Air Modeling Quality Guideline for Environmental Impact Assessment

Office of Natural Resources and Environmental Policy and Planning

Ministry of Natural Resources and Environment

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Environmental Engineering Association of Thailand

บริษัท แอร์เซฟ จำกัด
AIR SAVE CO.,LTD

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Title: Submit to Final Report on Air Quality Modeling Guideline for Environmental Impact Assessment

To: The Chairman of Working Committee for Designating and Supervising the Consultant.
Office of Natural Resources and Environmental Policy and Planning

Enclosure:

1.	Main Report (Thai Version)	10	copies
	Main Report (English Version)	10	copies
2.	Executive Summary (Thai Version)	10	copies
	Executive Summary (English Version)	10	copies
3.	Appendix	10	copies
4.	Air Quality Guideline (Thai Version)	100	copies
	Air Quality Guideline (English Version)	100	copies
5.	CD-ROM	10	copies
6.	Maptaput Estate's data disc	1	copy

Refer to Office of Natural Resources and Environmental Policy and Planning has designated the Environmental Engineering Association of Thailand and Air Save Company Limited to study on Air Quality Modeling Guideline for Environmental Impact Assessment, as such the consultant has complete the mentioned works for both Thai and English Reports; which the defined document has been attached here with this letter.

Please acknowledge with your kind consideration.

With respectful,

(Mrs.Meena Pittayasoponkij)
The project director

PREFACE

In Thailand, the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 has been enacted. Sections 46 – 51 of Part 4 in Chapter 3 of this Act state that 22 types of project development according to the Notification of Ministry of Science, Technology, and Environment are required to prepare reports on environmental impact assessment for submission to seek approval from the Office of Natural Resources and Environmental Policy and Planning prior to project implementation to ensure that the project will not cause environmental impact after its operation.

For an impact on air quality, a mathematical model is normally used as a tool to assess such impact, which it has been found later that a result of the model is not consistent with the actual measurement data. Impact assessments from different consulting agencies provide different results even though they use the same data source. In addition, a procedure of air quality impact assessment using the model is quite complicated. Realizing this limitation, the Office of Natural Resources and Environmental Policy and Planning, who is an agency responsible for considering the report, has set a concept on reorganizing a procedure of air quality impact assessment using the model by initiating the project on setting up a manual for using a model in air quality impact assessment as a part of an environmental impact assessment report. The objective of this project is to set up a guideline for an air quality impact assessment using the mathematical model so that consulting agencies can follow the same procedure in the guideline thereby allowing easy data inspection.

Nevertheless, this manual project is simply an initiative for an application of a model in assessing air quality in Thailand. In the future, an additional study is required and the manual needs to be modified so that it would be best fit for a condition in Thailand.

Office of Natural Resources and Environmental Policy and Planning

September, B.E. 2551

PREFACE

Thailand has introduced a tool for air quality assessment named a mathematical model or air quality modeling for more than 20 years. At present, the said air quality modeling has been applied as the main tool for air quality assessment in EIA report. Now, it appears that then are quite a few of air quality modeling types, which each of them has a different specific objective in terms of the applied principles and including the input data. This results in the air quality modeling in EIA report is different from one to other, though the assessors worked use the same ser of input data from the same sources.

From the above mentioned problem, the Office of Natural Resources and Environment on Policy and Planning has initialed to study on a preparation handbook/manual of air quality modeling for EIA report a being a guideline/framework for all with limitation existing in Thailand at the present time.

The handbook/manual being prepared as a preliminary guideline and needed to be further developed for a more appropriation and suitability in terms of the suitability of the applied model and the appropriate input data.

Finally, the Environmental Engineering Association of Thailand would like to expose its deep appreciation to the Office of Natural Resources and Environment on Policy and Planning for initiation on the study of air quality modeling seriously in the country. The association would do hope that this study would be a preliminary framework for this type of study and for further development leading to the benefit/advantage of the country in the future.

The Environmental Engineering Association of Thailand

September, B.E. 2551

CONTENT

Section 1

Introduction

It has been know that consequence of any project development is resources depreciation and environmental impacts. Resolving environmental problems generated from a project development requires large amount of budget. Agencies who are responsible for environmental issues therefore give emphasis to sustainable development approach by considering development together with environmental protection and pollution prevention. This has been accomplished by employing an important tool that is an environmental impact assessment. In Thailand, the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 has been enacted. Sections 46 – 51 of Part 4 in Chapter 3 of this Act state that 22 types of project development according to the Notification of Ministry of Science, Technology, and Environment are required to prepare reports on environmental impact assessment for submission to seek approval from the Office of Natural Resources and Environmental Policy and Planning prior to project implementation to ensure that the project will not cause environmental impact after its operation.

To follow a typical approach in environmental impact assessment, a project owner who is required to prepare the report needs to appoint an environmental consulting agency to conduct an environmental impact assessment. For an impact on air quality, a mathematical model is normally used as a tool to assess such impact, which it has been found later that a result of the model is not consistent with the actual measurement data. Impact assessments from different consulting agencies provide different results even though they use the same data source. In addition, a procedure of air quality impact assessment using the model is quite complicated. Realizing this limitation, the Office of Natural Resources and Environmental Policy and Planning, who is an agency responsible for considering the report, has set a concept on reorganizing a procedure of air quality impact assessment using the model by initiating the project on setting up a manual for using a model in air quality impact assessment as a part of an environmental impact assessment report. The objective of this project is to set up a guideline for an air quality impact assessment using the mathematical model so that consulting agencies can follow the same procedure in the guideline thereby allowing easy data inspection.

In Thailand, mathematical models have been used as a tool in impact assessment for at least 20 years. The popular model is Industrial Source Complex (ISC) model which currently is developed and replaced by the American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee's

Dispersion Model (AERMOD). At present, many environmental agencies have employed other air pollutant dispersion models in their work. For instance, Pollution Control Department (PCD), an agency under the Ministry of Natural Resources and Environment, has employed the CALPUFF model in a project on carrying capacity for air pollution. In this project, however, the consultant and the Office of Natural Resources and Environmental Policy and Planning have selected AERMOD as a principal model to assess air quality impact for preparation of an environmental impact assessment report since it has been developed from ISC model that is well-known in the past and similar to ISC model in data input requirement and data format. Nevertheless, this manual project is simply an initiative for an application of a model in assessing air quality in Thailand. In the future, an additional study is required and the manual needs to be modified so that it would be best fit for a condition in Thailand.

