations in these "unknown" parameters can result in deviations of the predicted concentrations of the same event, even though the "known" parameters are fixed. As a result of the deviations of the "unknown" parameters, a "perfect" model may be able to predict an average of identical events well, while each repetition of that event will provide somewhat different results. The statistics of these concentration residuals are termed "inherent" uncertainty of a model (US EPA 2005).

In addition, there are "reducible" uncertainties due to inaccuracies in the model, errors in input values and errors in the measured concentrations. "Reducible" uncertainties include inaccuracies in the input values of the known conditions (for example, poor quality or unrepresentative meteorological, geophysical and source emission data); errors in the measured concentrations that are used to compare with model predictions and inadequate model physics and formulation used to predict the concentrations. As the term indicates, "reducible" uncertainties can be controlled or minimized by collecting accurate input data, preparing the input files correctly, checking and re-checking for errors, correcting for odd model behaviour, insuring that the errors in the measured data are minimized and applying better model physics.

The performances of the models recommended in this **Code of Practice** have been evaluated using a range of modelling test kits and the detailed reports can be found at the U.S. EPA SCRAM website http://www.epa.gov./scram001. As such, for as long as the most appropriate model has been selected as "fit for purpose", the modeller is **not** mandated to perform any further modelling evaluations. To minimize the "reducible" uncertainties, modellers must exercise quality control and quality assurance (QA/QC) procedures to substantiate the accuracy of the input source, receptor, and meteorological data. The QA/QC procedures must be documented as part of the modelling report for the reviewing / licensing authority to evaluate the implications of the results in terms of the potential impacts of the predicted concentrations. However, in the case of AQMP developments or impact assessment reporting, the modeller is required to use ambient air quality measurements to evaluate modelling results, whenever the measurements are available.

7.2 Modelling Reporting Requirements

Sufficient information must be provided to the relevent authorities to allow a full understanding of the results, how they were derived in order to promote an orderly approach to modelling, and to ensure communication between the various parties. This section provides guidance on how an air dispersion modelling study plan and outputs are to be reported to the competent authorities. It is imperative that air dispersion modelling that is undertaken conforms to the following reporting requirements:

- A description of the input data, including source of data, validity of data and any assumptions must be provided.
- Electronic copies of input files required to run the model must be provided together with a hard and or electronic copy of the output text file.
- Plotted dispersion contours should be overlaid onto a current aerial photograph or topographic map or a street map of the relevant area.
- Time series plots must be provided to further support how the conclusions of compliance have been reached.
- Legible full colour reports and diagrams illustrating impacts must be submitted.
- The source site and closest sensitive receptors must be highlighted, including residential areas.
- The modelling scale selected must show all relevant ground level impacts.
- A discussion on the accuracy of the results and comparison with appropriate standards must be provided according to the various averaging periods that are applicable.
- Details of the ambient background levels of pollutants that were used and their source must be provided.
- The impact of the proposed operations on the ambient air quality must be demonstrated for all phases of the current and future development.

For specialist air quality reports, the reporting requirements detailed in this **Code of Practice** are aligned to those stipulated in Section 32 (a-h) of the EIA Regulations (DEA 2010), with specific details required for air dispersion modelling reports. These requirements must be followed in presenting atmospheric quality reports, prescribed in Section 30 of the AQA. However, for dispersion modelling studies in air quality management plans, these reporting requirements might need to be streamlined depending on the requirements of the AQMP.

7.2.1 Plan of Study Reporting Requirements

As described in **Code of Practice** Chapter 2.3.8, a plan of study is required as part of the AEL/EIA application process. The plan of study provide a general overview of the intended modelling approach and will facilitate further discussions between the competent authority and those conducting the assessment. For specialist air quality impact studies, the plan of study must be presented by the applicant to the competent authority outlining the proposed modelling protocols to be followed before such a study is undertaken as described in Chapter 2.3.8. The attached checklist must be used as a guide to ensure that applicable information is included and sufficiently addressed. The plan of study must be amended as required before being approved by the competent authority. Changes to the plan must be communicated to the competent authority in writing before final submission of modelling results.

Table 10 provides a guideline on the **minimum** information that must be submitted as part of a study plan for an activity that will trigger a specialist air quality assessment. This reporting guidance must be used by all parties as a checklist to determine if the study plan is complete.

Table 10. Information required in the Plan of Study Report.

