Emissions Inventory for Large-Scale Risk Assessments

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ABSTRACT

Risk assessments of air emissions are typically performed for new and expanding facilities. These assessments typically are time and resource intensive, and do not take into account existing local emissions and overall impacts from air toxics. Using available emissions inventories and new distributed network processing technology, it is possible to perform large-scale risk assessments within a reasonable timeframe. This paper describes the emissions inventory gap in application of large-scale risk assessment methods used in two pilot projects with the Minnesota Pollution Control Agency (MPCA) and the New Jersey Department of Environmental Protection (NJDEP).

1.0 INTRODUCTION

Historically, risk assessments have focused on air toxics from point sources, and assessments of air emissions were performed for new and expanding facilities. These assessments typically are time consuming, resource intensive, and focused on plants that tend to have the latest and best pollution control technology for air toxics. However, facility-level assessments are not capable of answering questions concerning potential impacts from proposed plants, and the overall impacts when combined with existing pollutants in the air. A more comprehensive answer to these questions requires the execution of large-scale, cumulative, risk assessments.

To facilitate a systematic, more objective, way of understanding and addressing impacts from emissions of air toxics, the risk assessment should integrate cumulative source information from point, mobile, and area. Currently, emissions inventories contain reported emissions permitted sources and estimations for the other sources. Chemical information is critical to define how a chemical moves through the environment, and its toxicity. Accurate source location is equally critical for disease cluster (e.g., cancer) risk assessments.

This paper will discuss the data gap filling methodologies applied in performing large-scale human health risk assessments using available emissions inventories. Additionally, important modeling parameters are still not collected, during the emissions inventory data gathering phase. These include surrounding buildings, temporal emissions variation, and release information on most of the Hazardous Air Pollutants (HAPs) emitted into the environment.

2.0 OVERVIEW OF THE APPLIED PROJECTS

2.1 MPCA Statewide Cumulative Risk

MPCA statewide risk project was developed to provide an easy-to-use, robust system to facilitate screening level human health risk assessments of sites located within the State of Minnesota. The GIS-enabled system incorporates sources from MPCA's most current emissions inventory data for point, area, and mobile sources. The GIS-based graphical system performs air dispersion modeling and risk assessment across the entire state, using the Minnesota existing meteorology, area source allocation to census track level, and geophysical databases,. Air dispersion modeling results are then used in conjunction with additional geophysical data to perform statewide multi-source, multi-pathway risk assessment enabling cumulative studies on a previously unattainable scale.

MPCA Risk was designed to conduct more refined analyses related to risk results by:

- Individual sources
- Source types
- Industrial sector
- Chemicals
- Demographics data

2.2 NJDEP Environmental Equity Project

Lakes Environmental was hired, on a sole source basis, to develop a unique Environmental Justice solutions. The American 1964 Civil Rights Act – Title VI mandates that all federal fund transfer be suspended from States that discriminate against race or ethnic groups. A lawsuit was brought against the State of New Jersey by a minority group arguing that environmental permits was causing disparate impacts.

A review on previous research studies in the field indicated that total Hazardous Air Pollutant (HAP) emissions when compared against population counts, stratified by race. It was evident that researchers were ignoring chemical toxicity from each chemical. Such ineffective previous research approaches resulted in unrealistic comparisons such as one gram of the highly toxic dioxin being evaluated against one ton of the less harmful carbon dioxide.

An environmental risk model was constructed which evaluated census data and exposure data from various stressors, such as air pollutants and hazardous sites, which are summarized at the census tract level. These data are combined and analyzed so that a statewide race specific ratio is determined. A ratio of greater than 1 indicates the race (subpopulation) under consideration may be receiving more than the average effect from the stressors and a ratio of less than one indicates less than the average statewide effect.

The risk assessment was conducted for thousands of sources within the prescribed census tracts. All source data was extracted from NJDEQ's available emissions inventory system.

3.0 USE OF PROVEN TECHNOLOGIES

Large-scale risk assessments must incorporate tested and accepted methodologies and technologies, such as standard U.S. EPA air dispersion models and risk assessment protocols. These tools are further extended through the use of proven GIS technologies, and established emissions inventories and emission estimation systems. The incorporation of all these components into a system is described in Figure 3-1, below.

