United States Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711
EPA-454/R-95-003
February 1995

Air

EPA

AIR/SUPERFUND NATIONAL TECHNICAL GUIDANCE STUDY SERIES

Volume V - Procedures for Air Dispersion Modeling At Superfund Sites

EPA-454/R-95-003

AIR/SUPERFUND NATIONAL TECHNICAL GUIDANCE STUDY SERIES

Volume V - Procedures for Air Dispersion Modeling At Superfund Sites

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Technical Support Division
Research Triangle Park, NC 27711

February 1995

Disclaimer

EPA-454/R-95-003

PREFACE

This manual is the fifth in a five-volume series dealing with air pathway assessments at hazardous waste sites and was developed for the U.S. Environmental Protection Agency (EPA) Office of Air Quality Planning and Standards in cooperation with the Office of Emergency and Remedial Response (Superfund). It is an update of the air dispersion modeling discussion in the original Volume IV of this series. This manual has been reviewed by a Technical Advisory Committee consisting of EPA Regional modelers and members of the Air/Superfund program.

This manual is an interim final document offering technical guidance for use by a diverse audience including EPA Air and Superfund Regional and Headquarters staff, State Air and Superfund program staff, Federal and State remedial and removal contractors, and potentially responsible parties in analyzing air pathways at hazardous waste sites. This manual is written to serve the needs of individuals having different levels of scientific training and experience in designing, conducting, and reviewing air pathway analyses. Because assumptions and judgements are required in many parts of the analysis, the individuals conducting air pathway analyses need a strong technical background in air emission measurements, modeling, monitoring, and risk assessment. Remedial Project Managers, On-Scene Coordinators, and the Regional Air program staff, supported by the technical expertise of their contractors, will use this manual when establishing data quality objectives and the appropriate scientific approach to air pathway analyses. This manual provides for flexibility in tailoring the air pathway analysis to the specific conditions of each site.

Air pathway assessments involve complex procedures requiring the use of professional judgment. The information set forth in this manual is intended solely for technical guidance. The procedures set out in this manual are not intended, nor can they be relied upon, to create rights substantive or procedural, enforceable by any party in litigation with the United States.

It is envisioned that this manual will be periodically updated to incorporate new data and information on air pathway analysis procedures. The EPA reserves the right to act at variance with these procedures and to change them without formal public notice as new information and technical tools become available on air pathway analyses. The EPA Regional Air/Superfund coordinator should be consulted on the availability and use of the most recent procedures

Copies of this manual are available, as supplies permit, through the Library Services Office (MD-35), U.S Environmental Protection Agency, Research Triangle Park, North Carolina 27711 or from the National Technical Information Services (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161 (Telephone 703/487-4650).

Acknowledgements

This manual was prepared for the U.S. Environmental Protection Agency (EPA) by Radian Corporation under EPA Contract No. 68-D30033, Work Assignment No. 3. The EPA Work Assignment Manager was Mr. Jawad Touma, of the Source Receptor Analysis Branch, Technical Support Division of the Office of Air Quality Planning and Standards (OAQPS). Special thanks go to Mr. Dean Wilson and Mr. John Irwin of OAQPS, Ms. Patricia Flores of EPA Region III and Mr. Bill Ryan of EPA Region X for their input on the initial draft.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

AAM	Ambient Air Monitoring
ALOHA	Areal Locations of Hazardous Atmospheres
APA	Air Pathway Assessment (or Analysis)
ARAR	Applicable or Relevant and Appropriate Requirement
BBS	Bulletin Board System
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CTDMPLUS	Complex Terrain Dispersion Model PLUS Algorithms for Unstable Situations
DEGADIS	Dense Gas Dispersion Model
EPA	U.S. Environmental Protection Agency
ER	Emergency Removal
FDM	Fugitive Dust Model
FS	Feasibility Study
GEP	Good Engineering Practice
HSL	Hazardous Substances List
ISC2	Industrial Source Complex Models
ISCLT2	Industrial Source Complex Long-Term Model

ISCST2	Industrial Source Complex Short-Term Model
MEI	Maximum Exposed Individual
MPRM	Meteorological Processor for Regulatory Models
msl	Mean Sea Level
NPL	National Priorities List
NSR	New Source Review
NTG	National Technical Guidance
NTGS	National Technical Guidance Study
NTIS	National Technical Information Service
NWS	National Weather Service
OAQPS	Office of Air Quality Planning and Standards
O&M	Operation and Maintenance
PA	Preliminary Assessment
PCB	Polychlorinated Biphenyl
PM/PM_{10}	Particulate Matter/Particulate Matter of less than 10 micrometers in diameter
PRP	Potentially Responsible Party (or Parties)
PSD	Prevention of Significant Deterioration
QA/QC	Quality Assurance/Quality Control

RA	Remedial Action
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
RTDM	Rough Terrain Dispersion Model
SARA	Superfund Amendments and Reauthorization Act
SCRAM	Support Center for Regulatory Air Models
SI	Site Inspection
STAR	Stability Array
TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzofuran
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VOC	Volatile Organic Compound

SECTION 1

INTRODUCTION

This manual presents guidance for designing, conducting, and evaluating air dispersion modeling analyses for Superfund sites. Its purpose is to provide a logical and systematic approach for applying air quality models, which are an integral part of several regulatory programs. This manual is intended to augment the primary U.S. Environmental Protection Agency (EPA) guidance document on air quality modeling, the Guideline on Air Quality Models (Revised)[1], as such it elaborates on modeling issues particularly related to Superfund Sites. All exposure pathways - including the air pathway - must be evaluated for every Superfund site; therefore, each site usually requires some level of air dispersion modeling.

In many cases the nature and complexity of atmospheric dispersion make exposure via the air pathway more difficult to predict than exposure via other pathways. The air pathway is unique in that any on-site release of emissions can have an almost immediate impact. Furthermore, the locations of impact can shift relatively quickly, with changes in wind speed and direction. In contrast, exposure through other pathways often requires extended time periods to occur, and can be minimized by limiting site access or prohibiting use of contaminated resources (e.g., drinking water).

Air dispersion models provide the ability to mathematically simulate atmospheric conditions and behavior and are used to calculate spatial and temporal fields of concentrations and particle deposition due to emissions from various sources. The output from air dispersion models is used to fill the gaps in data generated by air monitoring programs that cannot provide measured concentrations at all locations. Dispersion models can provide concentration or deposition estimates over an almost unlimited grid of user-specified locations, and can be used to evaluate both existing and forecasted emissions scenarios. In this capacity, air dispersion modeling is a vital tool in assessing the potential risk associated with existing and proposed emissions sources.

The remainder of this section provides background information related to the development of this manual, identifies the manual's objectives and scope, and contains an overview of air modeling for Superfund sites.

BACKGROUND

The EPA's national Air/Superfund Coordination Program helps EPA Headquarters and the Regional Superfund Offices evaluate Superfund sites and determine appropriate remedial actions to mitigate their effects on air quality Each Regional Air Program Office has an Air/Superfund Coordinator who coordinates activities at the Regional level. The Air/Superfund Coordinator Program has a number of responsibilities, including preparation of national technical guidance (NTG) documents. A bibliography of national technical guidance study (NTGS) documents is contained in Appendix E

Continuing EPA involvement in toxic and hazardous pollutant impact activities at Superfund sites has created a need for guidance in the appropriate modeling methods for such releases. In 1989, the EPA published guidance for dispersion modeling and air monitoring for Superfund Air Pathway Assessment (APA). That document (Volume IV of the four-volume APA series)[2] provided technical guidance for activity-specific and source-specific dispersion modeling and air monitoring. Since its publication, there have been changes in dispersion modeling guidance for Superfund sites, and a number of documents dealing with specific modeling techniques applicable to Superfund sources have been developed.

This manual constitutes a new volume (Volume V) in the APA series. It is an update of the air dispersion modeling discussion in the original Volume IV.[2] This fifth volume contains much of the modeling information of the old Volume IV, but emphasizes newly developed guidance and techniques applicable to Superfund sources. The guidance for ambient air monitoring included in the original volume has been revised to form the sole topic of the new Volume IV of this series. The documents comprising this multi-volume APA series are listed below:

- Volume I - Overview of Air Pathway Assessments for Superfund Sites (Revised)[3];
- Volume II - Estimation of Baseline Air Emissions at Superfund Sites (Revised)[4];

- Volume III - Estimation of Air Emissions from Clean Up Activities at Superfund Sites[5];
- Volume IV - Guidance for Ambient Air Monitoring at Superfund Sites[6]; and
- Volume V - Guidance for Ambient Air Modeling at Superfund Sites. (Current document to be published).

OBJECTIVES AND SCOPE OF THIS MANUAL

The overall objective of this project was to create a new and separate document dealing only with air dispersion modeling issues The new manual would contain relevant portions of the previous document, and would emphasize newly developed guidance and techniques applicable to Superfund sources. In designing this fifth volume, it was not the intention to provide detailed calculations and specific technical procedures, but rather to present concepts, definitions, and general procedures, and to reference readily available documentation for more detailed information

This manual offers technical guidance for use by a diverse audience, including EPA air and Superfund regional and headquarters staff, State air and Superfund staff, Federal and State remedial and removal contractors, and potentially responsible parties (PRPs). Remedial project managers, on-scene coordinators, and regional air program staff, supported by the technical expertise of their contractors, can use the information in this manual when developing air dispersion modeling programs. This manual is written to serve the needs of individuals with varying levels of training and experience in implementing air dispersion modeling methods in support of air pathway assessments. However, professional judgement is needed to develop air modeling approaches, so the individuals involved in this activity would benefit from having a strong technical background in source characterization, air monitoring, and risk assessment

Developing and implementing an air dispersion modeling program can be approached in a systematic manner, but cannot be reduced to simple "cookbook" procedures (i.e., procedures that are necessarily absolute). There is always a potential need for professional judgement and flexibility when developing modeling programs for specific Superfund sites.