Section 2

Conducting the Air Quality Analysis

2.1 Screening Analysis

There are two levels of sophistication of screening models.

Level 1 Screening Analysis

The first level consists of relatively simple estimation techniques that generally use preset, worst-case meteorological conditions to provide conservative estimates of the air quality impact of a specific source, or source category. These are called screening techniques or screening models.

Level 2 Screening Analysis

The purpose of such techniques is to eliminate the need of more detailed modeling for those sources that clearly will not cause or contribute to ambient concentrations in excess of either the National Ambient Air Quality Standards (NAAQS). Thailand's National Ambient Air Quality Standard, or Thailand's NAAQS show as **Table 2.1-1**

Table 2.1-1

Thailand's National Ambient Air Quality Standard, or Thailand's NAAQS

Pollutant	Average 1 hr. (mg/m^3)	Average 8 hr. (mg/m^3)	Average 24 hr. (mg/m^3)	Average 1 month (mg/m^3)	Average 1 year (mg/m^3)
Carbon Monoxide (CO)	34.2	10.26	--	--	--
Nitrogen Dioxide (NO_2)	0.32	--	--	--	--
Sulfur Dioxide (SO_2)	0.78	--	0.30	--	0.10
Total Suspended Particulate (TSP)	--	--	0.33	--	0.10
Particulate Matter (PM10)	--	--	0.12	--	0.05
Lead (Pb)	--	--	--	0.0015	--
Ozone (O_3)	0.20	0.10	--	--	--

2.1.1 Significant Impact Analysis; SIA

The preliminary analysis evaluates the potential increase in emissions from the project or the net increase in emissions associated with the modification. If the net increase in emissions associated with a PSD modification is to be evaluated, the project may include changes to the existing stack parameters. In this case the stack parameters and emission rates associated with the emission units before and after the modification are input into the same model run, with the emission units before the modification modeled as negative emissions and the emission units after the proposed modification modeled as positive emissions, each with the appropriate stack parameters.

The results of the preliminary analysis determine whether or not a full impact analysis is required. If predicted concentrations from the project are below the applicable Modeling Significance Levels (MSLs), a full impact analysis is not required. The MSLs are listed in Table 2.1-2

If any of the modeled concentrations from the preliminary modeling analysis equal or exceed the MSLs, then a full impact analysis must be conducted. The preliminary analysis should be used to determine the Significant Impact Area (SIA). The SIA is a circular area with a radius that extends from the source to the most distant point where the modeling predicts concentrations equal to the MSL, or 50 kilometers, whichever is less. The SIA is determined for each averaging period for each pollutant with predicted concentrations equal to or greater than the MSLs. The SIA used for the full impact analysis for a pollutant with more than one averaging period is the largest of the SIAs determined for that pollutant.

Table 2.1-2

Modeling Significance Levels, or MSLs

Pollutant	Averaging Period	Modeling Significance Level, (μg/m^3)
PM_{10}	Annual	1
	24-hour	5
SO_2	Annual	1
	24-hour	5
	3-hour	25
NO_x	Annual	1
CO	8-hour	500
	1-hour	2,000

Table 2.1-3

Wind Profile Exponent as a Function of Atmospheric Stability

Stability Class	10 meter Wind Speed (m/s)												
	1	1.5	2	2.5	3	3.5	4	4.5	5	8	10	15	20
A	•	•	•	•	•								
B	•	•	•	•	•	•	•	•	•				
C	•	•	•	•	•	•	•	•	•	•	•		
D	•	•	•	•	•	•	•	•	•	•	•	•	•
E	•	•	•	•	•	•	•	•	•				
F	•	•	•	•	•	•	•						

For "points" and "flares," use the U.S. EPA multiplying factors shown in **Table 2.1-4** to convert 1-hour concentration estimates from SCREEN3 to other averaging periods.

Table 2.1-4

"POINT" source multiplying factors to convert 1-hour average concentration estimates from the SCREEN3 model to longer averaging periods.

EPA Multiplying Factor for POINT sources	Averaging Period
0.9	3-hr
0.7	8-hr
0.4	24-hr
0.08	1-year

Source: "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised," EPA-454/R-92-019, page 4-16)

2.1.2 Area of Impact Analysis; AOI

1) Receptor Network

For the past assessment, ones conducting an assessment mostly identify observation points for pollutant concentration with an even distance between each point. To specify such distance, the detail of pollutants concentration needs to be considered. If observation points are roughly specified, assessment result obtained from a model may not well represent a concentration value especially in the area where there is a significant impact caused by the project. On the other hand, if there are too many observation points, more time is consumed than necessary especially when a study area is too distant from pollution source to cause a significant impact.

2) Sensitive Receptor

Sensitive receptors are people or other organisms that may have a significantly increased sensitivity or exposure to contaminants by virtue of their age and health (e.g. schools, day care centers, hospitals, nursing homes), status (e.g. sensitive or endangered species), proximity to the contamination, dwelling construction (e.g. basement), or the facilities they use (e.g. water supply well). The location of sensitive receptors must be identified in order to evaluate the potential impact of the contamination on public health and the environment.

2.1.3 Preconstruction Monitoring Analysis

Pre-construction ambient monitoring may be required for any criteria pollutant that is proposed to be emitted above the significant emission rates

If the predicted concentrations are above the significant monitoring concentrations and the determines that ambient monitoring is required, the applicant can satisfy the requirement by either 1) establishing a site specific ambient monitoring network, or 2) using existing ambient monitoring data. Should the applicant elect to use existing ambient monitoring data, then the Ambient Air Monitoring staff must be contacted regarding the use and representativeness of the existing monitoring data. The decision to accept or reject existing ambient monitoring data to meet this requirement is made by the monitoring and permitting staff.