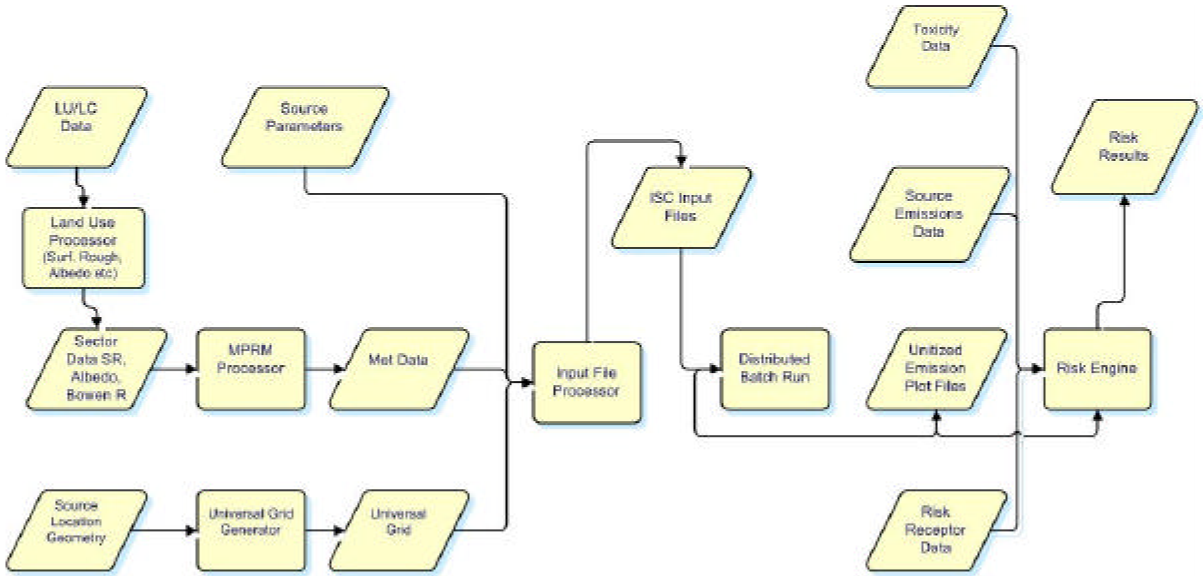

Figure 3-1: Complete large-scale risk assessment system architecture

3.1 ISCST3 and Air Dispersion Modeling

The U.S. EPA Human Health Risk Assessment Protocol (HHRAP) outlines standardized approaches to performing air dispersion modeling for human health risk assessments. The system is designed to model hourly and annual air concentrations for vapor, particle, and particle-bound chemical phases resulting from emissions from each facility within the modeling region using U.S. EPA's ISCST3 or AERMOD air dispersion model.

3.2 IRAP-h View and Human Health Risk Assessment

Risk modeling for cumulative risk screening is conducted following the methodologies contained in the *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (HHRAP). In turn, the HHRAP implements other U.S. EPA guidance documents, such as the *Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions*, which contains specific equations and inputs recommended in the *Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual* (RAGS), the *Exposure Factors Handbook*, and *Integrated Risk Information System* (IRIS) (U.S. EPA 1989; 1991; 1997a; 1998a; 1998b; 1998c; 2000e). Application of these guidances, in the cumulative risk screening, is performed using the IRAP-*h* View™ risk model engine, as the project platform.

Although the HHRAP guidance was developed for combustion facilities, it incorporates methodologies, equations, and protocols for emissions source characterization, air dispersion and deposition modeling, and media estimating equations for evaluation of any type of air toxic multi-pathway exposure. The HHRAP has proved successful in achieving objectives and goals in broad air toxic screening cumulative studies, such as the U.S. EPA Region 6 RAIMI Pilot Study (RAIME, 2000).

3.3 Emissions View

Current emissions inventory data is used for point, area and mobile sources. In turn, subsequent reruns of a large-scale risk assessment can by easily performed with revised emissions inventory information.

The emissions inventory database management is performed using select tools from *Lakes Environmental's* Emissions View software solution. This powerful system enables spatial and temporal management of sources across the entire state, and can be further extended to support emissions estimation for processes that contain no measured data.

3.4 Uncertainties of Large-Scale Risk Assessments

Any human health risk assessment will use the most advanced and up-to-date accepted protocols. However, the air toxic risk assessment field is evolving at a rapid pace and parameters used along with methodologies and accepted mathematical models are constantly changing. The complexity of multi-pathway risk assessment for chemicals requires a series of model and parameter approximations.

