Department of Environment

AIR QUALITY MODELLING GUIDANCE NOTES

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1 Introduction

The Department of Environment (DoE) is frequently required to review assessments of the air quality impact of existing or proposed sources of air pollutants. This often occurs in the course of individuals or companies (generically called "proponents" below) meeting their obligations under the *Environmental Protection Act 1986* ("the Act"), notably environmental impact assessment under Part IV of the Act or in relation to Works Approvals and Licences under Part V of the Act.

Most air quality assessments employ computer modelling to provide estimates of the environmental (ambient) air quality impact. The quality of modelling efforts reviewed by the DoE over many years has varied from highly skilled to very inadequate. These guidance notes have been prepared to provide a clear understanding of the DoE's expectations with respect to air quality modelling and associated meteorological monitoring and/or modelling.

2 Identify emissions and secondary pollutants

The proponent is responsible for identifying and quantifying all emissions to atmosphere with a potential to have a non-trivial impact on the environment (including impact on human health and well-being, odour, nuisance, amenity, vegetation - natural and agricultural, fauna - natural and agricultural). Emissions of potential concern include SO_2, NO_x, CO, particles, volatile organic compounds, fluorides, hydrogen sulphide, other odorous gases, heavy metals, dioxins, furans, PAH and other toxic compounds. All of these are to be considered explicitly, unless the proponent can demonstrate that the emission rates of these are insignificant. Additionally, the formation and impact of secondary pollutants such as photochemical smog and aerosols should be assessed if applicable. Greenhouse gases and ozone depleting compounds are beyond the scope of these guidelines.

3 Modelling to predict impacts (overview)

For all those primary and secondary pollutants which cannot be dismissed as being of no significance, the proponent must provide model predictions of the impact of emissions on the various elements of the environment, in the form of concentrations and/or rates of deposition over the range of averaging periods normally associated with relevant standards for each pollutant, and assess the magnitude of this impact against the relevant standards. "Relevant standards" refers to guidelines/goals/standards which the EPA/DoE has adopted or advised or, in the absence of an EPA/DoE position, guidelines/goals/standards proposed by the proponent on the basis of national or international practice and/or field investigations of environmental sensitivity. Data from experiments or justifiable extrapolations from published literature will also be required on the susceptibility of natural vegetation and crops.

Note:

The proponent may choose to carry out "worst case" screening analyses for particular pollutants (eg via simplified, <u>conservative</u> calculations or models) in order to demonstrate to the DoE that air quality impacts are insignificant and therefore that comprehensive modelling procedures are not warranted. The worst case analysis procedures (calculations, models) must be adequately described, with reference to their source. Most of the discussion which follows is directed towards detailed modelling exercises rather than screening analyses. A screening analysis will be considered inadequate if it ignores any of the features or factors described below which might be potentially significant.

4 Presentation of model results

Modelling results should be presented in the form of:

- contour plots covering the region of interest (including population centres or isolated residences), with a grid density adequate to avoid significant loss of resolution;
- numerical values of concentrations at the point(s) of maximum impact (explain where this occurs) and other locations (receptors) of interest (e.g. places of human residence).

For each pollutant so modelled, the contours and numerical values should be presented with reference to relevant standards (e.g. at the averaging period and percentile level of the relevant standard) and the model results evaluated against the standard. For NEPM pollutants, results should be presented for both maximum concentrations and concentrations at the allowed exceedance level (e.g. for SO_2, 2^{nd} highest 1-hour average on a day different to that on which the highest occurred). The meteorological conditions causing highest concentrations at important receptors should be assessed (if possible) to check that the model is yielding sensible results.

5 Modelling cumulative impacts

For each pollutant modelled, the assessment must account for existing concentrations caused by other sources plus (if significant) the background concentration (whether natural or man-made) in order to estimate the cumulative concentration. When cumulative concentrations are modelled, the contribution of the proposal to high percentile short term (say 1-hour) averages is often masked. Consequently, in order for the contribution to be properly assessed, the DoE requires modelling results (as described in the foregoing point) to be presented for:

- the existing emissions plus background concentration (pre-proposal);
- the proposed development in isolation (excluding existing emissions); and
- the combined (existing plus proposed plus background) emissions.

The "existing emissions" must include not only those of existing, operating sources of emissions but also those expected from yet-to-be-constructed sources which are at a stage of approval, and commitment to proceed, ahead of the proposal being assessed. Such sources will need to be identified on a case-by-case basis. Industries proposed for location in Kwinana or other regions with airshed management policies will need to be assessed in accordance with the provisions of those policies; the DoE will provide details.