Chapter 1: Facility and modellers' information		Submitted Yes / No	Comments, References
1.1	**Project identification information** • Applicant details • Facility identification • Physical address of facility • Atmospheric Emissions License reference number (if applicable) • Environmental authorization reference number (EIA reference where applicable) • Modelling contractor(s), when applicable		
1.2	**Project background** • Purpose(s) and objectives of the air dispersion modelling under consideration. • General descriptive narrative of the plant process (es) and proposed new source or modification.		
1.3 1.3.1	**Project location** **Detailed scaled layout plan of proposed project area including the following** • UTM coordinates on horizontal and vertical axis • Property lines, including fence lines • Roads and railroads within the proposed modelling domain • Location and dimensions of buildings and/or structures (on or off property) which could influence dispersion		
1.3.2	**Area map(s)** • Map of adjacent area (10 km radius from proposed source) indicating the following o UTM coordinates on horizontal and vertical axis o Nearby known pollution sources o Schools, hospitals and old age homes within 10km of facility boundary o Topographic features o Any proposed or existing off-site or on-site meteorological monitoring stations o Roads and railroads • Regional map that includes the following o Latitude/ Longitude on horizontal and vertical axis o Modelled facility o Topography features within 50 km o Known pollution sources within 50 km o Any proposed off-site meteorological monitoring stations		
1.4	**Land use determination in modelling domain** • Urban • Rural/ Agricultural		
1.5	**Elevation data (DEM) and resolution**		

	Chapter 2. Emissions characterisation	Submitted Yes / No	Comments, References
2.1	**Emission unit characteristics** • Include fugitive & secondary emissions when applicable • Emission unit descriptions and capacities (including proposed emission controls) • New structures or modifications to existing structures		
2.2	**Operating scenarios for emission units** • Operating condition applicable to the study o Upset conditions o Normal o Start-up o Standby o Shutdown		
2.3	**Proposed emissions and source parameter table (s)** • List all identifiable emissions • Include parameter table(s) for each operating scenario of each emission unit, which may include, but not be limited to the following: o Operating scenario(s) o Source location (UTM Coordinates) o Point source parameters o Area source parameters o Volume source parameters • Include proposed emissions (and supporting calculations) for all identifiable emissions		

	Chapter 3: Meteorological data	Submitted Yes / No	Comments, References
3.1	**Surface data discussions must include:** • Off-site o Source of data o Description of station (location, tower height, etc.) o Period of record o Demonstrate temporal and spatial representativeness o Seasonal wind- rose(s) o 3-year of representative off-site data o Evaluate if off-site data complies with regulatory **Code of Practice** o Program and version used to process data o Method used to replace missing hours o Method used to handle calm periods • On-site o Description of station (location, tower height, etc.) o Period of record o Demonstrate spatial representativeness o Minimum 1-year of representative on-site data o Evaluate if off-site data complies with regulatory the		

	Code of Practice o Program and version used to process data o Method used to replace missing hours o Method used to handle calm periods		
3.2	**Discuss proposed upper air data** • Discuss proposed upper air data from the most representative station. • Explain why it is "most representative".		

	Chapter 4: Ambient impact analysis and ambient levels	Submitted Yes / No	Comments, References
4.1	**Standards Levels** • National Ambient Air Quality Standards		
4.2	**Background Concentrations** • Specify background values to be used including supporting documentation.		

	Chapter 5: Modelling Procedures	Submitted Yes / No	Comments, References
5.1	**Proposed Model** • Assessment level proposed and justification • Dispersion model proposed • Supporting models and input programs • Version of models and input programs		
5.2	**Proposed emissions to be modelled** • Pollutants • Scenarios and emissions from Chapter 3.1 that will be modelled • Conversion factor utilized for converting NO_X to NO_2 (if applicable)		
5.3	**Proposed Settings** • Recommended settings to be utilized within model • Terrain settings (simple flat/ simple elevated/ complex) • Land characteristics (Bowen ratio, surface albedo, surface roughness)		
5.4	**Proposed Grid Receptors** • Property line resolution • Fine grid resolution • Medium grid resolution(s) • Course grid resolution • Hot spot resolution and size		

7.2.2 Air Dispersion Modelling Study Reporting Requirements

Table 11 contains a description of the general requirements to be included in the final dispersion modelling report submitted to the competent authority. It provides an overview of important information to be included as minimum requirements into the final report to enable sufficient review and decision making by the authority. Additional relevant information may be added but must be specified as such.

Table 11. Information required in the Air Dispersion Modelling Study report.

	Chapter 1: Facility and modellers' information	Submitted Yes / No	Comments, References
1.1	**Project identification information requirements** • Applicant • Facility identification • Physical address of facility • Air Emissions License reference number (if applicable) • Environmental authorization reference number (if applicable) • Modelling contractor(s), when applicable		
1.2	**Project background requirements** • Purpose(s) and objectives of the air dispersion modelling under consideration. • General descriptive narrative of the plant processes and proposed new source or modification.		
1.3 1.3.1	**Project location requirements** **Detailed scaled layout plan of proposed project area including the following:** • UTM coordinates of facility • Property lines, including fence lines • Roads and railroads that pass through property line • Location and dimensions of buildings and/or structures (on or off property) which could cause downwash o Location o Length o Width o Height • Indication of shortest distance to property line from significant sources		
1.3.2	**Area map(s) that include the following:** • Map of adjacent area (10 km radius from proposed source) indicating the following o Latitude/ Longitude on horizontal and vertical axis o Nearby known pollution sources o Schools and hospitals within 10km of facility boundary o Topographic features o Any proposed off-site or on-site meteorological monitoring stations o Roads and railroads • Regional map that includes the following o UTM coordinates		