There are a significant amount of uncertainties in assessments of this nature. Many of these uncertainties are described in HHRAP. A summary of the uncertainties and limitations is described below:

1) Emissions Inventory lack critical data for modeling and risk assessment. Some of the missing data include accurate list of HAPS, correct source paramateters (location, release height, release conditions), spatial and temporal profiles.
2) Cancer and non-cancer health benchmarks are used as the criteria to judge whether a problem may exist with a given pollutant. Further explanation and justification for this approach is needed.
3) Health risks assessments are limited by inherent uncertainties. Health benchmarks are not definitive lines or absolute boundaries. Unknowns such as gaps in data, differences in individual susceptibility, and extrapolation of animal studies to humans are accounted for by incorporating a margin of safety when establishing a health benchmark. Assessments of risk to human health are often limited to available emissions data. A pollutant that turns into another toxic pollutant cannot be adequately addressed when risk is based only on emission data.
4) The assessment method examines only outdoor concentrations. It does not take into account indoor sources/concentrations/exposures from sources such as off-gassing of carpets or second-hand smoke.
5) Individual choices about where people live, work and play, as well as lifestyle choices were not addressed in this paper, although those choices significantly affect exposure.
6) Desegregation of emissions processes and release points are critical to the understanding of realist risk drivers. This type of data is being requested by the USEPA on the 2002 NEI reporting (due June 1, 2004). This problem is represented in Figure 3-2, below.

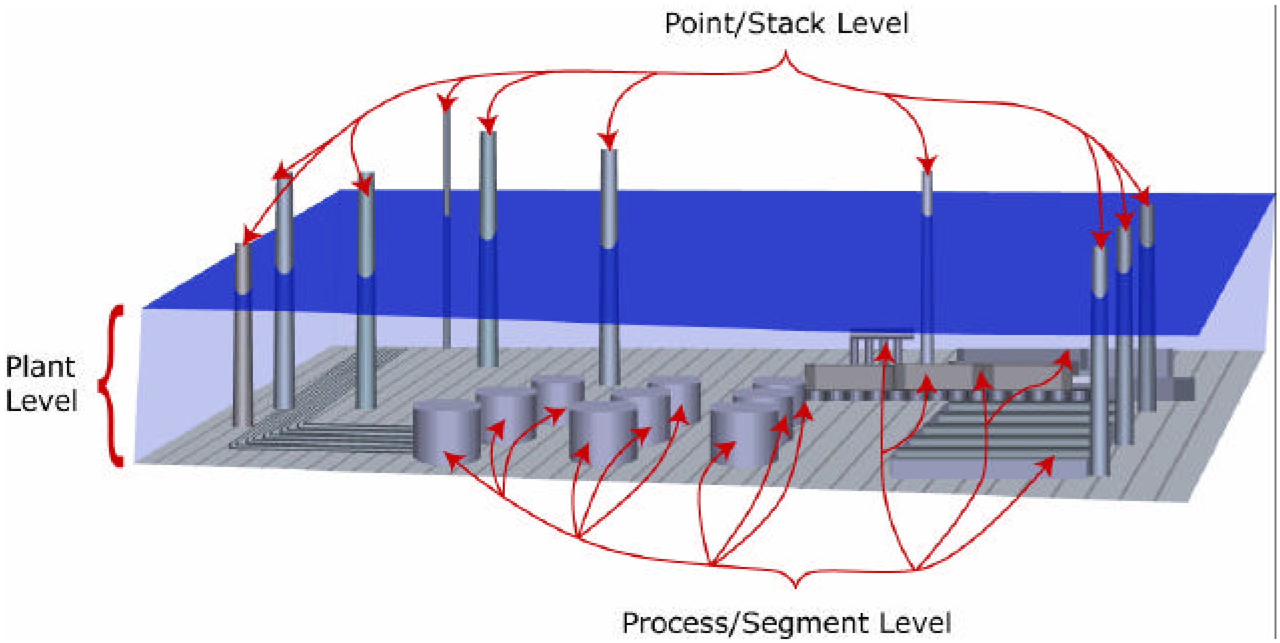

Figure 3-2 – Representation of the Process and Point level emissions. Desegregation is required.