2.2 National Ambient Air Quality Standard Analysis, or NAAQS Analysis

In USA, a national ambient air quality standard is the standard which the federal environmental agency has enforced as an ambient air quality standard for criteria pollutant. The standard is used for reference in 2 cases.

Unlike USA, a single ambient air quality standard has been enforced in Thailand and used as reference for considering an environmental impact.

2.3 Ozone Ambient Impact Analysis

Ozone occurs both naturally in the stratosphere to provide a protective layer high above the earth, and at ground-level (troposphere) as the prime ingredient of smog. Tropospheric ozone, which is regulated by the NAAQS, is formed by both naturally occurring and anthropogenic sources. Ozone is not emitted directly into the air, but is created when its two primary components, volatile organic compounds (VOC) and oxides of nitrogen (NOx), combine in the presence of sunlight.

VOC and NOx are often referred to as ozone precursors, which are, for the most part, emitted directly into the atmosphere. Ambient ozone concentrations are directly affected by temperature, solar radiation, wind speed and other meteorological factors. Ultraviolet radiation from the sun plays a key role in initiating the processes leading to ozone formation. However, there is little empirical evidence directly linking day-to-day variations in observed surface ultraviolet radiation levels with variations in tropospheric ozone levels. The rate of ozone production can be limited by either VOCs or NOx.

In general, ozone formation using these two precursors is reliant upon the relative sources of hydroxide (OH) and NOx. When the rate of OH production is greater than the rate of production of NOx, indicating that NOx is in short supply, the rate of ozone production is NOx-limited. In this situation, ozone concentrations are most effectively reduced by lowering current and future NOx emissions, rather than lowering emissions of VOCs. When the rate of OH production is less than the rate of production of NOx, ozone production is VOC-limited.

Here, ozone is most effectively reduced by lowering VOCs. Between the NOx- and VOC-limited extremes there is a transitional region where ozone is nearly equally sensitive to each species. However ozone is relatively insensitive to marginal changes in both NOx and VOC in this situation. In urban areas with a high population concentration, ozone is often VOC-limited. Ozone is generally NOx-limited in rural areas and downwind suburban areas. Additional nformation on ozone formation can be found in "Atmospheric Chemistry and Physics" (Seinfeld et.al., 1998).

2.3 Additional Impact Analysis

The purpose of this analysis is to make the public aware of the impacts the proposed project will have on residential, commercial, and industrial growth in the area, and on soils, vegetation and visibility in the vicinity of the proposed project location. Therefore, data from the additional impacts analysis must be presented so that it is logical and understandable to the interested public.

Section 3

Model Selection and Inputs

3.1 Dispersion Models

Dispersion modeling uses mathematical formulations to characterize the atmospheric processes that disperse a pollutant emitted by a source. Based on emissions and meteorological inputs, a dispersion model can be used to predict concentrations at selected downwind receptor locations. These air quality models are used to determine compliance with National Ambient Air Quality Standards (NAAQS), and other regulatory requirements.

These models are typically used in the permitting process to estimate the concentration of pollutants at specified ground-level receptors surrounding an emissions source.

AERMOD is a steady-state plume dispersion model for assessment of pollutant concentrations from a variety of sources. AERMOD simulates transport and dispersion from multiple points, area, or volume sources based on an up-to-date characterization of the atmospheric boundary layer.

AERMOD is appropriate for the following applications:

- Point, volume, and area sources;
- Surface, near-surface, and elevated releases;
  - Rural or urban areas;
  - Simple and complex terrain;
- Transport distances over which steady-state assumptions are appropriate, up to 50km;
  - 1-hour to annual averaging times; and
  - Continuous toxic air emissions.

3.2 Meteorological Data

The U. S. Environmental Protection Agency (EPA), in conjunction with the American Meteorological Society (AMS) has developed a new air quality dispersion model, the AMS/EPA Regulatory Model (AERMOD). This model requires a preprocessor that organizes and processes meteorological data and estimates the necessary boundary layer parameters for dispersion calculations in AERMOD. The meteorological preprocessor that serves this purpose is AERMET.

AERMET is designed to be run as a three-stage process (see Figure 1-1 of the AERMET User's Guide) and to operate on three types of data

(1) Hourly surface data from National Weather Service (NWS)
(2) Upper air sounding data from National Weather Service (NWS) or NWS twice-daily upper air soundings
(3) on-site measurement

The AERMET meteorological preprocessor requires input data as allowed:

- Wind speed/wind direction
- Temperature
- Pressure
- Stability
- Dew point
- Mixing height
- Albedo
- Surface roughness length
- Bowen ratio
- etc,.

Two files are produced by the AERMET meteorological preprocessor for input to the AERMOD dispersion model. The surface file contains observed and calculated surface variables, one record per hour. The profile file contains the observations made at each level of a meteorological tower (or remote sensor), or the one-level observations taken from other representative data

3.2.1 Raw Meteorological Data Processing

AERMOD use basic input data for AERMET processing as allowed:

1) Surface Data

The minimum meteorological input data requirements using only NWS data to produce the two meteorological files for input to AERMOD are:

- Hourly Surface Observations:
- wind speed and direction;

- ambient temperature;
- opaque sky cover; in the absence of opaque sky cover, total sky cover;
- station pressure is recommended, but not required, since it is used only to calculate the density of dry air; AERMET will use a default value of 1013.25 millibars (sea level pressure) in the absence of station pressure.

2) Upper Air Sounding Data

This parameter indicates that the data are in NCDC's TD-6201 format (the 6201 portion) and that the data are fixed-length blocks (the FB part). Sounding data in this format consist of 2876-character records with 79 levels of data per record. If there are less than 79 levels in a sounding, the record is filled out with missing data indicators. The parameter after the format is the data blocking factor and indicates the number of soundings (logical records) per physical record in the file. In this example, the blocking factor is 1. The default value for this parameter is 1 and the value could have been omitted in this example. For data on a diskette, there is a maximum of one sounding per physical record. However, archive files on magnetic tape may contain more than one logical record per physical record variable-length blocks as a space-saving measure. Currently, AERMET is designed to retrieve data only from the TD-6201 format.