OVERVIEW OF AIR MODELING AT SUPERFUND SITES

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Superfund Amendments and Reauthorization Act (SARA), the EPA is required to develop and implement measures to clean up hazardous or uncontrolled waste sites. The cleanup of a contaminated site under the Superfund program proceeds via a series of actions designed to remove or stabilize the contaminated material in a controlled way

Among the requirements of the National Contingency Plan (NCP) for CERCLA sites are that a risk assessment be performed, there is compliance with ARARs, and the remedial action be protective of human health. The compliance with these requirements, and the documentation of this compliance, are the primary areas where atmospheric dispersion modeling is needed for Superfund sites In addition, dispersion modeling may be useful for other aspects of the Superfund process. The remainder of this section is a discussion of the various steps of the Superfund process and how dispersion modeling may be incorporated

Phases of the Superfund Process

As outlined in Figure 1-1, Superfund activities can be classified in three phases: pre-remediation, remediation, and post-remediation.

Pre-Remediation Phase--

The pre-remediation phase consists of the Site Discovery, a Preliminary Assessment (PA), and a Site Inspection (SI). This phase is concerned with evaluating the potential risk to public health and the environment posed by the discovered (identified) site. PA is then conducted to collect as much information as possible about the site, with emphasis on assessing the pollutants present and their physical state. The PA is meant to be a relatively quick and inexpensive undertaking, involving the collection of all relevant documentation about the site. In addition, general descriptions of local land use, topography, demography, and meteorology may be formulated for use in developing a preliminary modeling approach. The information gathered in the PA is used by the EPA to determine whether further investigation or action is warranted.

If further investigation is warranted, a SI is conducted. This is the first action that involves some form of sample collection, and it is primarily concerned with determining the urgency of the health risk posed by the site. Samples from various media are collected and analyzed, and the results are used to rank the site within the Hazard Ranking System model This model ranks the relative contamination posed by the site over three pathways air, groundwater, and surface water. The direct contact and fire/explosion pathways are evaluated by the model, but they are not currently included in the ranking. If a site ranks above a predetermined score, it is placed on the National Priorities List (NPL)

During the pre-remediation phase, the main dispersion modeling objectives include providing a sufficient database of toxic air pollutant concentrations for performing a detailed assessment of risk to public health and the environment. This assessment can pertain to both on-site and off-site receptors, and will typically address baseline conditions and those associated with various remedial alternatives. Generally, a risk assessment is performed that is a comprehensive, qualitative determination of the baseline risk associated with the site In some cases, only a risk evaluation may be performed, wherein calculations are performed to develop boundary estimates of the potential risk. Air dispersion modeling during the pre-remediation phase may also be used to provide input to the design of an ambient air monitoring (AAM) network.

After a site is placed on the NPL, the necessity of an Emergency Removal (ER) is evaluated through a site inspection by personnel from the removal program. This site inspection may take place during the remedial investigation phase. If the site is believed to pose an immediate and significant health risk, actions are taken to ameliorate the problem In some cases, the ER action will temporarily increase site emissions. In such cases, air modeling prior to the ER action may be needed to determine whether, and to what extent, the local populace should be evacuated. Additional modeling may be needed during the actual ER action to update earlier predictions as new information becomes available. Following the SI and any ER actions, the remediation phase begins.

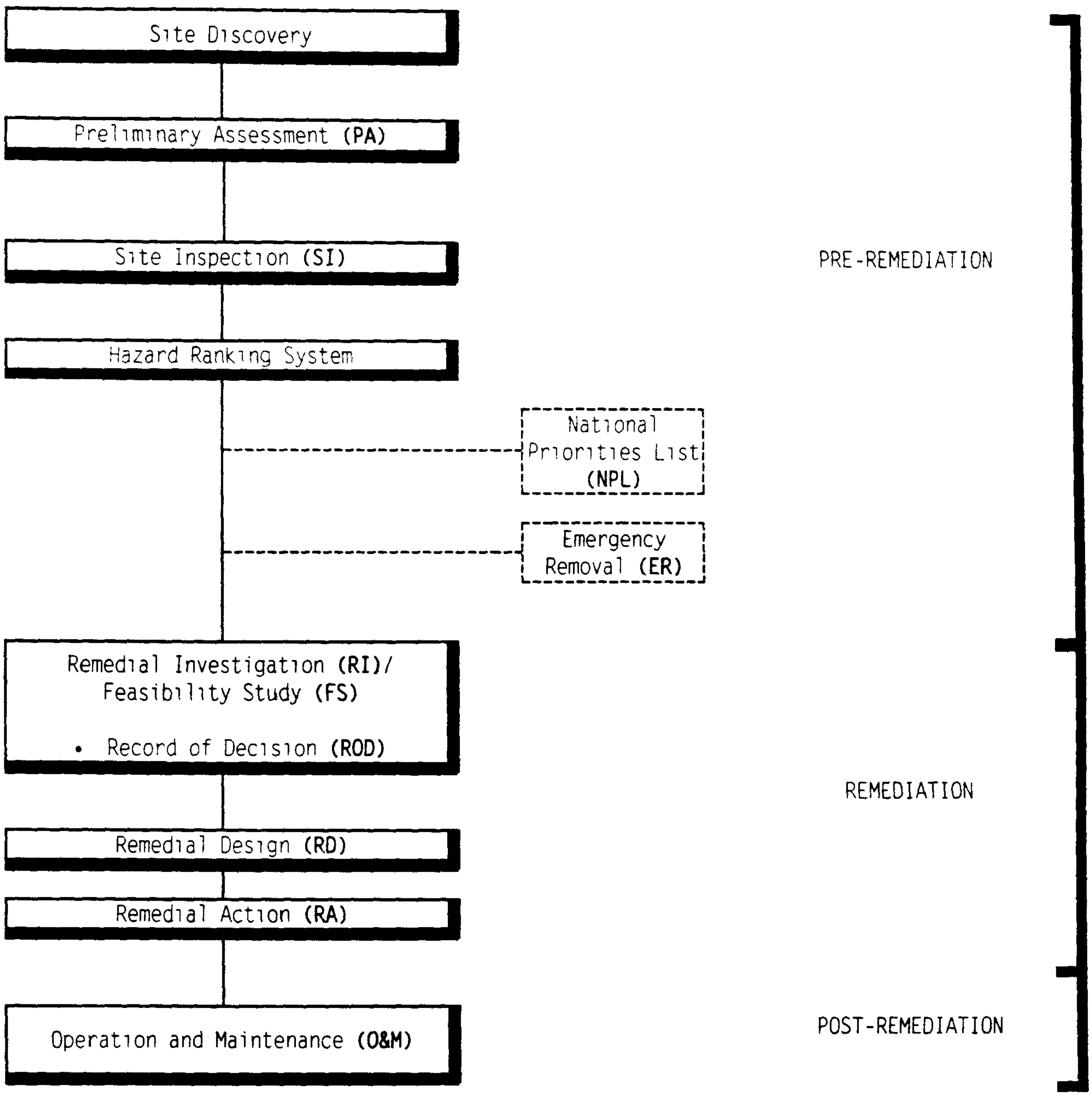


Figure 1-1. Phases of the Superfund Process.

Post-Remediation Phase--

Once the remediation phase has ended, a brief monitoring period is conducted during which the effectiveness of the cleanup is determined. This is called the post-remediation, or Operation and Maintenance (O&M) phase. If the monitoring shows that the site no longer poses a health or environmental threat, the site may be removed from the NPL.

Remediation Phase--

The remediation phase consists of the Remedial Investigation (RI) and Feasibility Study (FS), production of a Record of Decision (ROD) and Remedial Design (RD), and performance of the Remedial Action (RA) This phase takes more time to complete than the pre-remediation phase, and is designed to transform the site into a clean site in a controlled manner

The RI and FS are separate steps, but are typically conducted simultaneously and interactively. During the RI, data are collected to determine more precisely the types of compounds present at the site and the locations and extent of contamination. The data gathered during the RI are used as input to dispersion models and ultimately the results are used to estimate the chronic baseline exposure as part of the risk assessment. The data are also used to help identify appropriate cleanup procedures and remedial alternatives. The FS is concerned with identifying the preferred cleanup alternative. In this step, dispersion modeling may be used to help rank alternatives by identifying the potential air impacts of each, and to aid in siting long-term AAM stations.

After the FS is completed, the ROD is issued. The ROD serves as the official EPA decision about the preferred course of subsequent action. The next activities are the preparation of the RD, a detailed plan for the site remediation, and then the actual RA is initiated. The RA can take a variety of forms, from short-term activities to long-term activities that can take several years to complete. During the RD, modeling may be performed to support the development of an air emissions control strategy.

During the remediation phase, the primary modeling objectives include providing a sufficient database of toxic air pollutant concentrations for assessing the effects of the remedial action evaluated. The modeling objectives also include providing predicted concentration data for routine and non-routine releases in support of protecting on-site workers, the off-site populace, and the environment[36,37]. Predicted concentration data are provided as a component of the ER system employed at the site Air dispersion modeling may also be conducted to provide input to the design of the AAM network for this phase

During the post-remediation phase, the main dispersion modeling objective is to provide a database of toxic air pollutant concentrations for the site boundary and for off-site locations. All the main objectives of the Superfund process are part of assessing the effectiveness of the RA, and for demonstrating that the off-site populace and environment are protected. Modeling may be performed as part of the O&M if a post-remediation risk assessment is required.

Typical APA Activities

Typical APA activities associated with steps in the Superfund process are summarized in Table 1-1. These activities can be divided into the following four categories:

1) Screening evaluation of site emissions and their impacts on air quality under baseline or undisturbed conditions;

2) Refined evaluation of site emissions and their effect on air quality under baseline or undisturbed conditions;

3) Refined evaluation of emissions and their effect on air quality from pilot-scale remediation activities, and

4) Refined evaluation of emissions and their effects on air quality from full-scale remediation activities.

Other APA activities may be appropriate for specific site applications. Screening evaluation activities are most likely to occur during the SI, early RI, or O&M steps of the Superfund process. Refined evaluations are most likely to occur during the RI, FS, RA and O&M steps. In general, screening studies are performed to define the nature and extent of a problem and are considered conservative, particularly for long-term predictions.

They are often used to eliminate the need for more detailed modeling of a particular situation. Refined studies are performed to provide more detailed treatment of atmospheric processes and source-receptor relationships, and provide, at least theoretically, a more accurate estimate of source impact. Further discussion on screening and refined analyses with respect to dispersion modeling is presented in Section 4.