4.0 EMISSIONS INVENTORY DATA

4.1 Overview

Comprehensive large-scale risk assessments require emissions data from facilities, mobile sources, and other sources of air toxic pollutants. The most complete source would likely be in the form of an emissions inventory, maintained by facilities, counties, states, and/or regional organizations. These emissions inventory are required by regulations to serve various programs, from reporting to the U.S. EPA to evaluating the impact of emissions on nearby sensitive regions. This emissions inventory serves as the raw input data for a large-scale risk assessment. It should be noted that the Data Quality Objectives (DQO) while collecting emissions inventory data do not typically include risk assessment as part of the collecting schema. In this way, emissions inventories often lack some essential information, which will be described below. A sample of the data gaps is described below:

1) Facilities do not have to describe the surrounding buildings. This results in building downwash effects on point sources not being readily resolved
2) Facilities can sum emissions for an entire site. This leads to many sources lacking accurate real-world coordinate assignments.
3) Many chemicals are not reported by their chemical constituents. For example, many toxic volatile organic compounds (VOCs) were summed in the report as "Non-Methane Organic Carbon (NMOCs). This lack of chemical speciation can be partially resolved by using "Speciation Profiles" created by environmental agencies. However, such an exercise would add more uncertainty in the study.

4.2 Emissions Characterization Approach

The approach for emissions characterization focuses on:

(1) Identifying the existence of potential emissions sources
(2) Obtaining the necessary emissions data to complete air and risk modeling components, as described in Figure 4-1, below.

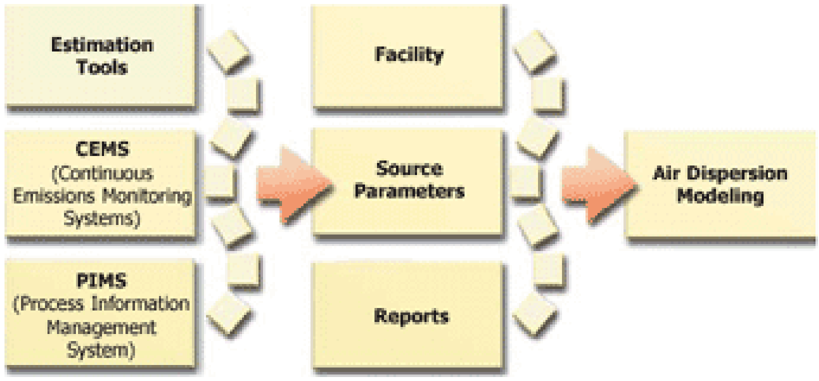

Figure 4.1 – Emissions Inventory data collection for large scale modeling purposes

Specific to emissions characterization is the need to:

(1) Support a standardized and consistent means for the assessment and evaluation of risk and hazard from multiple emissions sources of multiple contaminants from multiple facilities
(2) Provide the necessary levels of detail for risk-based source-specific prioritization and decision making
(3) Support the calculation and tracking of risks generated in a fully transparent fashion such that aggregate concentrations, and through the use of exposure scenarios, cumulative risk levels are completely traceable to each contaminant, each pathway, and each source.

Characterization of emissions and physical parameters of each source are required information to support implementation of air dispersion modeling and risk assessment protocols. Therefore, the data requirements of modeling are unique and specific to each source type.

The source-specific data needs for model inputs to conduct air and risk modeling are identified in Table 4.1. These data generally fall into two categories: physical characteristics and emissions characteristics.

Table 4-1: Source-Specific Emissions Data Needs for Model Input

	Stack Source	Fugitive Source	Mobile Source
Physical Characteristics	- Stack height [m] - Base elevation [m] - Stack diameter [m] - Stack gas exit velocity [m/s] - Stack gas exit temp. [K] - Control device description - Location [NAD 83]	- Area [m^2] - Release height [m] - Base elevation [m] - Location [NAD-83]	- Area [m^2] - Release height [m] - Base elevation [m] - Location [NAD-83]
Emissions Characteristics	- Contaminant CAS number and name - Speciated emission rate [g/s]	- Contaminant CAS number and name - Speciated emission rate [g/s]	- Contaminant CAS number and name - Speciated emission rate [g/s]

Notes:

m	meters	NAD-83	North American Datum 1983
m/s	meters/second	g/s	grams/second
K	Kelvin	CAS	Chemical Abstract Service

4.3 Available Sources of Emissions Data

4.3.1 Characterization of Point Sources

Point sources are defined as large stationary sources whose emissions are tabulated in the emissions inventory system. Air toxics from point source emissions are preprocessed according to the description for the determination of air toxics emissions from point sources is described in [Pratt, et al.]. In that paper, the authors describe that the air toxics emissions data was obtained by:

1) Direct facility reporting
2) The use of emission factors
3) Incorporating data from the United States Superfund Toxics Release Inventory.