Thai Meteorological Department is the only agency that performs measurement of upper air sounding data. There are only 5 measurement stations: Chiang Mai Station, Ubon Ratchathani Station, Bangkok Station, Phuket Station, and Songkhla Station. Due to this limited numbers of station, it is questionable for a study area that is far from a measurement station whether the data obtained from these stations and which station can be used.

Typically, air condition in each area depends on location and local geographical condition in that area since the earth surface in each area receives the sun energy differently there by resulting in different climate condition. Data obtained from each measurement station therefore are different from one another. In meteorology, climate condition is normally presented on isobars.

3.2.2 Meteorological Station Selection

1) Thailand Meteorological Department, Ministry of Information and Communication Technology

A. Surface Data

Surface measurement station has installed 104 weather stations which can be classified into 16 hydrometeorological stations, 32 agrometeorological stations, and 56 weather stations and meteorological centers

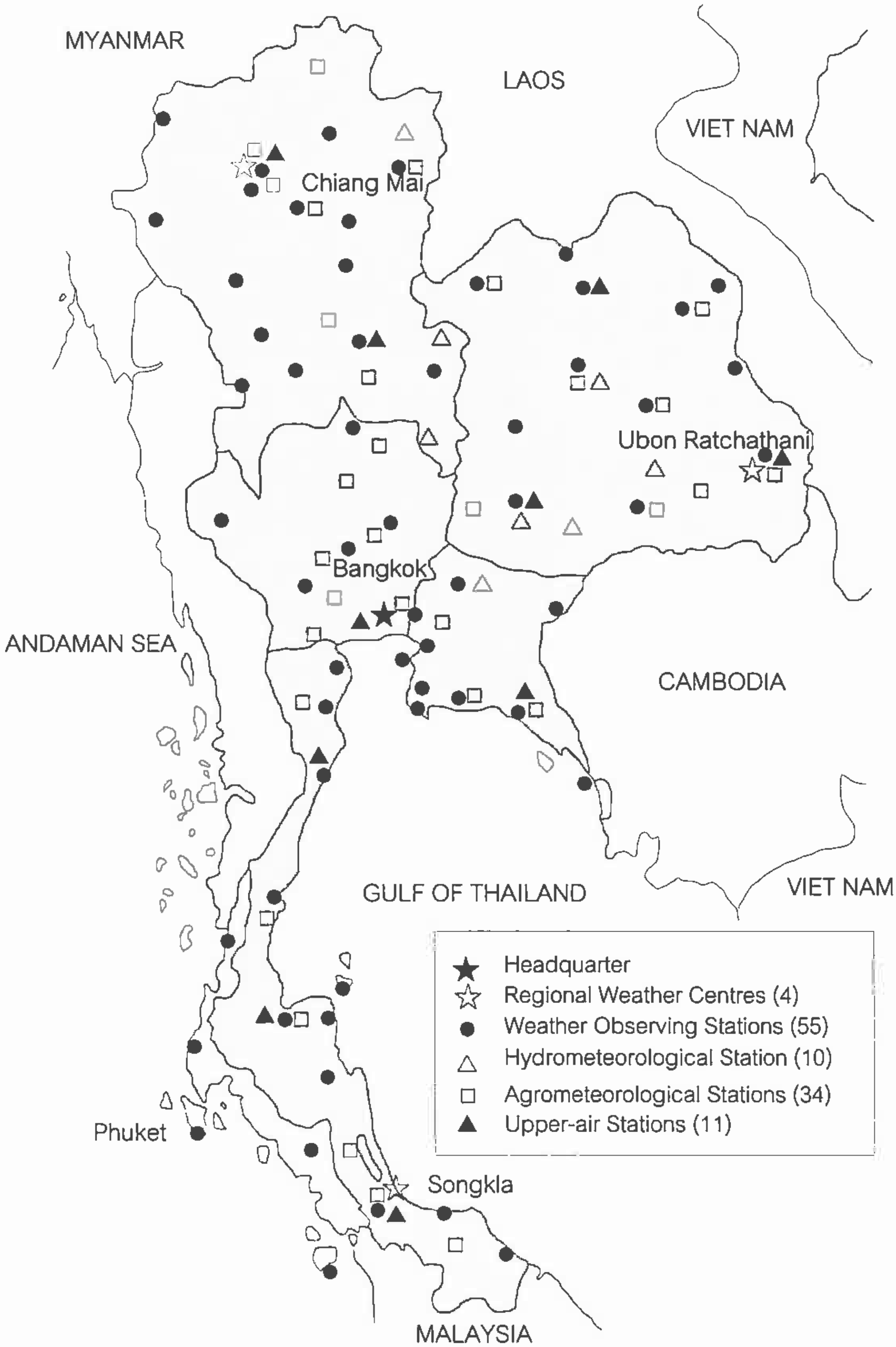
B. Upper Air Sounding Data

Thai Meteorological Department is the only agency that performs measurement of upper air sounding data. There are only 5 measurement stations: Chiang Mai Station, Ubon Ratchathani Station, Bangkok Station, Phuket Station, and Songkhla Station. Typically, air condition in each area depends on location and local geographical condition in that area since the earth surface in each area receives the sun energy differently there by resulting in different climate condition. Data obtained from each measurement station therefore are different from one another. In meteorology, climate condition is normally presented on isobars.

Thai Meteorological Department's Meteorological Stations show as **Figure 3.2-1**

Figure 3.2-1

Thai Meteorological Department's Meteorological Stations



2) Pollution Control Department, Ministry of Natural Resources and Environment

- 49 air quality and surface meteorology monitoring stations
- 5 tower stations with 100 meter high that can measure 2-3 wind levels

3.2.3 Quality Assurance Information for Meteorological Stations

An appropriate meteorological database must be used as input for sequential dispersion modeling. Before beginning to process any meteorological data, it is very important to determine that the meteorological data is representative. Representative is defined as the extent to which a set of measurements taken at the collection site (met tower) spatially and temporally reflects the actual conditions at the application site (source/facility). The collected meteorological data should closely mimic the conditions affecting the transport and dispersion of pollutants in the area of interest as determined by the locations of the sources/receptors being modeled. Representative ness of meteorological data depends on the following factors:

- Character and complexity of the terrain in the source surroundings and between the source and the meteorological monitoring or observing site;
- Proximity of the meteorological monitoring site to the source;
- Instrumentation and exposure of the meteorological monitoring site; and
- Quality, completeness, and period of record of the meteorological data.