TABLE 1-1 APA ACTIVITIES DURING VARIOUS SUPERFUND ACTIONS

Action	Data Needs	Typical Ambient Concentration Levels Involved (ppb)	Typical Air Modeling Strategy/Objective	Typical Air Monitoring Strategy/Network Design	Typical Uses of APA Data
SI	Qualitative	≤10	Screening Study. Aid in siting of AAM stations	IH monitoring. Limited fenceline monitoring	Assess type and general magnitude of site emissions
ER	Quantitative	≥ 200	Evaluate evacuation options	IH monitoring. Fenceline monitoring. Monitoring at MEI	Estimate risk to on-site workers and off-site populace
RI	Semi-quantitative	≤ 10	Evaluate off-site exposure. Aid in siting of AAM stations	IH monitoring. Limited fenceline monitoring	Estimate risk to on-site workers and improve knowledge of emission sources. also estimate risk to off-site populace
FS	Quantitative	100-200	Evaluate impacts of various remediation alternatives - input to RD	IH monitoring. Emission rate measurements	Estimate air impacts during full-scale remediation Air impact issues include evaluation of chronic and/or acute risk as well as compliance with ARARs.
RA	Quantitative	≥ 200	Provide updated, regular estimates of downwind impacts	IH monitoring. Fenceline monitoring. Monitoring at MEI	Estimate risk to on-site workers and off-site populace.
O&M	Semi-quantitative	≤ 10	Input to any final risk determination	Limited fenceline monitoring.	Estimate risk to off-site populace

Notes

ppb = parts per billion
AAM = Ambient Air Monitoring
APA = Air Pathway Assessment
ARAR = Applicable or Relevant and Appropriate Requirement
ER = Emergency Removal
FS = Feasibility Study
IH = Industrial Hygiene
MEI = Maximum Exposed Individual
O&M = Operations and Maintenance
RA = Remedial Action
RD = Remedial Design
RI = Remedial Investigation
SI = Site Inspection

SECTION 2

DEVELOPMENT OF A MODELING PLAN

A dispersion modeling plan, or protocol, should be developed for each Superfund Air Pathway Assessment (APA). The purpose of preparing such a plan is to document the modeling methodology and inputs proposed for use in the APA In addition, all appropriate portions of the plan should provide an indication of how the selected procedures compare to existing guidance, and where there are deviations from guidance, provide the rationale for such deviation

The modeling plan provides an opportunity for peer review and approval of the modeling program by the Remedial Program Manager, in coordination with the EPA Regional Air/Superfund Coordinator, and the EPA Regional Modeler. Approval of the protocol before modeling begins helps ensure that modeling analyses are properly designed and will meet with regulatory approval. Furthermore, with a plan in place the modeler will know how to proceed in the event certain outcomes unfold (e g., if screening-level modeling indicates that risks are unacceptable, the procedure for conducting a refined analysis will already be known and approved). A good protocol will also serve as a checklist, clarifying what is relevant and particularly significant with respect to modeling the site (e.g., the plan will state that predicting impacts in complex terrain does not apply to the site in question).

To assist in preparing a modeling plan, a suggested outline is provided in Table 2-1. It should be noted that, aside from the benefits already mentioned, the effort involved with preparing a modeling plan typically reduces the eventual effort required in conducting the modeling analysis.

Specific aspects of the modeling plan are discussed in the following sections of this manual. Section 3 discusses the source inputs needed for proper application of air dispersion models. Section 4 addresses model selection, and the concept of screening and refined analysis. In Section 5, other primary components of a modeling analysis are discussed. The final section, Section 6, discusses the assessment of model results.

TABLE 2-1. AN OUTLINE FOR A SUPERFUND APA MODELING PLAN

I. INTRODUCTION:

- General characteristics of the site;
- General site activities (through all planned phases of the Superfund process); and
- Characteristics of the surrounding environment:
  - -- Topography,
  - -- Climatology,
  - -- Demography,
  - -- Presence of water bodies, and
  - -- Vegetation types.

II DATA QUALITY OBJECTIVES

- Modeling objectives (consistent with the Superfund activity involved and the overall project objective);
- Model application to each Superfund activity APA; and
- Overall rationale for the proposed modeling approach.

III. POLLUTANTS TO BE MODELED:

- Physical, chemical and toxicological properties of pollutants to be modeled, and
- Averaging times associated with pollutants to be modeled, as prescribed by state and federal applicable or relevant and appropriate requirements (ARARs).

IV. SOURCE CHARACTERISTICS AND EMISSIONS:

- Identification of all point and fugitive sources to be modeled;
- Characterization of point sources (e.g., applicability of building downwash);
- Characterization of fugitive sources (i.e., line, area, or volume);
- Methods for estimating emission rates (as a starting point see Volume I of the Air/Superfund Guidance Study Series[3] and <u>Models for Estimating Air Emission Rates from Superfund Remedial Actions</u>)[7];
- Determination of maximum short-term, and annual average emission rates;
- Characterization of the duration and frequency of emissions from each source (e.g., continuous or intermittent); and
- Particle size distribution and chemical composition for modeling metals and fugitive dust.

TABLE 2. (Continued)

V. MODELING METHODOLOGY:

- Determination of rural/urban classification;
- Treatment of building downwash effects for point sources;
- Treatment of surrounding terrain;
- Treatment of particle deposition (if appropriate);
- Model(s) selected and rationale,
- Model options proposed;
- Meteorological data
  - -- Source of data,
  - -- Length of data record,
  - -- Quality and completeness of the data, and
  - -- Representativeness of the data (for off-site monitoring locations);
- Receptor grid:
  - -- Spatial extent,
  - -- Resolution around site boundary,
  - -- Especially sensitive locations (to address specific public health and environmental concerns), and
  - -- Plan for refined grid to isolate maximum concentrations.
- Background concentrations.
  - -- Treatment of nearby sources of pollutant emissions, and
  - -- Use of existing ambient air monitoring (AAM) data.

VI. MODEL RESULTS:

- Presentation of model results;
- Assessment of model results;
- Input to risk assessment;
- Discussion of methods used to determine target compounds and risk assessment threshold values; and
- Modeling uncertainties and their implications to the APA.

VII. REFERENCES.

(State reference for procedures cited in the modeling plan)

SECTION 3

POLLUTANT RELEASE CHARACTERIZATION

This section describes the source inputs needed for proper application of air dispersion models Atmospheric dispersion modeling for Superfund sites includes a composition of sources that, in general, are different in configuration and characteristics from the sources traditionally modeled for regulatory air permitting of elevated buoyant point sources (e g , boiler or process stacks). Superfund sources primarily consist of fugitive area and volume sources and, to a smaller extent, point sources

Air emissions from Superfund activities can be continuous, intermittent, or a one-time release of a defined duration, and may have large temporal and spatial variability. Releases can be anticipated (occurring from routine operations and known sources) or can be unforeseen (resulting from accidental or nonroutine events). Both gaseous and particulate emissions to the atmosphere must be considered. Volatile organic compounds are emitted as gasses. Semivolatile organic compounds are emitted as gasses and particulate depending on vapor pressure and ambient conditions. Metals and other inorganic substances with the exception of metallic mercury are emitted as particles. Particles are treated separately because of their different dynamics, such as settling velocity.

Point sources involve the release of emissions from a well-defined stack or vent, at a well-defined temperature and flow rate. Air strippers, incinerators, thermal desorption units, and *in situ* venting operations constitute the common point sources at Superfund sites.

Fugitive sources, generally characterized as area, volume, and line sources in dispersion modeling, involve the release of emissions from a defined surface or depth of space. The amount of emissions released from a fugitive source is more directly related to environmental conditions (e.g., ambient temperature and wind speed above the surface). Area sources at Superfund sites generally include landfills, lagoons, contaminated soil surfaces, materials handling and transfer operations, and solidification and stabilization operations. Volume sources include structures within processing facilities, and may include individual tanks or tank farms, and chemical storage containers. Line sources include paved and unpaved roads.

For particular guidance on determining source emission rates during pre-remediation, remediation, and post-remediation activities, the reader is referred to the Air/Superfund National Technical Guidance Study (NTGS) series documents that exist on this subject (see Appendix E) A good overview document for those interested in estimating source emissions would be Models for Estimating Air Emission Rates from Superfund Remedial Actions[7].

For dispersion modeling, an important consideration in emissions estimation is the averaging period. Depending on the design of the air pathway assessment (APA), it may be necessary to estimate both the long-term (i.e., annual) and short-term (24-hour or less) emissions potential from the source. Although some of the emissions from Superfund sources include reactive constituents, the phenomenon of chemical reactivity is not addressed in the models described in this document.

General characteristics of sources associated with the primary phases of the Superfund process are shown in Table 3-1. The source classification for modeling of the primary Superfund sources is indicated, as well as the important air emission mechanisms. Each source may also be described as having a fundamental release classification (for some sources, multiple classifications may apply). For pre-remediation sources, the document Guidance for Baseline Emissions Estimation Procedures for Superfund Sites[39] should be reviewed.

SELECTING POLLUTANTS TO MODEL

Selecting the specific toxic air pollutant compounds to model is generally less critical than when selecting target analytes for ambient air monitoring, where the selections may be significantly limited by technical, budget, and schedule constraints. With the sophistication of computer modeling techniques, numerous pollutants may be modeled for any particular site with relative efficiency. For assessing the impacts of multiple pollutants from a single source, it is possible to model the source only once with a unit emission rate (i.e., 1 gram per second [g/s]), and then scale the results by the actual pollutant emission rates.