6 Emissions estimates

The DoE requires assurance that the estimates of emissions employed in modelling assessments are realistic and that uncertainty is balanced by conservatism. Details on how the source parameters (stack dimensions, mass emission rates, gas flow rate, temperature, density, etc) were derived should be summarised. This is to include whether these parameters were derived from stack testing (in relation to an existing facility), from theoretical calculations such as from a mass balance approach, from other existing facilities or standard emission factors published by relevant authorities (e.g. USEPA). If the emissions are derived from stack testing, details should be given on how many stack tests were taken and how representative these were. Unless otherwise agreed, the level at which emissions should be set for modelling purposes is described in EPA Vic (1985).

7 Variable or intermittent emissions

In the experience of the DoE, intermittent emissions (plant start-ups, plant upsets, etc) result in more pollution complaints than normal emissions from operating industries. The modelling must properly assess both emissions which are continuous in nature and emissions which are intermittent. Intermittent emissions which are insignificant in magnitude and/or very improbable in the lifetime of the plant may be screened out and the remaining emissions modelled together on a probabilistic basis to estimate the total plant impact. Screening of emissions cases must be based on the joint consideration of probability and magnitude of emission. The DoE is able to provide guidance on how to screen and model intermittent emissions.

8 Model capability

The models and/or worst case calculation procedures and data employed in the assessment must be demonstrably capable of simulating, or accounting for, all of the features which are important in the context of determining the air quality impact of the project. The proponent is responsible for identifying and properly accommodating these. The following list may not be exhaustive but is provided for checking purposes:

- trapping of plumes in mixed layers of limited height or, alternatively, penetration of plumes through elevated temperature inversions;
- vertical plume dispersion in convective conditions;
- fumigation of plumes into an encroaching mixed layer or thermal internal boundary layer near a coastline. Investigations of this phenomenon may require estimates of wind direction shear in stable layers;
- sea breeze trapping, recirculation of pollutants;
- near-surface dispersion under very stable calm conditions (a feature of WA winter meteorology);
- topographic influences - impact of plumes on elevated terrain, effect on spatially varying wind fields, valley winds (anabatic and katabatic winds), ponding of air in stable conditions;
- surface roughness;
- building wake effects, stack tip downwash (avoided by good engineering stack design);
- deposition, chemical transformation;
- effects of positive or negative buoyancy;
- radiation from flares.

The modelling report should describe how each of the relevant features was treated. Examples are:

- Physical description of the site to be modelled. This is to include details on the topography, ie highest hill/mountain within the model region, distance to coast or any other major water bodies and how this was dealt with in the modelling;
- For a coastal site, details on how sea breeze effects were incorporated in the modelling;
- The value(s) of the roughness length and details on how this was determined (refer to USEPA (2000) for recommended approaches).

9 Meteorological data for modelling

If using a conventional model, the proponent will need to obtain at least one (preferably two or more) year's data on the meteorology of the area, with high data recovery and verifiable data accuracy. In the simplest situations, the data may be limited to that necessary to provide reliable hourly average estimates, at a representative site, of:

- wind speed;
- wind direction;
- air temperature;
- mixing height, estimated or measured via methods acceptable to the DoE;
- atmospheric stability, estimated by a method acceptable to the DoE.

Proponents are welcome to discuss the acceptability of proposed methods.

The proponent's report should include a description of the meteorological data used or alternatively a reference to a publicly available report which contains this information. The description is to include details of the methodology used to derive estimates of stability and mixing heights and is to present (as a minimum) the annual wind rose, annual stability frequency distribution and details of the mixing height distribution. The description should also include details about the quality of the anemometers used and their starting threshold.

Meteorological data collected in the immediate vicinity of the emissions source being modelled are to be used, unless an exemption is obtained for reasons along the following lines:

- On-site meteorological monitoring can be demonstrated to be unrepresentative of the broader region containing receptors of interest due to (for example) local topographic features or distribution of trees at the site;
- High quality meteorological data exists for a location within a few kilometres of the emissions source and these data are shown by the proponent, to the satisfaction of the DoE, to be representative of the emissions source site, i.e. subject to the same factors (such as topography, vegetation and water bodies) as would be expected to influence the meteorology at the emissions source site. For winds and temperature measured well above the surface by remote sensing or radiosondes, data from a site many kilometres from the emissions source might be acceptable;
- Meteorological data are to be computed by a sophisticated prognostic model that has been adequately proven against measurements in the region of interest and is expected to yield pollutant dispersion predictions superior to those which might be obtained from using on-site meteorological data from a single location. (Note, however, that there may still be good reason to undertake on-site meteorological monitoring to enable site-specific confirmation of the prognostic model);
- The cost and time required for on-site monitoring can be clearly demonstrated to be not warranted for a particular development (e.g. by demonstrating that no conceivable difference between the meteorology of the site and that employed in modelling could alter the conclusion that pollutant concentrations are clearly acceptable). This analysis is likely to include worst case calculations.