The acceptability of a meteorological database, expressed in terms of percentage recovery and duration of record, must be in the context of adequacy and suitability for modeling in accordance with the document Meteorological Monitoring Guidance for Regulatory Modeling Applications (EPA, 2000).

Upper air sounding data measured by Thai Meteorological Department can be used as follows.

- Data from Chiang Mai Station are suitable for high mountain area in the Upper part of the Northern region.
- Data from Ubon Ratchathani Station are suitable for normal plain area.
- Data from Bangkok station, Phuket station, and Songkhla station are suitable for costal area.

Data from Bangkok station can be used for area in the Eastern region and the upper part of the Southern region adjacent to the Gulf of Thailand. Data from Phuket station can be used for the area in the west side of the Southern region. Data from Songkhla station can be used for the area in the east side of the Southern region.

As stated in the Guideline on Air Quality Models (EPA, 2001), the user should "acquire enough meteorological data to ensure worst-case meteorological conditions are adequately represented in the model results." Section 9.3.1.2 recommends using five years of "off-site" data or at least one year of "on-site" data. For air quality analysis in Thailand, if more than one year data is available, then all years, up to tree years, shall be used. Therefore,

3.2.4 On-Site Meteorological Data Collection

On-site meteorological data is generally defined as data that is collected within close proximity to the modeled source and is truly representative of localized conditions near the stack. While EPA no longer interprets "on-site" to mean "data that has been collected on-property", for air quality analysis in Thailand does require strong justification for a source located somewhat further away from the collection site for the meteorological data to be considered "on-site".

The representative ness of "on-site" data for use with "off-site" sources depends on the distance from the source and the complexity of terrain both immediately surrounding the source and between the source and collection location. One may consider data as "on-site" if the terrain is generally simple around the source, at the collection site, and between the source and collection site. Conversely, data is not likely to be considered "on-site" where significant intervening terrain separates the source and collection location and/or where significant local circulation's (sea breeze, channeled flow, etc.) affect either the source or collection location, etc.

3.2.5 AERMOD Meteorological Parameters

1) Albedo

The albedo of an object is the extent to which it diffusely reflects light from the sun. It is therefore a more specific form of the term reflectivity. Albedo is defined as the ratio of diffusely reflected to incident electromagnetic radiation. It is a unitless measure indicative of a surface's or bodies diffuse reflectivity. The word is derived from Latin *albedo* "whiteness", in turn from *albus* "white". The range of possible values is from 0.1 (deciduous forest) to 0.9 (snow cover) show as **Table 3.2-1**

2) Bowen ratio

A Bowen ratio is the ratio of energy fluxes from one medium to another by sensible and latent heating respectively. The range of possible values is from 0.1 (water fresh and sea) to 10.0 (desert area) show as **Table 3.2-1**

3) Surface Roughness length

Surface Roughness length (z_0) is a parameter which is a measure of terrain roughness as "seen by" surface wind. It is formally the height (in meters) at which the wind speed becomes zero when the logarithmic wind profile above the roughness sub-layer is extrapolated to zero wind speed. In fact, the roughness length lies within the roughness sub-layer, where the wind speed deviates from the logarithmic wind profile. This parameter represents the bulk effect of roughness elements in the surface layer and very approximately has a value of around 0.1 times the height of the roughness elements. The range of possible values is from 0.0001 m. (water fresh and sea) to 1.0 m. (deciduous forest and coniferous forest) show as **Table 3.2-1**

ตารางที่ 3.2-1

Surface characteristic classified by Land Use

Land Use	Surface Roughness Length	Bowen ratio	Albedo
Water fresh and sea	0.0001	0.1	0.10
Deciduous Forest	1.30	0.2	0.12
Coniferous Forest	1.30	0.2	0.12
Swamp	0.20	0.1	0.14
Cultivated Land	0.20	0.3	0.20
Grassland	0.10	0.4	0.18
Urban	1.00	1.0	0.16

From above data base, if not surface characteristic data base in Thailand can be used followed value;

Surface Roughness Length	**0.2**	**m.**
Bowen ratio	**0.3**	
Albedo	**0.2**	

3.3 Land Use and Dispersion Regime

In other countries, there are 2 principles to determine whether the area is urban or rural area.

1) Auer Land Use Analysis

The following land use procedure should be used when determining whether urban or rural dispersion coefficients should be used when performing an ambient impact analysis using dispersion modeling. Should urban dispersion coefficients be required and your particular model gives you the option of URBAN-1, URBAN-2, or URBAN-3, the URBAN-3 dispersion coefficients should be selected.

A. Classify the land use within the total area, Ao, circumscribed by a 3 kilometer (km) radius circle about the source using the meteorological, land use, typing scheme proposed by Auer1.

B. If land use types I1, I2, C1, R2, and R3 (defined below) account for 50 percent or more of Ao, use urban dispersion coefficients; otherwise use appropriate rural dispersion coefficients.