TABLE 3-1. GENERAL CHARACTERISTICS OF SOURCES ASSOCIATED WITH SUPERFUND ACTIVITIES

Superfund Source	Typical Source Classification for Modeling[a]	Release Classification	Important Air Emission Mechanisms: Gas Phase	Important Air Emission Mechanisms: Particulate Phase
PRE-REMEDIATION:				
• Landfills	Fugitive (area)	Gas release from solid	Volatilization	Wind erosion, mechanical disturbances
• Lagoons	Fugitive (area)	Low volatility release from liquid	Volatilization	Wind erosion, mechanical disturbances

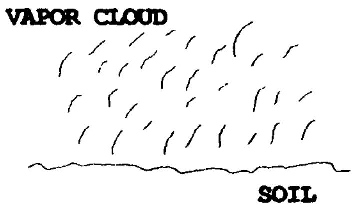


TABLE 3-1. (Continued)

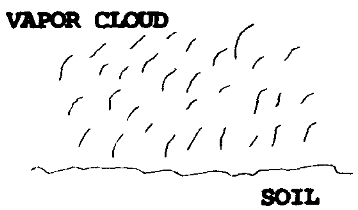
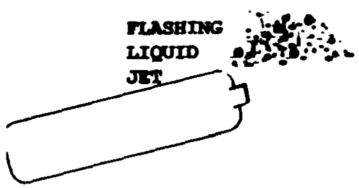
Superfund Source	Typical Source Classification for Modeling[a]	Release Classification	Important Air Emission Mechanisms: Gas Phase	Important Air Emission Mechanisms: Particulate Phase
• Contaminated soil surfaces 	Fugitive (area)	Fugitive particulate	Volatilization	Wind erosion, mechanical disturbances
• Containers 	Fugitive (area, volume)	Gas release from solid Low volatility release from liquid High volatility release from liquid Gas release	Volatilization	Mechanical disturbance

TABLE 3-1. (Continued)

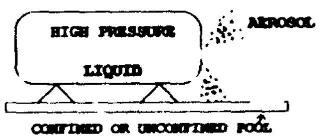
Superfund Source	Typical Source Classification for Modeling[a]	Release Classification	Important Air Emission Mechanisms: Gas Phase	Important Air Emission Mechanisms: Particulate Phase
• Storage tanks	Fugitive (area)	Gas release from solid	Volatilization	NA
		Low volatility release from liquid		
		High volatility release from liquid		
		Gas release		

TABLE 3-1. (Continued)

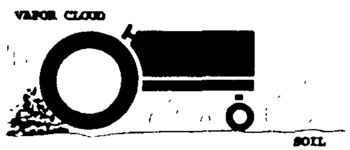
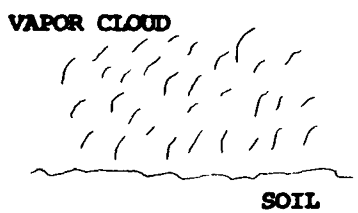
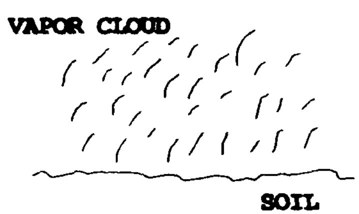
Superfund Source	Typical Source Classification for Modeling[a]	Release Classification	Important Air Emission Mechanisms: Gas Phase	Important Air Emission Mechanisms: Particulate Phase
REMEDIATION:				
• Soil handling 	Fugitive (area, volume)	Gas release from solid	Volatilization	Wind erosion, mechanical disturbances
• Air stripper[b] 	Point	Gas release	Volatilization	NA

TABLE 3-1. (Continued)

Superfund Source	Typical Source Classification for Modeling[a]	Release Classification	Important Air Emission Mechanisms: Gas Phase	Important Air Emission Mechanisms: Particulate Phase
• Incinerator/ Thermal desorption[b]	Point	Gas release	Combustion	Combustion
				
• In situ venting	Point	Gas release	Volatilization	NA
• Solidification/ Stabilization	Fugitive (area, volume)	Gas release from solid	Volatilization	Wind erosion, mechanical disturbances

TABLE 3-1. (Continued)

Superfund Source	Typical Source Classification for Modeling[a]	Release Classification	Important Air Emission Mechanisms	
			Gas Phase	Particulate Phase
POST-REMEDIATION:[c]				
• Landfills 	Fugitive (area)	Gas release from solid	Volatilization	Wind erosion, mechanical disturbances
• Soil surfaces 	Fugitive (area)	Fugitive particulate	Volatilization	Wind erosion, mechanical disturbances

[a]Most Superfund sources are ground level or near ground level, non-buoyant releases.
[b]Small stacks where plume is frequently influenced by downwash in the wake of nearby structures.
[c]Emissions may still result during post-remediation, but should be at levels consistent with the goals of the remediation effort. Sources shown are remediated.
Notes: NA = Not Applicable

For multiple pollutants from multiple sources with the relative emission rates of pollutants different for each source, the unit emission rate is not suggested. In this typical case the point of maximum concentration of each pollutant at the fenceline may be at different locations. These different locations would be impossible to identify if all sources were simply modeled at unity. If each source is modeled separately and the predicted concentrations at each receptor location summed, the resulting concentrations would be unrealistically high. It is suggested to model on a pollutant by pollutant basis with the largest source assigned a unit emission rate and all other sources assigned an emission rate equal to its relative emission strength.

The Hazardous Substances List (HSL)[38] developed by the EPA for the Superfund program provides an initial, comprehensive list of target compounds for dispersion modeling. Other target compounds can be found in the Clean Air Act, Title III (Hazardous Air Pollutants), Section 112. Compounds included in the Applicable or Relevant and Appropriate Requirements (ARARs) should also be used to identify candidate pollutants for modeling. To the extent possible, the target compound list should be based on source and ambient air monitoring (AAM) results. The Remedial Investigation/Feasibility Study (RI/FS) should identify most or all of the contaminants present at the site.

It frequently is not practical to address every emitted compound in the modeling analysis, so typically a subset of compounds - referred to as target compounds - is selected. When conducting dispersion modeling for refined APAs, target compounds should include, at a minimum, all contaminants with concentrations greater than or equal to 10 percent of the appropriate health-based action level. These contaminants are expected to represent the greatest contributors to potential health impacts. This approach provides a practical basis for addressing refined modeling at sites with a large number of potential emission compounds (e.g., over 100) of which only a limited subset significantly affects inhalation exposure estimates. However, it is generally recommended to also evaluate all appropriate site/source-specific contaminants, as practical, for refined modeling APAs (especially if the cumulative effect due to exposure to a mixture of constituents is used for comparison to health criteria). RAGS Part A[34] contains a recommendation that all compounds be addressed that represent 1 percent or more of the total risk from a given exposure pathway. The pollutants selected for modeling at a particular site must ultimately meet the approval of the Remedial Program Manager.

SOURCE DEFINITION

Generating the source inventory for modeling is intertwined with the creation of the pollutant inventory. Each emissions source and the constituents each source emits must be specifically identified. For dispersion modeling, each source will need to be classified as a point, area, volume, or line source. Building the source inventory usually begins with mapping the locations of point sources and the locations and spatial extent of fugitive sources on a site plot plan, drawn to scale. This plot plan should also indicate the location of the site property boundary, and any on-site receptors of interest. Such a drawing identifies the necessary near-field, source-receptor relationships for modeling

Refined dispersion models can currently accommodate a large number of sources; therefore, the modeler should not feel unnecessarily constrained to limit the number of sources involved in the analysis. A large area source such as a landfill, for example, can be subdivided into multiple smaller area sources. This is a good way to account for any spatial or temporal variability in emissions over the source as a whole. Unique sources will be defined by the multiple emission points resulting from activities at the site. For example, an initial breakout of sources resulting from soil excavation would be the excavation pit, the area over which the excavated material is transported, and the short-term storage piles.

Because source inputs vary with the type of source modeled, an important first step in creating the inventory is to identify each source of emissions as a point, area, volume, or line source. With the source types established, the appropriate model inputs can be determined. The following subsections describe the various source types and associated inputs for modeling.

Point Source Characterization

Point sources involve the release of emissions from a well-defined stack or vent, at a known temperature and flow rate. Consequently, characterizing point sources for modeling is fairly straightforward. The basic model inputs for any point source are: stack height above ground level; inside diameter at stack exit; gas velocity or flow rate at stack exit; gas temperature at stack exit; building dimensions (for stacks subject to downwash, to be discussed in Section 5.5); and emission rate. The location of the source will also need to be defined in terms of the model receptor grid used (see Section 5.3).

The influence of any air pollution control equipment (e.g., carbon absorption and incineration in the case of air strippers and *in situ* venting; wet absorbers and scrubbers in the case of incinerators) on a pollutant specific basis should be taken into account when defining model inputs The presence of air pollution control equipment can alter the gas exit temperature and flow rate which effect plume bouyancy. In defining point source inputs for modeling, the focus should always be on the characteristics of the exhaust as it is released to the atmosphere. APC equipment may also affect the particulate size distribution of controlled particulate emissions.

In the event that there are multiple point sources at the site (e.g., multiple air stripping towers), it may be possible to conduct the modeling by treating all of the emissions as coming from a single, representative stack (particularly useful when conducting a screening-level analysis) when using the SCREEN2 or TSCREEN models. Merging stacks is appropriate if 1) the individual point sources emit the same pollutant(s), 2) have similar stack parameters, 3) are within about 100 meters (m) of each other, and 4) the maximum distance between any two stacks is small relative to the distance between any stack and the closest receptor. For each stack, the following parameter M would be calculated as shown below

$$M = \frac{[h_s \; V \; T_s]}{Q}$$

where,

M	=	merged stack parameter that accounts for the relative influence of stack height, plume rise, and emission rate on concentrations
h_s	=	stack height (m)
V	=	$(\pi/4)d_s^2v_s$ = stack gas volumetric flow rate (cubic meters per second [m^3/s])
d_s	=	inside stack diameter (m)
v_s	=	stack gas exit velocity (meters per second [m/s])
T_s	=	stack gas exit temperature (Kelvin [K])
Q	=	pollutant emission rate (g/s)

The stack with the lowest calculated value of M is designated the representative stack The sum of the emissions from all stacks is assumed to be emitted from the representative stack (i.e., dispersed based on the parameters of that stack). To be conservative, it is recommended to use the closest location to the receptors of interest as the source location of the stacks being merged.