Specialised and detailed meteorological data and associated calculations are necessary to accurately model some of the features listed in point 8. For example, to model shoreline fumigation, knowledge of the onshore-flow vertical temperature structure is required. The proponent is responsible for assessing the full range of pollution dispersion issues and designing an appropriate monitoring program. Where items of data are not based on the results of continuous monitoring (eg. based instead on prognostic model estimates, intermittent field experiments or unverified hypotheses), the uncertainty of estimates must be offset by conservatism in these estimates. The proponent is invited to demonstrate to the DoE that complicated or costly monitoring programs and/or modelling procedures for particular meteorological parameters are not warranted.

10 Advanced models

The DoE accepts that advanced prognostic models may be less reliant on measurements than conventional (eg Gaussian) models. These advanced models would need to be well supported by published validation studies before the DoE would accept their use in isolation.

11 Model acceptability and verification

The DoE does not generally prescribe which models must be used in particular circumstances. The DoE takes this position in order to allow scientific and technical advances to be introduced without regulatory delays. However the DoE reserves the right to reject a proposed model, or application thereof, if it considers it to be inadequate, inappropriate or unproven. The AUSPLUME model is frequently used in a manner acceptable for modelling industrial emissions, but has limitations (in some respects serious) which model users should understand and respect. The USEPA-approved models AERMOD and CALPUFF have significantly improved scientific formulations and more advanced capabilities than AUSPLUME or ISCST3. At the time of writing, CALPUFF is widely used in Australia, being favoured for its capability to handle light winds, long-range transport and the effect of topography. The results of some models like CALMET/CALPUFF are strongly dependent on the settings of model options, which in some cases are numerous. In such cases, expert knowledge is required.

At the time of writing, the CSIRO model TAPM has a significant tendency to overestimate wind speed relative to measurements in night-time / early morning stable conditions and therefore to underestimate atmospheric stability at these times. While this may be of little consequence to tall stacks with buoyant plumes, the concentration of pollutants from near-surface sources with zero or low buoyancy is likely to be underestimated at these times, due to the combined influence of overestimated speed and underestimated stability. The highest concentrations from such sources occur under low wind speed, high stability conditions. Therefore the DoE will not accept the use of TAPM to model dispersion of low sources with zero or low buoyancy, either directly (TAPM calculating concentrations) or indirectly (TAPM producing a meteorological file for another model) unless performance of the model(s) is demonstrated to be reliable, or there is a margin of safety in results which is demonstrably larger than model errors. In the event that TAPM performance is improved this restriction will be withdrawn.

At the time of writing, the DoE is reviewing odour assessment methodology, including the appropriate form of odour criteria and modelling methods acceptable for determining odour impacts, size of buffer areas, etc. Proponents may contact the DoE to discuss how to proceed with assessments pending the release of revised guidance.

Unless the DoE agrees otherwise, proponents are required to present, in addition to model results, all of the model input and configuration files (via email for small files, or digital media appropriate to the size of files) to allow the DoE to check and reproduce the model results. Printouts of files in reports are not sufficient for the DoE's purposes. Model output which describes the model configuration should also be provided. If the model has not been well validated and documented in the public domain (like AUSPLUME, USEPA regulatory models), references to model validation reports (and provision of these on request) are required.

12 Reporting

To enable effective and timely evaluation of air quality studies the DoE requires reports to be provided in two forms:

- paper copies for reading (although this may not be necessary for all documents, e.g. detailed appendices containing large spreadsheets, many contour plots, etc);
- electronic copies of every document (normally .pdf format) for rapid searching and from which to copy portions of text, diagrams, etc for incorporation in advice. Document security may disallow document changes, but must be set to allow copying, printing, text highlighting, text notes and comments. Electronic copies are stored with advice to improve retention of knowledge and thereby consistency of advice.

References

EPA Vic (1985) Plume Calculation Procedure: an approved procedure under Schedule E of State Environment Protection Policy (The Air Environment). Environment Protection Authority of Victoria, March 1985, Publication 210.

USEPA (2000) Meteorological Monitoring Guidance for Regulatory Modeling Applications. U.S. Environmental Protection Agency, February 2000.