- **I-1 Heavy Industrial** - Major chemical, steel and fabrication industries; generally 3 - 5 story buildings with flat roofs. Grass and tree growth extremely rare; < 5% vegetation

- **I-2 Light-moderate industrial** - Rail yards, Truck depots, Warehouses, Industrial parks, Minor fabrications; generally 1 - 3 story buildings with flat roofs. Very limited grass, trees almost totally absent; < 5% vegetation

- **C-1 Commercial** - Office and apartment buildings, hotels < 10 stories; with flat roofs. Limited grass and trees; < 15% vegetation

- **R-2 Compact residential** - Single, some multiple family dwellings with close spacing; generally < 2 story, pitched roof structures; garages (via alley); no driveways. Limited lawn sizes and shade trees; <30% vegetation

- **R-3 Compact residential** - Compact Residential - Old multi-family dwellings with close (< 2 meter) lateral separation; generally 2 story, flat roof structures; garages (via alley); no driveways. Limited lawn sizes, old established shade trees; < 35% vegetation

2) Considers land use pattern from population density

Population density $\geq$ 750 person/square kilometer: considered as urban area
Population density $<$ 750 person/square kilometer: considered as rural area

3.4 Good Engineering Practice or GEP

Good Engineering Practice (GEP) stack height is the minimum stack height needed to prevent the stack exhaust plume from being entrained in the wake of nearby obstructions. If a proposed stack is below the GEP height, then the plume entrainment must be taken into account by modifying certain dispersion parameters used in air dispersion models. However, if the stack height equals or exceeds the calculated GEP stack height, then the stack height is considered the GEP stack height. Plume entrainment within the wake of nearby obstructions is unlikely and need not be considered when modeling stacks at the GEP stack height.

3.5 Building Downwash Analysis

When one or more structures interrupt the wind flow, an area of turbulence called building downwash is created. Pollutants emitted from a fairly low level (e.g., a roof, vent or short stack) can be caught in this turbulence, affecting their dispersion. Modeling that includes calculations for building downwash gives a more accurate representation of pollutant impact than does modeling that omits consideration of downwash affects.

A building is any physical obstruction to airflow at the modeled facility. A structure is a building or group of buildings determined to be important in downwash considerations. The dominant downwash structure is the structure that renders the highest GEP recommended stack height. If a stack is at GEP or higher, then downwash is not a factor.

3.6 Receptor Grid

Receptor sites for refined modeling should be utilized in sufficient detail to estimate the highest concentrations and possible violations of a NAAQS or a PSD increment. In designing a receptor network, the emphasis should be placed on receptor resolution and location, not total number of receptors. The selection of receptor sites should be a case-by-case determination taking into consideration the topography, the climatology, monitor sites, and the results of the initial screening procedure.

3.7 Terrain Considerations

A procedure for selecting morphological data as input data for the model to ensure the consistency and accountability of assessment is suggested and based on the following principles.

(1) If domestic data is complete and available, standard data of government agency should be selected at first priority since it is more accountable than international data source. However, accessibility of data, level of technical requirement in application and valid data format should be taken into account.

(2) The detail of data should be kept at most 1 kilometer. Better detailed data such as at 0.5 km or 0.1 km will benefit the assessment result of a model and can be applied into assessment of Short Rang Transport.

(3) Data should not be too outdated to be a good representative. For area of medium or large mining, care should be exercised since terrain can be changed significantly each year.

3.8 Coordinate System

Only use UTM coordinate system for located all of receptors in property line, buildings, coordinate and receptor height, and location of source.

3.9 Source Characteristics

In addition to emissions from the project, the full impact analysis considers emissions from any existing sources at the facility, nearby sources, and also the growth associated with the new project. The existing sources to consider for inclusion in the full impact analysis are all sources within the screening area (the annular area extending 50 kilometers beyond the SIA).

3.9.1 Default Source Parameters

1) Type of Source

General types of source include;

- Point Source
- Line Source
- Area Source
- Volume Source

2) Source Input Data

Source Input Data include UTM Coordinate system, actual stack height, stack inside diameter, stack release, stack gas temperature, stack gas exit velocity, and emission rate

3) Other Non-Standard Type Emission Units

Guidance for evaluating non-standard types of emission units can use stack parameter followed below;

- stack gas temperature 0 K
- stack gas exit velocity 0.001 m/s
- Stack inside diameter 1 m.

3.9.2 Fugitive Emission Sources

All fugitive sources such as storage piles, transfer points and haul roads must be included in the modeling analysis. Fugitive emissions at nearby facilities generally do not need to be included in the full modeling analysis, unless the nearby facility is located adjacent to the source being evaluated.

3.9.3 Wind Blown Emissions

Windblown dust emissions predicted for fugitive dust emission inventories are inaccurate for several reasons. These include using wind erosion models developed for purposes other than air quality emission inventories, temporally- and spatially-averaged meteorological data that averages out wind gusts, inadequately characterized soil and topographic characteristics, and models that do not properly characterize the emission processes. For a detailed discussion of the processes involved in wind erosion and the various models developed to address fugitive windblown dust, the reader is directed to the report by Countess et. al.(2001) and the companion paper for this conference by Claiborn (2001)

3.9.4 Flares

Flare source can be treated in a similar way as point source, except that there are buoyancy flux reductions associated with radiative heat losses and a need to account for stack diameter. For air quality analysis can use stack parameter followed below;

- Actual stack height or GEP stack height (65 m.)
- Stack gas exit temperature 1,273 K
- Stack gas exit velocity 20 m/s
- Stack diameter is subject to net heat release rate (H, calories/min) calculate from equation below;

$$\text{Diameter(meter)} = 9.88 \times 10^{-4} \sqrt{0.45 \times \text{H(cal/s)}}$$

3.9.5 Rain-caps or Horizontal Releases

Rain-caps or Horizontal Releases can be treated in a similar way as point and can use stack parameter followed below;

- Used actual stack height, or GEP stack height (65 m.)
- Stack gas exit temperature

- Stack gas exit velocity 0.001 m/s
- Stack inside diameter 1 m.

3.9.6 Utility Sources with Variable Loads

If a source(s) will be operated continuously at reduced loads (50 percent, 75 percent, etc.) then screening modeling should be performed to determine which operating load produces the worse-case predicted impacts for each applicable averaging period. Additional information on this requirement can be found in Section 8.1 of Appendix W of 40 CFR Part 51. If a source(s) will operate at greater than design capacity for periods that could result in violations of the NAAQS, this load should be modeled. In either case, the load causing the highest predicted concentration, in addition to the design load, should be modeled. Alternatively, the worse-case stack parameters (lowest temperature and exit velocity, and highest emission rate) from each of the operational loads for each source may be modeled simultaneously to produce a conservative prediction. If the conservative approach results in model concentrations that are less than the applicable standards, then a more refined method is not necessary. This approach can significantly reduce the time it takes to conduct the analysis, as well as the time it takes for the Agency review.