Parameters from dissimilar stacks should be merged with caution. For example, if the stacks are located more than about 100 m apart, or if stack heights, volumetric flow rates, or stack gas exit temperatures differ by more than about 20 percent, resulting model impacts due to the merged-stack procedure may be unacceptably high

<u>Area Source Characterization</u>

Various types of toxic waste sources fall into the area source category. For a Superfund site these sources include landfills, waste lagoons, evaporation and settling ponds, and regions where long-term exposure to toxic chemicals has contaminated the soil.[8] For all of these sources, pollutants are emitted at or near ground level. The sizes of these sources can range from a few square meters in the case of settling ponds, to a few square kilometers or larger in the case of contaminated soils.

Emissions from area sources are assumed to be of neutral buoyancy. Therefore, plume phenomena such as downwash and impaction on elevated terrain features are not considered relevant for modeling area sources. The emission rate for area sources is unique in that it is entered in units of mass per unit time per unit area [e.g., g/(s-meters squared[m^2])]. It is an emission flux rather than an emission rate. As an example, assume the pollutant emission rate from a small lagoon is 150 g/s The dimensions of the lagoon are 10 m by 20 m (total area is 200 m^2). If this source were modeled as a single, square area source, then the modeled emission flux would be 0.75 g/s-m^2 (150 g/s ÷ 200 m^2). If the source were subdivided into smaller area sources, the individual area source emission rates would be determined by multiplying the modeled emission rate based on the total area by the relative fractions of the total area represented by the individual area sources. The emission flux for each sub-area will be the same as for the total pool. For example, if the source were modeled as two square area sources, each of dimensions 10 m by 10 m (100 m^2), then the modeled emission rate for each source would be 75 g/s [(150 g/s) x (100 m^2 - 200 m^2)].

The emission flux would still be the same as the total pool example, 0.75 g/s-m^2 (75 g/s - 100 m^2). Summing the modeled rates for the two areas yields the modeled emission rate for the total area of 150 g/s. It is easier to work with emission fluxes for area sources than emission rates since the emission flux is the same for all sub-areas of the source. Only the total area of the source must be checked to ensure correctness.

For dispersion modeling, the important parameters used to characterize area sources are location, geometry, and relative height. In current models (for example, the current versions of the Industrial Source Complex [ISC2][9] and TSCREEN[10]) area sources are defined by the location of the southwest corner of a square and a side length. As this document is being written revisions are being made which expand the definition capability refined modeling The location is expressed by a single east-west (X) and north-south (Y) coordinate of a corner (normally southwest) of a square or rectangular geometric shape. The side lengths need to be defined. By default the area source is assumed to be a square. The area source can also be rotated about the specified corner for areas not aligned north-south. An area source of irregular shape (i.e., neither a square nor a rectangle) can be simulated by dividing the area source into multiple squares and/or rectangles that approximate the geometry of the source. The particular model user's guide will need to be consulted to verify whether both square and rectangular definitions of the source are allowed. The model user's guides normally provide examples of input for complex area sources.

If the area source is not at ground level, a height for the source may be entered (for example, a non-zero value would typically be entered for the height of a storage pile). If the release height of the source is greater than approximately 10 m, it should probably be modeled as a volume source.

EPA is currently in the process of revising the area source algorithm contained in the ISC2 model. In this new version, there will be no restrictions on the placement of receptors relative to the area source(s). Receptors will be allowed within an area source itself and at the edge of an area source. The model will integrate over the portion of the area that is upwind of the receptor (specifically for portions of the area that are no closer than 1 m upwind of the receptor).

In the interim, an alternative technique is recommended for defining the receptor grid in relationship to the area source location(s). The general recommendation is to subdivide the area source into smaller area sources if the separation distance between the area source and a receptor is less than the length of the side of the area source. Hence, the area source nearest the receptor(s) would be subdivided into smaller squares such that there is no area source with a distance to a receptor of less than the source's side length (this may not be practical if the receptors of interest include on-site workers). For specific guidance, the particular model user's guide should be consulted. The EPA document Review and Evaluation of Area Source Dispersion Algorithms for Emission Sources at Superfund Sites[8] may also provide some perspective on modeling area sources

Volume Source Characterization

There are two basic types of volume sources: surface-based or ground-level sources that may also be modeled as area sources, and elevated sources. Most of the Superfund release sources can be regarded as surface-based sources. The effective emission height of a surface-based volume source, such as a surface rail line, is usually set equal to zero. An example of an elevated volume source is an elevated conveyor with an effective emission height set equal to the height of the conveyor. A source may be defined as a volume source for modeling when its emissions can be considered to occur over a certain area and within a certain depth of space. At a Superfund site, fugitive exhaust from on-site structures such as tanks, or a treatment facility may be modeled as a volume source. A roadway over which contaminated soil is hauled may also be modeled as a series of volume sources. As with area sources, emissions from volume sources are assumed to be of neutral buoyancy.

The important parameters used to characterize volume sources for dispersion modeling are location and initial lateral and vertical dimensions. The particular model user's guide will have instructions on defining the initial lateral and vertical dimensions of the source. The length of the side of the volume source will need to be known, as will the vertical height of the source, and whether it is on or adjacent to a structure or building. Generally, the north-south and east-west dimensions of each volume source must be the same. For refined modeling, the location is simply expressed by a single east-west (X) and north-south (Y) coordinate.

Line Source Characterization

Line sources are typically used to represent roadways. Certain dispersion models differentiate line sources from area or volume sources In these cases, basic model inputs are the overall source length, width, and height. Emissions may be entered in units of grams per meter per second.

Line sources may also simply be modeled as a series of area or volume sources In the case of a long and narrow line source, it may be impractical to divide the source into N volume sources, where N is given by the length of the line source divided by its width. Dividing the length of the line source by its width effectively splits the line source into a string of squares (for example, if the length of the line source was 100 m, and the width was 5 m, then the line source could be split into twenty, adjacent square volume sources) An approximate representation of the line source can be obtained by placing a smaller number of volume sources at equal intervals along the line source (for example, for the line source of length 100 m and width 5 m, a total of 10 square volume sources separated from one another by 5 m could be defined) With this option, the spacing between individual volume sources should not be greater than twice the width of the line source. A larger spacing can be used, however, if the ratio of the minimum source-receptor distance and the spacing between individual volume sources is greater than about 3.

CONTAINER/ACUTE RELEASES

Although not a typical concern for Superfund sites, except in contingency planning, the highest concentration impacts can occur from a short term release of a gas or liquid in a container or a solid such as burning tires. If the potential for accidental releases is known to exist prior to remediation, the site Health and Safety Plan should include a contingency plan, based in part on dispersion modeling results, for addressing such situations.

Descriptions of the possible source terms from such releases and subsequent dispersion modeling are described in Contingency Analysis Modeling For Superfund Sites and Other Sources,[11] and Guidance on the Application of Refined Dispersion Models to Hazardous/Toxic Air Pollutant Releases.[12] Appendix F outlines how these two references can be used to determine the source term for such releases.

In a typical Superfund source the release is not denser than air. Many of the container releases result in dense gas releases. Most hazardous chemicals have molecular weights greater than air's molecular weight. Chemicals stored under pressure cool from expansion during a release. Chemical vapor parcels which are cooler than the surrounding air (even if the chemical's molecular weight is the same as air's) will be more dense than the surrounding air

SECTION 4

MODEL SELECTION

Determining the level of model sophistication and the specific model to use are integral to a meaningful Superfund Air Pathway Assessment (APA). This section, therefore, is designed to assist the modeler in determining what approach to take for a particular analysis, and presents the major considerations. The EPA has approved numerous models for use in regulatory application. Non-regulatory models also may be used if it can be shown that they are more suitable for a given scenario. The use of any non-EPA model should be reviewed and approved by the RPM or their designate before the modeling is performed. It is not the intention of this manual to discuss each available technique; rather, the most generally applicable and commonly used models are mentioned. For any given APA, it is the responsibility of the modeler to ensure that the most appropriate technique is selected.

Where possible, models selected to provide estimates of ambient concentrations should be consistent with the requirements and guidance specified in the <u>Guideline on Air Quality Models (Revised)</u>[1] Since dispersion models are periodically revised, the model user should verify that the most updated version of code is being executed for the APA. For models issued by the EPA Office of Air Quality Planning and Standards (OAQPS), this can be done by checking the Support Center for Regulatory Air Models (SCRAM) Bulletin Board System (BBS), as described in Section 4.5.

In general, determining the level of model sophistication and making the appropriate model selection will depend on the following key factors:

- Site-specific goals of the APA;
- Superfund dispersion modeling objectives;
- Legal and liability aspects of the Superfund project; and
- Pragmatic aspects of the program, including:
  - -- Quality and availability of the input data, including the ability of the emission models to adequately simulate emission rates and their variability.
  - -- Applicability of existing dispersion models to site-specific characteristics, including source types.

-- Ability of existing dispersion models to reasonably simulate transport and dispersion of the particular air pollutants of interest released from the site, given the chemical and physical processes involved, and

-- Ability to accomplish the dispersion modeling objectives with modest uncertainties.

The overall goal of a Superfund APA is to evaluate the exposure of the off-site population, and the impact to the environment, depending on the phase and related activities of the Superfund program. As discussed in Volume I of this APA series, air monitoring is usually performed to determine worker exposure because on-site personnel may work relatively close to emission sources and they tend to move around over time. Within the scope of this document, exposure of the off-site populace and impact to the environment are a basic matter of producing adequate concentration and deposition estimates in the locations of interest.

In this section, determination of the proper model to use is discussed in the context of a general two-step procedure for assessing air quality impacts. This two-step procedure involves an initial screening-level analysis to obtain conservative estimates of air quality based on limited data, followed by a refined analysis, as necessary, to provide more realistic estimates of air quality based on more detailed model inputs. The following subsections further describe each of these classifications and their applicability.

SCREENING ANALYSIS

Screening-level dispersion modeling involves simplified calculation procedures designed with sufficient conservatism to determine if a source of pollutants (1) is clearly not a threat to air quality, or (2) poses a potential threat that should be examined with more sophisticated estimation techniques or measurements. Therefore, screening-level dispersion modeling techniques provide conservative estimates of air quality impacts. These techniques also eliminate the need for further, more refined modeling if the impacts on air quality are shown to not pose a risk to public health or the environment. Based on simplified procedures, screening-level modeling is more readily implemented than a refined modeling approach.