	Chapter 1: Facility and modellers' information	Submitted Yes / No	Comments, References
	o Modelled Facility o Topography features within 50 km o Known pollution sources within 50 km o Any proposed off-site meteorological monitoring stations		
1.4	**Geophysical data** • Discuss land use characterization procedures utilized to determine dispersion coefficients (urban or rural) • Discuss the elevation data (DEM) and its resolution		
1.5	**Elevation data (DEM) and resolution** • Discuss DEM data utilized		

	Chapter 2. Emissions characterisation	Submitted Yes / No	Comments, References
2.1	**Emissions characteristics** • Include fugitive and secondary emissions when applicable • Emission unit descriptions and capacities (including proposed emission controls) • New structures or modifications to existing structures as a results of project		
2.2	**Operating scenarios for emission units** • Operating conditions simulated in the modelling study o Normal o Start-up o Standby o Shutdown		
2.3	**Proposed emissions and source parameter table (s)** • List all identifiable emissions • Include parameter table(s) for each operating scenario of each emission unit, which may include, but not be limited to the following: o Operating scenario(s) o Source location (UTM Coordinates) o Point source parameters o Area source parameters o Volume source parameters Include proposed emissions (and supporting calculations) for all identifiable emissions		

	Chapter 3: Meteorological data	Submitted Yes / No	Comments, References
3.1	**Surface data discussions must include:** • Off-site o Source of data o Description of station (location, tower height, etc.) o Period of record o Demonstrate temporal and spatial representativeness o Seasonal wind- rose(s)		

	o 3-year of representative off-site data o Evaluate if off-site data complies with regulatory **Code of Practice** o Program and version used to process data o Method used to replace missing hours o Method used to handle calm periods • On-site o Description of station (location, tower height, etc.) o Period of record o Demonstrate spatial representativeness o Minimum 1-year of representative on-site data o Evaluate if off-site data complies with regulatory **Code of Practice** o Program and version used to process data o Method used to replace missing hours o Method used to handle calm periods		
3.2	**Discuss upper air data utilised** • Discuss upper air data utilised from the most representative station. • Explain why it is "most representative".		

	Chapter 4: Ambient impact analysis and ambient levels	Submitted Yes / No	Comments, References
4.1	**Standards Levels** • National Ambient Air Quality Standards		
4.2	**Background Concentrations** • Specify background values used including supporting documentation.		

	Chapter 5: Modelling Procedures	Submitted Yes / No	Comments, References
5.1	**Model used in the study** • Assessment level proposed and justification • Dispersion model used. • Supporting models and input programs • Version of models and input programs		
5.2	**Specify modelled emissions** • Pollutants • Scenarios and emissions that were modelled • Conversion factor utilized for converting NO_x to NO_2		
5.3	**Specify setting utilized within the model(s), which may include:** • Recommended settings utilized within model • Terrain settings (simple flat/ simple elevated/ complex) • Land characteristics (Bowen ratio, surface albedo, surface roughness) • Specify number of sectors used and why (if applicable) • Specify assumptions (if applicable) • Include discussion on non-regulatory settings utilized and reasons why		

5.4	**Describe the receptors grids utilized within the analysis** • Property line resolution • Fine grid resolution • Medium grid resolution(s) • Course grid resolution • Hotspots and sensitive location resolutions and sizes • Figures that show locations of receptors relative to modelled facility and terrain features.		

	Chapter 6: Ambient impact results documentation		
6	**At a minimum, the Ambient Air Quality Standards results are to be documented as follows:**		
6.1	**Table(s) of modelling results including** 1. Pollutant 2. Averaging time 3. Operating scenario 4. Maximum modelled concentration 5. Receptor location of maximum impact (coordinates) 6. Receptor elevation 7. Date of maximum impact 8. Grid resolution at maximum impact 9. Name of output e-file(s) where data was taken from		
6.2	**Figure(s) showing source impact area including** 1. UTM coordinates on horizontal and vertical axis 2. Modelled facility • Boundary • Buildings • Emission points 3. Topography features 4. Isopleths of impact concentrations 5. Location and value of maximum impact 6. Location and value of maximum cumulative impact		

	Chapter 7: Ambient impact supporting documentation		
7.1	**All warning and informational messages within modelling output files must be explained and evaluated**		
7.2	**Required electronic files to be submitted with report** 1. Input & output files for models 2. Input & output files for pre-processors 3. Input & output files for post-processors 4. Digital terrain files 5. Plot files 6. Final report		
7.3	**Report shall include a list and description of electronic files**		
7.4	**Report shall include a discussion on deviations from the modelling protocol**		