Section 4

Additional Modeling Information

Selection of the best techniques for each individual air quality analysis is always encouraged, but the selection should be done in a consistent manner. A simple listing of models in this *Guideline* cannot alone achieve that consistency nor can it necessarily provide the best model for all possible situations.

Determination of acceptability of a model is a Regional Office responsibility. Where the Regional Administrator finds that an alternative model is more appropriate than a preferred model, that model may be used subject to the recommendations of this subsection. This finding will normally result from a determination that (1) a preferred air quality model is not appropriate for the particular application; or (2) a more appropriate model or analytical procedure is available and applicable.

An alternative model should be evaluated from both a theoretical and a performance perspective before it is selected for use. There are three separate conditions under which such a model may normally be approved for use:

(1) If a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model

(2) if a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the alternative model performs better for the given application than a comparable model in Appendix A; or

(3) if the preferred model is less appropriate for the specific application, or there is no preferred model. Any one of these three separate conditions may make use of an alternative model acceptable.

Section 5

Modeling Data Submittal Requirements

5.1. Plan Layout and Area Maps

The site plan is a vital part of the modeling analysis submittal. The site plan MUST contain ALL of the following:

- A North arrow oriented with true north, not plant north.
- A graphical scale (a printed bar on the map with tick marks indicating the true scale of the plot plan). A simple statement of "1 inch equals 10 feet" is not adequate by itself.
- The reason for this is that, when the map is enlarged or reduced, the true scale is no longer evident. When a graphical scale bar is printed on the map, it is resized along with the map if reduced in size for shipping, etc.
- All solid structures (buildings) on the facility property and the surrounding area (if they could influence plume downwash at the facility in question) must be shown along with the peak height of each building and/or tier. Eave heights may be included in addition to the peak heights, but are generally not required. Lattice-type structures, such as substations, should not be included on the site plan.
- All emission points should be shown on the plot plan and must be labeled, including internal emissions and fugitive emissions (storage piles, haul roads, etc.)
- The property line, the fence line, and any other boundary that would preclude the public access, must be shown on the map. If necessary, a separate, smaller scale map may be included with the submittal to show the full extent of the boundaries.

The site plan may be submitted in either hard copy or electronic format. If submitted electronically it must be in AutoCAD's DWG or DXF formats. Alternatively, the site plan may be converted into a PDF file (Adobe Acrobat) or any type of image file (BMP, JPG, TIF, etc.). Site plans that are submitted electronically allow the modeling group to import them directly into the modeling software, which tends to simplify the review process.

5.2 Emission Rates and Source Parameters

All applicable emission rates and source parameters must be summarized in the modeling report.

This includes the following:

- Potential hourly emission rates for all applicable pollutants
- Actual hourly emission rates (only necessary if actual emissions are used)
- Stack height
- Diameter (or dimensions if rectangular)
- Flow rate
- Temperature
- Exhaust type (vertical, obstructed, horizontal, etc.)
- Any enforceable operating restrictions

The summary must include all sources that were included in the modeling analysis, not just those that are a part of the project. The summary must contain enough detail so that the modeling group can easily verify every emission rate and source parameter used in the analysis. The modeling report must also indicate the reference(s) from which the emission rates and source parameters were obtained.

5.3 File Format

Electronic modeling files must be submitted. Hard copies of the input and output files should not be submitted. All model input and output files are required, including the AERMAP and input and output files provide:

- All input and output files for each dispersion model run, in clouding data, grids and plot files.
- All file produced by a software entry program.
- All automated downwash program input and output files and any computer assisted drawing files.
- All meteorological data files in ASCII format.
- All boundary files including computer assisted drawing files specifying coordinates for property lines.

Include all spreadsheet files used for comparison of predicted concentration with standards or guidelines.

5.4 Media

The electronic files may be submitted on either CD-ROM or DVD. The files may also be emailed to the modeler assigned to the project if known. However, attachments must be limited to 10 Mb, and may not contain an ".exe" or ".zip" file extension. Contact the modeling group for additional information regarding email attachments and alternative methods for submitting data.

Bibliography

Auer, Jr., A.H., 1978. "Correlation of Land Use and Cover with Meteorological Anomalies." Journal of Applied Meteorology, 17:636-643.

EPA, 1985. Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for Stack Height Regulations (Revised)). EPA-450/4-809¬023R, U.S. Environmental Protection Agency.

EPA, 1987. Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD). EPA-450/4-87-007. U.S. Environmental Protection Agency.

EPA, 1990. New Source Review Workshop Manual - Prevention of Significant Deterioration and Nonattainment Area Permitting - DRAFT. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. October 1990.

EPA, 1992a. Screening Procedures for Estimating the Air Quality Impact of Stationary Sources (Revised). EPA-454/R-92-019. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. October 1992.

EPA, 1992b. Workbook for Plume Visual Impact Screening and Analysis (Revised). EPA¬454/R-92-023. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA, 2005. Guideline on Air Quality Models. Appendix W of 40 CFR Part 51, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

Holzworth, George C., 1972. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, Environmental Protection Agency, Office of Air Programs, Research Tri angle Park, North Carolina.

EPA, 2000. Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-005. US EPA, Office of Air Quality Planning and Standards.

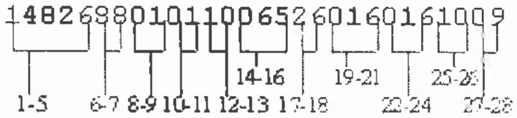
EPA, 2005. Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, U.S. EPA, Office of Solid Waste and Emergency Response, EPA 530-R-05-006.

LDEQ, 1999. Louisiana Office of Environmental Assessment – Environmental Technology Division Air Quality Modeling Procedures. Louisiana Department of Environmental Quality, Air Quality Division. October 1999.