There are two primary distinctions between screening-level techniques and refined modeling techniques. One distinction is that the screening-level approach incorporates "generic" meteorological data, thus eliminating the need for site-specific meteorological data. The maximum concentration for any averaging period is considered to occur in any direction from the source. Screening-level models typically estimate hourly average impacts, with impacts for other averaging periods (e.g., 3-hour, 8-hour, 24-hour, and annual) derived through the use of time scaling factors.

The second primary distinction between screening and refined models is that screening models can only estimate the impacts from a single source with each model execution. When impacts are required for multiple sources, the sources must be processed separately, and their individual, maximum impacts summed to produce the total maximum impact. The greater the distance between sources, and the less similarity they have in dispersion characteristics, the more conservative this summed impact will be. This is because dissimilar sources tend to have maximum impacts in different places, especially when located some distance apart.

Various screening-level techniques are identified in the Guideline on Air Quality Models (Revised). Two interactive screening models that are commonly used to predict air quality impacts are SCREEN2[13] and TSCREEN[10]. The SCREEN2 model incorporates the methodology presented in Screening Procedures for Estimating the Air Quality Impact of Stationary Sources (Revised)[14] and is capable of predicting impacts for point, volume, and area sources. Area source calculations are performed using a finite line segment approach, consistent with the Industrial Source Complex (ISC2) models (described in the following subsection). The volume source calculations are also consistent with ISC2; however, unlike ISC2, the volume source algorithm in SCREEN2 is for single-volume sources only. TSCREEN[10] incorporates the dispersion algorithms used in SCREEN2 and also provides algorithms for calculating some source terms and for estimating noncontinuous releases. The TSCREEN model incorporates the procedures documented in Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants (Revised).[15]

Both models are capable of predicting concentrations in simple terrain (elevation below stack top) and intermediate/complex terrain (elevation above stack top). They use a range of stability classes and wind speeds to identify those meteorological conditions (e.g., combinations of wind speed and stability) resulting in maximum ground-level concentrations.

Summary

Screening models are most appropriate for assessing the air quality impacts of single sources, and sources with continuous, constant emission rates. Screening-level dispersion modeling is applicable to the screening step of the Remedial Investigation/Feasibility Study (RI/FS), and can be used to provide a preliminary indication of the potential impacts of possible remedial alternatives. The availability of representative meteorological data is probably the most significant determining factor in applying a screening model--without representative meteorological data, refined dispersion modeling cannot be conducted.

In the past, screening techniques for estimating ambient concentrations have been developed that do not involve use of a computer model. These techniques utilize formulas and predefined charts or tabular values relating concentration with downwind distance from the source. Examples of these approaches may be found in A Tiered Modeling Approach for Assessing the Risks Due to Sources of Hazardous Air Pollutants[16] and Guideline for Predictive Baseline Emissions Estimation Procedures for Superfund Sites[17]. With the development of "user-friendly" computerized screening techniques such as TSCREEN and SCREEN2, it is recommended that these computerized techniques be used to ensure that the results reflect the latest modeling guidance.

REFINED ANALYSIS

Refined dispersion modeling requires more detailed and precise input data and, consequently, provides more accurate estimates of source impacts. Refined dispersion models have been developed for both simple and complex terrain and for rural and urban applications. Thus, the topography and land use in the area surrounding the facility must be evaluated to determine the appropriate model The model selected should most accurately represent atmospheric transport and dispersion in the area under analysis.

Refined dispersion modeling requires additional detail in meteorological data, definition of the receptor grid, and definition of the emission sources. Actual coordinates of the sources need to be specified, and for point sources, the building dimension data to account for downwash are considerably more extensive. Another distinguishing feature of refined dispersion models is their ability to vary source emission rates as a function of time and/or meteorological conditions.

Many refined models require meteorological data in the form of hourly weather observations and twice-daily mixing heights that are processed into a format suitable for model execution. Models designed to predict only long-term averages commonly use Stability Array (STAR) summaries, which are joint frequency distributions of wind speed, wind direction, and Pasquill-Gifford atmospheric stability class.[18] For the receptor grid, a spatial array of locations where concentration predictions are desired must be defined relative to some user-specified grid origin. Unlike screening models, receptor impacts from refined models are no longer simply a function of downwind distance from the source, but are a joint function of distance and orientation from the source. Meteorological data and receptor requirements for refined dispersion modeling are further described in more detail in Sections 5.1 and 5.3, respectively.

One of the most commonly used models for conducting a refined dispersion modeling analysis is the Industrial Source Complex Model, which has a long-term version (ISCLT2) and a short-term version (ISCST2).[9] The short-term version can also produce long-term concentrations, and is often used in an analysis when both short-term and annual average concentrations are required. Although there are numerous models appropriate for regulatory application, the ISC2 models have experienced widespread use because of their versatility. The ISC2 models have the following attributes:

- accommodate multiple point and/or fugitive sources;
- allow for a sophisticated treatment of building downwash for point sources;
- predict impacts for flat and rolling terrain;
- predict impacts for urban and rural land use classifications; and
- allow input of time-varying emission rates (e.g., emission rates may vary by season, month, or hour-of-day).

Another model, recommended for use in urban areas, is the Gaussian-Plume Multiple Source Air Quality Algorithm (RAM)[19]. This model is a steady-state Gaussian plume model used for estimating the impacts of multiple point and area sources in flat terrain and urban settings.

In summary, refined dispersion modeling is applicable to all phases of the Superfund process, provided representative meteorological data are available. Relative to screening models, refined models generally provide more accurate estimates of the impact of Superfund sources on public health and the environment by relying on fewer assumptions and providing a consistent means of making multiple, detailed calculations in a single execution. The output from refined models can provide an extensive amount of information. For example, the impacts at a large number of receptors for varying averaging times is a basic outcome of many refined models. For modeling sources with continuous emission rates located in a rural area, the ISC2 models should be given first consideration. If multiple sources in an urban area are to be modeled, and terrain is not a significant consideration, the RAM model should be used For modeling sources with instantaneous emission rates, the TSCREEN[10] model or a refined model such as described in Guidance on the Application of Refined Dispersion Models to Hazardous/Toxic Air Pollutant Releases[12] may be used.

DENSE GAS RELEASE SIMULATIONS

Dense gas modeling is not a typical consideration for Superfund sites except for contingency modeling. Releases of liquids or gases from containers can lead to dense gas clouds. Knowing whether a release should be treated as a dense gas (heavier than air) release is important to selecting the appropriate model. If a release can be considered neutrally buoyant or lighter-than-air, standard "passive" dispersion modeling or a model capable of handling neutrally buoyant releases should be applied. If not neutrally buoyant, then the analysis requires the use of a specialized model to adequately characterize such phenomena.

To determine whether a release should be considered a dense gas release, a comparison is made between the Richardson number describing the release and a selected, known value. (In atmospheric science, the Richardson number is a measure of dynamic stability.)

The formulation of the Richardson number and, thus, the calculation, depends on the release density, and whether the release is instantaneous or continuous. The equations for determining the density of a release are given in Section 4.13 of Guidance on the Application of Refined Dispersion Models to Hazardous/Toxic Air Pollutant Releases.[12]

Over the last few years, much focus has been placed on the development of models to address the dispersion of dense gas releases. Guidance on the Application of Refined Dispersion Models to Hazardous/Toxic Air Pollutant Releases[12] discusses and presents example applications for five dense gas dispersion models: the Dense Gas Dispersion model (DEGADIS), the SLAB model, the ADAM model, the Areal Locations of Hazardous Atmospheres (ALOHA) model, and Heavy Gas System (HGSYSTEM). This document should be consulted as a starting point for understanding the requirements of dense gas dispersion models.

DEPOSITION MODELING

Remedial activities at National Priorities List (NPL) sites very often involve the handling of contaminated soil. This handling may result in fugitive dust emissions, that can carry inorganic and organic constituents in, or attached to, the dust particles. One remediation activity that may be a significant source of fugitive dust is solidification/stabilization.[20] Non-remediation sources of fugitive dust emissions include storage piles and dry impoundments. Particulate matter (PM) impacts should be evaluated even when the material is not contaminated, because particulate matter less than 10 micrometers (μm) in diameter (PM_{10}) is a criteria pollutant. If the particulate emissions are contaminated, the fraction of contaminant will need to be determined to properly establish the actual emission rate of the contaminant.

In addition to estimating ambient concentrations of the particulate emissions (used in evaluating inhalation exposure), it may be important to characterize particle deposition as part of the overall risk assessment. The importance of assessing particle deposition for a given site will depend on the size of the particulate matter involved and the proximity of receptors. The smaller the particles, the greater the likelihood that deposition will occur off site. For example, particulate emission factors and equations defined by EPA are given as a function of particle diameter.[21]

Large particles with diameters greater than 100 μm are likely to settle within 5 to 10 meters (m) of the emissions source, while those that are 30 to 100 μm in diameter are likely to settle within 100 m or so of the source, except in cases of high atmospheric turbulence. Smaller particles, especially those with diameters less than 10 to 15 μm, are much more likely to stay airborne

Deposition is actually a complex process that is highly dependent on the specific location, meteorology, and chemical species Dry deposition is strongly influenced by the particle size distribution of the particulate species and by meteorological and surface characteristics The larger the particle, the greater its deposition velocity; however, there is a point where the deposition velocity of smaller particles actually increases because of the effect of turbulence Deposition models calculate a gravitational settling velocity and a deposition velocity for each particle size class. As its name suggests, the gravitational settling velocity accounts for removal of particulate matter due to gravity. This mechanism is only significant for particles in the larger size ranges (i.e., greater than 20 to 30 μm in diameter) because only the larger particles have sufficient mass to overcome turbulent eddies. The deposition velocity accounts for PM removal by all methods, including turbulent motion, which brings the particles into contact with the surface and allows them to be removed by impaction or adsorption at the surface. Wet deposition includes the effect of precipitation scavenging

The "deposition" produced by dispersion models is actually a flux, or the mass of particulate deposited over a square area over a unit of time (e.g., micrograms per meter squared per hour [$\mu g/m^2/hr$]). The magnitude of the deposition flux will directly affect the soil concentration of the pollutant and, consequently, the level of human exposure through direct soil ingestion, plant and animal consumption, and dermal contact with soil. The deposition flux over water bodies (e.g., reservoirs, lakes, and streams) may also affect the level of exposure through human consumption of fish and drinking water.