7.3 Archiving of submitted electronic files

All electronic files submitted to the competent authorities must be documented and archived by the respective authorities. This would assist the competent authority to ensure that all information is available;

- If according to Section 38 (1b) of the AQA, the licensing authority may conduct its own investigation on the likely effect of the proposed licence on air quality.
- For any subsequent licence appeals, modifications, upgrades and reviews of the existing licences, in the case of AEL applications, or atmospheric impact reports.
- To provide input data in the development and review of AQMPs and other dispersion modelling initiatives the competent authority might undertake.

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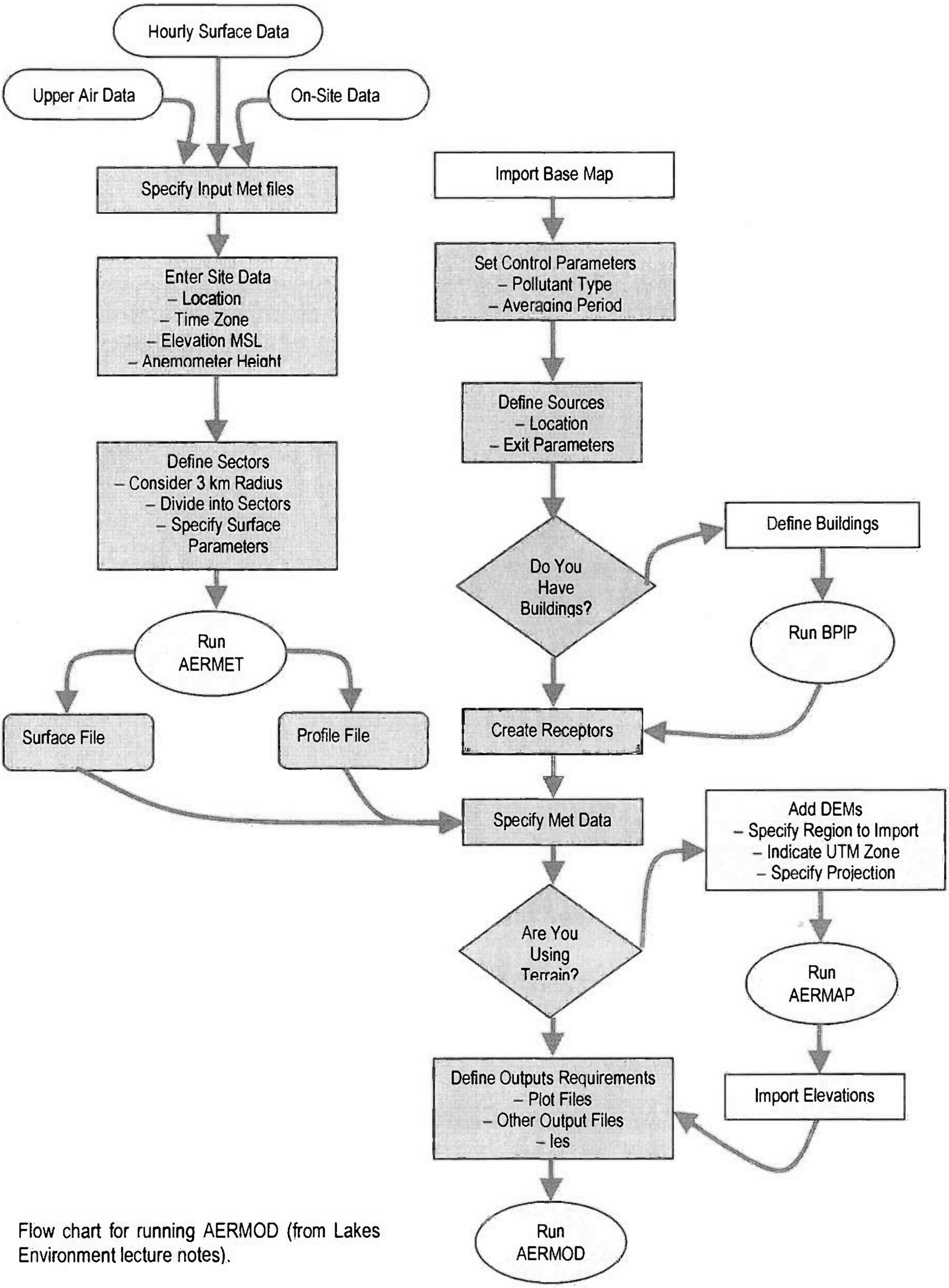
8 FLOW CHART – RUNNING AERMOD



Flow chart for running AERMOD (from Lakes Environment lecture notes).

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