Point source locations were determined by:

1) Facility self-reporting
2) Global positioning system (GPS)
3) Geographic information system (GIS) addressing matching.

Point source stack parameters were taken from:

1) Regulatory agency files
2) Default values developed by the Ozone Transport and Assessment Group (OTAG) Source classification code (OTAG is a partnership between the US EPA, the Environmental Council of the States (ECOS) and various industry and environmental groups aimed at creating agreements among industry and government for control of ground-level ozone and related pollutants in the eastern U.S.)
3) Average OTAG values across all facilities.

Within a given facility, stack-by-stack emissions were not available. Therefore, each facility was represented as a single stack whose location was taken as the centroid of the facility (when available) or as the location of the front entrance. Similarly, stack parameters were taken as averages across all emission points at the facility, weighted by the throughput for the emission point.

Regardless of how complete an emissions inventory is, four major considerations must remain in focus:

2) Process upset conditions with elevated air toxic emissions, for specific processes and facilities. Upset conditions may contribute a substantial increase on emissions into the atmosphere. Such episodes may last from a few minutes to days.
3) Site characterization information. This characterization is very desirable for an emissions inventory database. The type of data that would help better define the air dispersion model includes:
   a) Surrounding building details – Buildings may cause significant increase in ground level concentrations. More detail on this topic is provided in Chapter 4.
   b) Stack location and facility fenceline coordinates – It is usual that facilities sum all the emissions data and report the accumulated value. This way, each individual source contribution is hidden from view. Ideally, individual source locations would be provided for the risk assessment. Additionally, for very high-resolution studies (e.g., neighborhood level), it would be ideal to be able to associate specific sources to sensitive receptors. These issues were not as significant as initially thought, since the air model does not accurately predict the impact position.
4) Chemical speciation.
5) Actual, allowable, or reported emissions for the point sources.

<u>4.3.2 Characterization of Area Sources</u>

Sources that are not stationary, or are too small to be included as point sources are grouped into a general category defined as Area Sources. This type of source is usually not subject to licensing or to other regulatory requirements, such as periodical reporting. As a result, most of these sources are estimated at a county level. For example, the use of solvents in paint can be estimated by the total volume annual sales. The area source category is defined as "Stationary sources of emissions that are too small and diffuse to be inventoried as individual sources; they are generally smaller in terms of the mass of contaminants emitted than major sources [CAA major source facility designation] and are often ubiquitous in developed areas" (U.S. EPA 2000c).

A complete description of the County to Census Tract level emissions apportionment is explained in [Pratt, et al] and is quoted here with permission. Mobile sources were apportioned to the census tracts in the same way as the area sources. The census tract polygons were taken from GIS coverage of 2000 census tracts. These polygons were processed to obtain equivalent census tract representations with ten (10) or less vertices. This simplification reduces model calculation time. Figure 4-0.1 graphically describes this area source allocation.