Deposition modeling requires the definition of particle size categories (typically up to 20 categories may be defined). For each category, the particle diameter, mass fraction, and density are specified. Using as many particle size categories as possible helps ensure that the most representative results are obtained. Generally, definition of these parameters will need to be done on a site-specific basis. Proper source testing provides the best information, however, data previously collected from another site with similar characteristics (e.g., similar soil characteristics) may provide information. In the event site-specific data are not available, the modeler should consult with the EPA Regional Modeler should be committed.

Techniques for evaluating particle deposition are currently being developed by the EPA. Although the ISC2 model allows for deposition estimates to be made, its present algorithm is appropriate for large particles dominated by gravitational settling (i.e., particles with diameters larger than approximately 20 μm) but not for small particles or gaseous pollutants. A draft revision to the deposition algorithm in the ISC2 model (ISCSTDFT) incorporates a new method for estimating deposition velocity and will account for plume depletion by removing mass from the plume as it is deposited on the surface. The net result will be a new method for obtaining dry deposition flux of particulate matter. The model will also include an estimate of wet deposition amount.

In addition to the basic inputs (particle diameter, density, and mass fraction), the improved methodology requires the following site-specific parameters: surface roughness height, displacement height, noon-time albedo, soil moisture availability parameter, fraction of net radiation absorbed by the ground, anthropogenic heat flux, and minimum Monin-Obukhov length. In addition to these parameters and the standard set of meteorological variables, the methodology requires the Monin-Obukhov length and friction velocity. To provide these parameters an additional processor (provided with the model) is required. This processor, the Dry DEPosition METeorological processor (DDEPMET) needs as input a RAMMET output file and NWS surface pressure and cloud cover data in the CD144 format. An additional processor, precipitation merge program (PMERGE) merges hourly precipitation data (amount and type) with the output from DDEPMET to compute wet deposition.

Guidance on determining these values and using DDEPMET will be provided in the user's instructions associated with the new model. Section 5.1.4 of this document may be referred to for guidance on determining surface roughness. In the Air/Superfund National Technical Guidance Study (NTGS) Series document Estimation of Air Impacts for the Excavation of Contaminated Soil[23], a typical value of 2.65 g/cm^3 is presented. Density may be less than 1.0 g/cm^3 for particles from combustion sources such as incinerators.

In the interim, an alternative technique that may be considered for Superfund sites is the gradient-transfer deposition algorithm contained in the Fugitive Dust Model (FDM).[22] The ability to treat both turbulent and gravitational removal mechanisms is a key feature of this model. Sources entered into the model may be point, line, or area sources. Because this model is not designed to compute the impact of buoyant point sources, it will be overly conservative for point sources with significant plume rise.

A unique characteristic of fugitive dust is that its emission rate is often a function of wind speed. In the FDM, emission rates may be defined as varying with wind speed based on a simple power law formula and a threshold wind speed. The same formula can be used to calculate emission rates for use in ISC2

Deposition actually occurs through both dry and wet processes. The emphasis in regulatory model development has been on the dry deposition process. A discussion of wet deposition (also known as precipitation scavenging) can be found in Chapter 11 of Atmospheric Science and Power Production [24]

Another phenomenon that could affect air quality is particle resuspension. Resuspension occurs primarily as a result of mechanical disturbances of the soil, such as vehicular traffic, but is also a function of wind disturbance. Mechanical stresses can raise particles from the ground into the main airstream so that they are more rapidly transported downwind than they would be by general wind resuspension. Variables that affect resuspension include particle, soil, and surface properties, particle-soil interaction, topography, and weather conditions. It may be important to consider the effects of particle resuspension if particle inhalation is of concern. As with wet deposition, particle resuspension has not been emphasized in regulatory model development. Chapter 12 of Atmospheric Science and Power Production[24] provides a general discussion of resuspension rates and factors.

MODEL AVAILABILITY

Source and executable code for regulatory dispersion models can be obtained from the SCRAM BBS This system is part of the OAQPS Technology Transfer Network (TTN), and is managed by the Air Quality Modeling Group, Emissions, Monitoring and Analysis Division of OAQPS Model documentation and other support materials can also be obtained from the SCRAM BBS. Information necessary to connect with the SCRAM BBS is shown in Table 4-1. The TTN help line can be accessed by dialing (919) 541-5384.

TABLE 4-1 SCRAM BBS COMMUNICATION PARAMETERS

Modem Telephone Number	Baud Rates	Line Settings
(919) 541-5742	1200 - 9600, 14.4K	8 data bits no parity 1 stop bit

Model code can also be obtained for a fee through the National Technical Information Service (NTIS), which can be reached at (800) 533-6847, and from private vendors. Private vendors frequently supply interactive or menu-driven data entry programs that can simplify implementation of the more refined models. When purchasing models through NTIS or from private vendors, model users should verify that they are acquiring the most up-to-date versions

SECTION 5

COMPONENTS OF A MODELING ANALYSIS

This section presents various topics that are relevant to any dispersion modeling analysis. Specifically, this section discusses components of a modeling analysis other than those directly pertaining to source characterization, which were discussed in Section 3. This section is designed to give the Superfund modeler an understanding of the integral components of a modeling analysis, and an appreciation for how the treatment of each component directly affects the concentrations that are predicted. The U.S. Environmental Protection Agency (EPA) document Guideline on Air Quality Models (Revised)[1] is the principal source of guidance on the various components of an air dispersion modeling analysis.

METEOROLOGICAL CONSIDERATIONS

Meteorological conditions govern the transport and dispersion of contaminants and, in the case of some fugitive sources, such as lagoons or landfills, can affect the amount of contaminant that becomes airborne. It is important, therefore, to use meteorological data that are representative of the site area and vicinity. A minimum of either one year of on-site data or five years of off-site (NWS) data is required to run refined dispersion models. If long-term risk is an issue, it is desirable to have five or more years of on-site meteorological data to support long-term exposure assessments for refined Air Pathway Assessments (APAs). As stated in the Guideline on Air Quality Models (Revised),[1] a five-year data set should capture the variability in maximum predicted concentration that could occur over a longer time span.

Certain models, such as dense gas release models, are executed on a single set of meteorological conditions. In this situation, meteorological conditions producing worst-case impacts should be determined (see various subsections within this section).

It is recommended that an on-site meteorological monitoring program be initiated immediately after a site is included on the National Priorities List (NPL) if representative data are not available. Even at flat terrain sites where nearby NWS data are available, it is recommended that an on-site meteorological station be installed and operated during the remedial action (RA) phase.

The short-term temporal and spatial variability of wind conditions limits the applicability of off-site meteorological data for real-time decision making (for example, during non-routine air releases)

In the absence of a year of on-site data, if representative, data applicable for use in dispersion modeling may be available from National Weather Service (NWS) stations or stations operated by state meteorological programs. Selected NWS data may be obtained from the Support Center for Regulatory Air Models (SCRAM) electronic Bulletin Board System (BBS) (see Section 4.5) Meteorological data for stations throughout the United States may also be obtained, for a fee, from the National Climatic Data Center in Asheville, North Carolina (for placing an order, call 704/271-4800) Other sources of meteorological data may include nearby universities or military stations. Guidance on determining the representativeness of off-site data can be found in the Guideline on Air Quality Models (Revised)[1] and On-Site Meteorological Program Guidance for Regulatory Modeling Applications.[25]

In general, judgements regarding the representativeness of meteorological data must consider both spatial and temporal dependence. The Superfund site and meteorological observation locations must have similar spatial characteristics with respect to terrain features, land use, and synoptic flow patterns. Further, the meteorological data set must include hourly observations for one year, collected over the four seasons. From a practical standpoint, if NWS data are available and considered representative, NWS data could be used in most applications, because such data are subject to well-defined quality assurance/quality control (QA/QC) programs. The quality of data available from other sources should be evaluated based on EPA guidance.

If representative data are not available, it is recommended that an on-site meteorological monitoring program be initiated immediately after a site is included on the NPL. The meteorological monitoring program should continue throughout the remediation and post-remediation phases. The quality and siting of the meteorological data collected should meet EPA requirements, as outlined in the following technical references: On-Site Meteorological Program Guidance for Regulatory Modeling Applications[25], Quality Assurance for Air Pollution Measurement Systems, Volume IV - Meteorological Measurements[32], and Ambient Air Monitoring Guidelines for Prevention of Significant Deterioration (PSD)[33].

On-Site Meteorological Program Guidance for Regulatory Modeling Applications[25] also contains guidance on processing of meteorological data for dispersion modeling applications. To produce a meteorological data set in the proper format for model input, the EPA has developed the Meteorological Processor for Regulatory Models (MPRM)[26]. This computer program and the associated user's guide are available from the SCRAM BBS.

Wind Speed and Direction

In dispersion modeling, wind speed is used in determining: (1) plume rise, (2) plume dilution, and (3) mass transfer rate into the atmosphere (used mostly in fugitive dust and evaporation rate models). Wind direction is used to approximate the direction of transport of the plume. Most wind data are collected near ground level (the standard height for wind measurement is 10 meters [m]).

The wind speed at release height is frequently determined internally by the dispersion model using a power law equation. As wind speed increases, plume rise decreases, plume dilution increases, and concentration estimates predicted by air dispersion models decrease. However, as speed increases the mass transfer rate also increases (see Section 5.7).

For close-in distances where gravity effects are dominant, dense gas models are less sensitive to increases in wind speed. Under very light wind conditions, dense gas releases tend to form "pancake-shaped" clouds near the source, and the dense cloud may not be very deep until further downwind. At higher wind speeds, the rate of air mixing increases, and the maximum concentrations decrease. For releases from liquid pools, high wind speed increases the rate of evaporation and, thus, the emission rate of the source. However, high wind speed also results in more dilution due to increased entrainment of outside air, which can lead to a lowering of maximum concentrations.