Appendix 1

SCRAM format or MET144 format

```
SURFACE AIR DATA RECORDS
    (CD-144 FORMAT)
14826880101 0027260170241010
14826880101 1027260130231010
14826880101 2029260140221010
14826880101 3029250160211010
14826880101 4029250150201010
14826880101 5027240150201010
14826880101 6026240140191010
14826880101 7029260160181010
14826880101 8029260180171010
14826880101 9037250160161010
1482688010110065260160161009
```



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

Appendix 2

FSL Radiosonde Database

FSL Rawinsonde data format

The official FSL data format is similar to the format used by the National Severe Storms Forecast Center (NSSFC) in Kansas City. The first 4 lines of the sounding are identification and information lines. All additional lines are data lines. An entry of 32767 (original format) or 99999 (new format) indicates that the information is either missing, not reported, or not applicable.

---COLUMN NUMBER---

1	2	3	4	5	6	7
LINTYP						
			header lines			
254	HOUR	DAY	MONTH	YEAR	(blank)	(blank)
1	WBAN#	WMO#	LAT D	LON D	ELEV	RTIME
2	HYDRO	MXWD	TROPL	LINES	TINDEX	SOURCE
3	(blank)	STAID	(blank)	(blank)	SONDE	WSUNITS
			data lines			
9	PRESSURE	HEIGHT	TEMP	DEWPT	WIND DIR	WIND SPD
4						
5						
6						
7						
8						

LEGEND

LINTYP: type of identification line
- 254 = indicates a new sounding in the output file
- 1 = station identification line
- 2 = sounding checks line
- 3 = station identifier and other indicators line
- 4 = mandatory level
- 5 = significant level
- 6 = wind level (PPBB) (GTS or merged data)
- 7 = tropopause level (GTS or merged data)
- 8 = maximum wind level (GTS or merged data)
- 9 = surface level

HOUR: time of report in UTC
LAT: latitude in degrees and hundredths
LON: longitude in degrees and hundredths

D: direction latitude ('N' or 'S') or longitude ('E' or 'W') -note this
only appears in the online archive containing international observations.

ELEV: elevation from station history in meters
RTIME: is the actual release time of radiosonde from TTBB. Appears in GTS data only.
HYDRO: the pressure of the level to where the sounding passes the hydrostatic check (see section 4.3).**
MXWD: the pressure of the level having the maximum wind in the sounding. If within the body of the sounding there is no "8" level then MXWN is estimated (see section 3.2).
TROPL: the pressure of the level containing the tropopause. If within the body of the sounding there is no "7" level, then TROPL is estimated (see section 3.3)**
LINES: number of levels in the sounding, including the 4 identification lines.
TINDEX: indicator for estimated tropopause. A "7" indicates that sufficient data was available to attempt the estimation; 11 indicates that data terminated and that tropopause is a "suspected" tropopause.
SOURCE: 0 = National Climatic Data Center (NCDC)
1 = Atmospheric Environment Service (AES), Canada
2 = National Severe Storms Forecast Center (NSSFC)
3 = GTS or FSL GTS data only
4 = merge of NCDC and GTS data (sources 2,3 merged into sources 0,1)
SONDE: type of radiosonde code from TTBB. Only reported with GTS data
10 = VIZ "A" type radiosonde
11 = VIZ "B" type radiosonde
12 = Space data corp.(SDC) radiosonde.
WSUNITS: wind speed units (selected upon output)
ms = tenths of meters per second
kt = knots

PRESSURE: in whole millibars (original format)
in tenths of millibars (new format)
HEIGHT: height in meters (m)
TEMP: temperature in tenths of degrees Celsius
DEWPT: dew point temperature in tenths of a degree Celsius
WIND DIR: wind direction in degrees
WIND SPD: wind speed in either knots or tenths of a meter per second (selected by user upon output)

An example of fortran format statements necessary to read output rawinsonde data, according to LINTYP, is as follows:

LINTYP	
254	(3i7,6x,a4,i7)
1	(3i7,f7.2,a1,f6.2,a1,i6,i7)
2	(7i7)
3	(i7,10x,a4,14x,i7,5x,a2)
4,5,6,7,8,9	(7i7)

Note the format descriptor for LINTYP=1 has changed to conform with the

CDROM archive.

**- section of noaa tech memo on the data base (in print)

TECHNICAL INFORMATION: Schwartz, B.E., and M. Govett, 1992: "A hydrostatically consistent North American Radiosonde Data Base at the forecast Systems Laboratory, 1946-present." NOAA Technical Memorandum ERL FSL-4. Available from NOAA/ERL/FSL 325 Broadway, Boulder, CO 80303.

Appendix 3

Recommendations on substituting 3-hourly values with hourly values

Meteorological data at ground level is available for all required parameters recorded in several files and in different forms: figure, table and text. To obtain such data in hourly basis, this procedure should be preceded.

1. Select a meteorological monitoring station located closed to the study area.
2. Record the station code, location coordinate and height of the wind speed measuring device.
3. Choose the data files to be used as the input data for AERMET as follows,

   3.1 hourly data for wind speed and wind direction

   3.2 hourly data for temperature

   3.3 cloud cover

   3.4 ceiling height

4. For the data of 3-hourly basis, this should be substituted with the hourly values by means of the following.

   4.1 Use the average means to obtain the missing 2 sets of data, except for the wind direction data. For example, if we have the values of 1st and 4th hour, we are able to obtain the values of 2nd and 3rd hour by:

   2nd hour value = 1st hour value + (4th hour value – 1st hour value)/3

   3rd hour value = 1st hour value + (4th hour value – 1st hour value)*2/3.

   4.2 For wind direction

   4.2.1 If the 1st hour value is more or less than the 4th hour value = 90 degrees, or if the 1st hour value = 0 or the 4th hour value = 0, therefore

   2nd hour value = 1st hour value

   3rd hour value = 4th hour value.

   4.2.2 If the 1st hour value is more or less than the 4th hour value < 90 degrees, and the 1st hour value and the 4th hour value $\neq$ 0, therefore

   2nd hour value = 1st hour value + (4th hour value – 1st hour value)/3

3rd hour value = 4th hour value + (4th hour value – 1st hour value)*2/3.

5. Convert the measurement unit to conform to SCRAM Format.
6. Rearrange the values in text file.