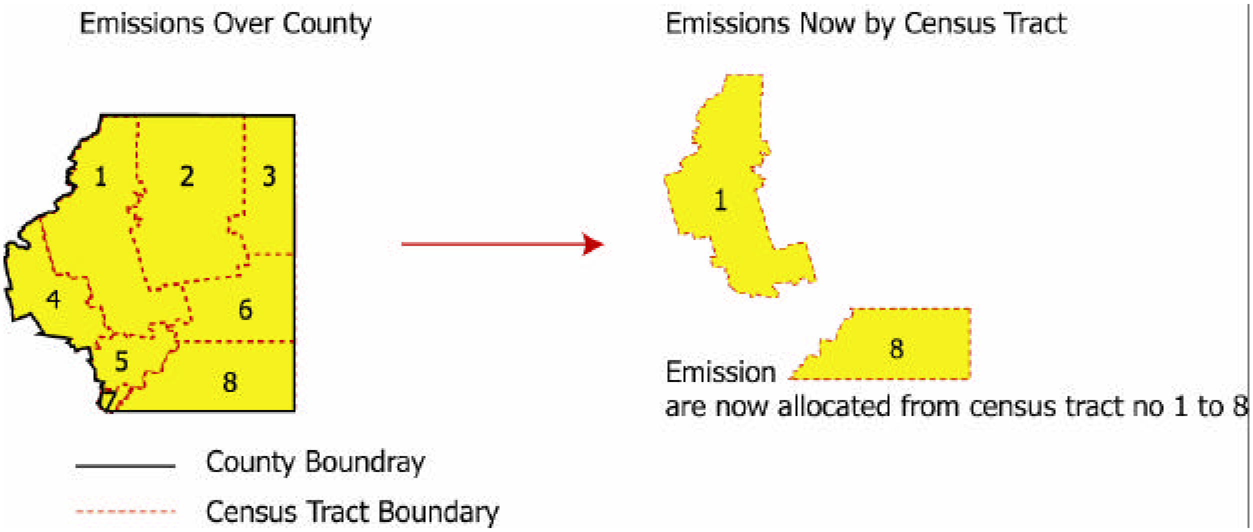

Figure 4-0.1: Description of Area source emissions allocations to census

A risk assessment study can benefit by better spatially defined area emissions allocation. Allocation of county level area sources to census tracts level was performed using emissions surrogates. Aircraft emissions were apportioned to the census tracts in which the airports were located, depending upon the proportion of air traffic occurring at each airport. Railway emissions were apportioned to census tracts according to the length of the railway in the tract as a fraction of the county total. All other non-road mobile source emissions were apportioned to census tract according to population [Pratt, et al.].

4.3.3 Initial Emissions Inventory Data Quality Objectives

The initial Data Quality Objectives (DQO) of Emissions Inventories was to collect data for regulatory purposes. This study extends the use of the data beyond its purpose. We even suggest that the emissions inventory maintained by the MPCA should modify the DQO to include the use of the data for studies like the Statewide Cumulative Screening study.

The RAIME report (RAIME, 2000) indicates that upcoming Title V permit requirements for other source categories of interest may contain important and relevant information for emissions characterization and risk modeling, although the availability of the data is dependent on the submittal date and regulatory review.

4.3.4 Emissions Speciation

The MPCA statewide risk project report presents a good description of the Emissions Speciation problem that a large-scale risk assessment study will face. The lack of adequately speciated emissions data imposes a significant limit to emissions characterization, and subsequent inclusion in risk modeling. A review of the emissions inventory's assessment area would be required to determine the degree of speciation reported, as follows:

- Speciated to specific contaminant, which enables risk modeling because contaminant-specific toxicity factors can be obtained (e.g., benzene, 1,3-butadiene)
- Speciated to contaminant class that is not acceptable for modeling because the toxicity factors for individual isomers may vary considerably and cannot be speciated without a source-specific apportionment scheme (e.g., total xylenes, including one or more of the ortho-, meta-, and para-isomers)

- Unspeciated as a product or process mixture that may be manually speciated with an appropriate apportionment scheme (e.g., gasoline, crude oil)
- Unspeciated as a categorical mixture that cannot be further speciated, except, possibly, by the facility (e.g., non-methane VOCs, particulates)

Environment Canada is currently addressing the speciation problem in their annual regulated emissions gathering, from stationary point sources. Their regulatory program developed a fast and accurate software (CAC2003 by Lakes Environmental Software Inc.) that employs emissions speciation profiles, according to SCC process level information. We can only guess that temporal profiles will be the next step in Environment Canada's planning. Such approach partially addresses some of the uncertainties described in this section.

4.3.5 Accounting for Emissions Temporal Variation

This project executed using the best available emissions data. However, these emissions were provided as average annual values. Important temporal variations should be accounted for in future work. Some examples of these variations include seasonal emissions of evaporative losses, daily fluctuations of fossil fuel based electricity production, and process upset conditions.

5.0 CONCLUSIONS

A more refined Data Quality Objective (DQO) for Emissions Inventory is required. Currently the DQOs satisfy federal reporting, compliance, and permitting demands. However, recent needs for data impose additional requirements on existing emissions inventory databases. Since emissions data collection involves multi-year programs, we strongly suggest that more accurate data should be gathered to meet local air dispersion modeling, visibility studies, and human health risk assessments.

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8.0 KEYWORDS

Emissions Inventory
Risk Assessment
Air Dispersion
Human Health