The variability of the direction of transport (i.e., plume meander) over a period of time is a major factor in estimating ground-level concentrations averaged over that time period. Take for example the two "wind roses" shown in Figure 5-1. (The term "wind rose" is commonly used to refer to an illustration depicting the joint frequency of wind speed and direction at some location.)

As shown, the distribution of winds in Case A is relatively symmetrical, especially when compared to that of Case B. Considering wind direction alone, long-term averages predicted with the Case B data set would be greater than those predicted with the Case A data set, due to the strong persistence of wind direction in Case B (which reflects data collected in a mountain valley setting). Wind direction should be estimated from on-site measurements for emergency removal or accidental release analyses For planning analyses, wind direction should be chosen to maximize potential off-site impacts.

Calm wind conditions pose a special problem in model applications because Gaussian models assume that concentration is inversely proportional to wind speed. EPA has developed a procedure to prevent the occurrence of overly conservative concentration estimates during periods of calm wind. This procedure acknowledges that a Gaussian plume model does not apply during calm conditions and that our knowledge of plume behavior and wind patterns during these conditions does not presently permit the development of a better technique[1]. Therefore, the procedure disregards calm hours by using a pre-processor which ignores the calms. The applicable model user's guide should be consulted to ensure that hours of calm wind observation are properly interpreted from the meteorological data set. If calm wind periods are the periods of concern, a nonguideline technique may be used in consultation with the EPA Regional Modeler.

Atmospheric Stability

Dispersion models currently use stability categories as indicators of atmospheric turbulence. Based on the work of Pasquill and Gifford, six stability categories have been defined, where Category A represents extremely unstable conditions and Category F represents moderately stable conditions.[18] Methods for estimating atmospheric stability categories from on-site data are provided in the Guideline on Air Quality Models (Revised)[1] and On-Site Meteorological Program Guidance for Regulatory Modeling Applications.[25]

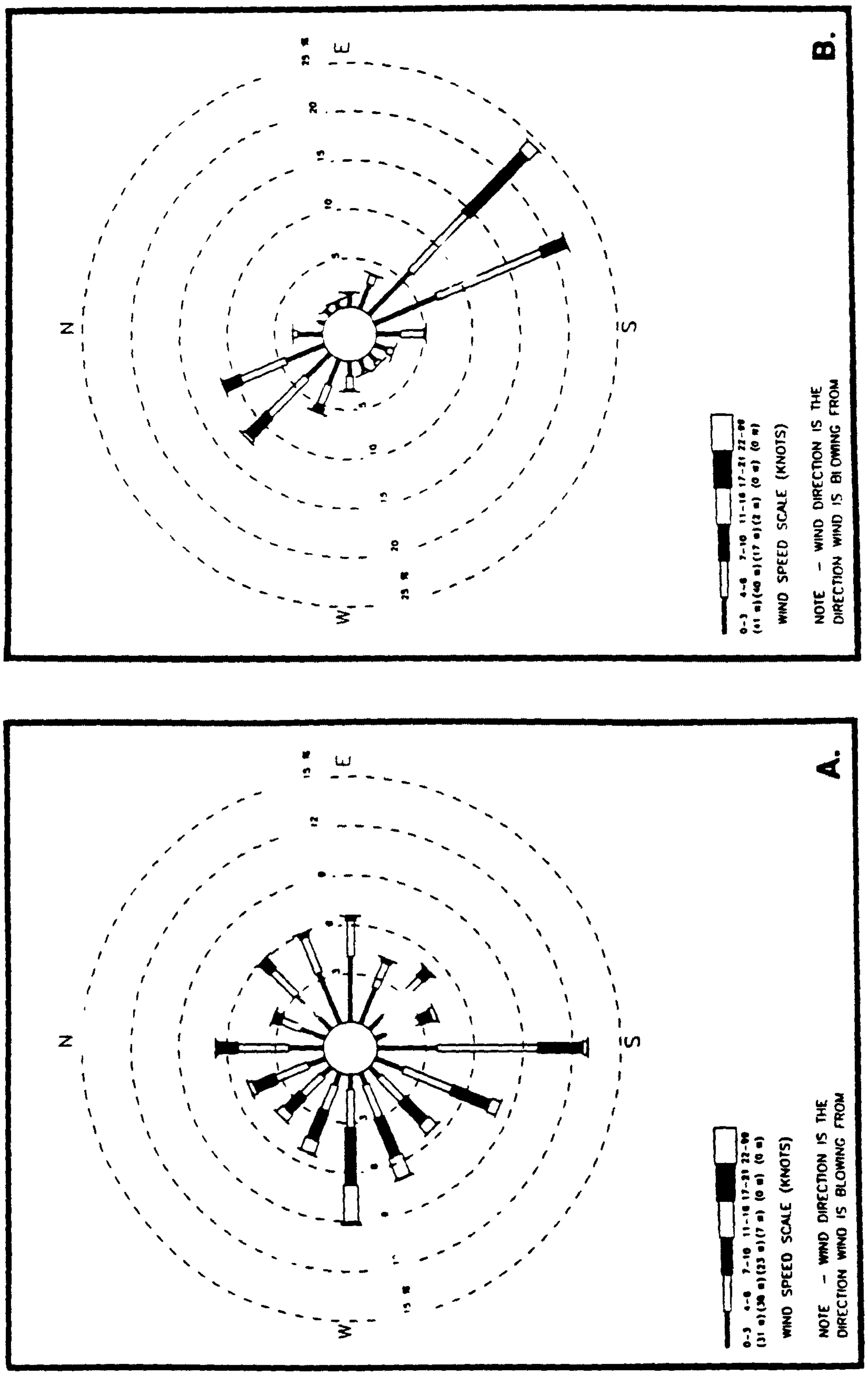


Figure 5-1. Wind Roses Exhibiting Distinct Frequencies of Wind Speed Direction

The amount of turbulence in the atmosphere has a major impact on the rise of stack gas plumes, and upon subsequent plume dispersion by diffusion. Turbulence is a result of many factors, including: windflow over rough terrain, trees, or buildings (mechanical turbulence); rising warm air (thermal turbulence); and migrating high and low pressure air masses. Any factor enhancing the vertical motion of air (either rising or sinking), will increase the amount of turbulence. For a given wind speed, stable atmospheric conditions provide smaller levels of atmospheric turbulence than do unstable conditions, and can lead to higher model-predicted concentrations.

For near-field impacts, dense gas releases will be only weakly sensitive to stability class. As the release becomes neutrally buoyant, the plume is more influenced by atmospheric conditions such as stability class.

Ambient Temperature, Relative Humidity, and Pressure

Ambient temperature is routinely used in dispersion models to calculate the amount of rise of a buoyant plume and to calculate evaporation rates. Relative humidity affects the amount of energy available in the atmosphere for plume entrainment. Atmospheric pressure data are used in calculating gas and liquid release rates from storage and process vessels, and from pipes. Therefore, the emission rate from a container at a high altitude (in Denver, for example) could be different from those of a spill at sea level.

Surface Roughness

The intensity of mechanical turbulence at a site is a function of the surface roughness. Surface roughness, a required input for some models, is characterized by a roughness length, which in principle is a measure of the roughness of a surface over which a fluid (i.e., the air) is flowing. For a homogeneous surface, the value of the surface roughness length is sometimes approximated as 1/10th of the average height of the surface irregularity. When the landscape contains obstructions (i.e., is nonhomogeneous), an effective length must be determined. Typical values of surface roughness length are provided in Table 5-1. In the event of multiple surface roughness surrounding a site, it is most conservative to use the lowest value for modeling.

Mixing Height

The mixing height defines the depth through which pollutants released to the atmosphere are typically mixed by dispersive processes. The mixing height determines the vertical extent of dispersion for releases occurring below that height, and releases occurring above that height are assumed to have no ground-level impact (with the exception of fumigation episodes) Morning and afternoon mixing heights are estimated for selected NWS stations from vertical temperature profiles (otherwise known as upper air data) and surface temperature measurements. Hourly mixing heights for input to dispersion models are derived from the twice-daily values, based on procedures defined by EPA.

For refined dispersion modeling, values of hourly mixing height for selected NWS stations are available on the SCRAM BBS. In general, upper air data from the closest, representative NWS station with topography similar to the site may be used for refined modeling. The EPA Regional Modeler should be contacted to ensure that the appropriate data set is selected.

From a climatological perspective, seasonal and annual average values of morning and afternoon mixing heights are available for selected cities throughout the United States (Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States[27]). Where models require a singular value of mixing height, these values can be used for planning purposes.

TABLE 5-1. REPRESENTATIVE VALUES OF SURFACE ROUGHNESS FOR A UNIFORM DISTRIBUTION OF SELECTED TYPES OF GROUND COVER

Surface	Surface Roughness (meters)
Water	0.1 to 10 0 x 10^{-5}
Ice	0.00001
Snow	0.00005 to 0 0001
Sand	0.0003
Soils	0.001 to 0.01
Short grass	0.003 to 0.01
Long grass	0.04 to 0.10
Agriculture crops	0.04 to 0.20
Deciduous Forest	1.0 to 6.0
Coniferous Forest	1 0 to 6.0

References:

Pielke, R.A., 1984. Mesoscale Meteorological Modeling. Academic Press, Orlando, FL.
Oke, T R., 1978. Boundary Layer Climates. Methuen and Co. New York, Ny.

TERRAIN CONSIDERATIONS

Incorporating the effect of elevated terrain in the vicinity of the site may be significant in situations involving point sources of emissions. This is because with point sources, high impacts can be predicted due to plume impaction on terrain at elevations greater than or equal to plume centerline. Incorporating terrain is generally not a consideration when modeling fugitive releases because these releases are typically neutrally buoyant with no plume rise to consider and, hence, are essentially ground-level releases. Maximum impacts from fugitive releases are thus expected to occur at the nearest downwind location.

The remainder of this subsection discusses terrain considerations as they apply to modeling point sources. As a general note, complex terrain models for regulatory use acknowledge only "unique" features, and do not address the influence of intervening terrain. For example, if a terrain feature, such as a hill, existed between the source location and the receptor location, the model predicted impacts at the receptor location would not have taken the effect of the hill into account In reality, the plume may have impacted on the hill and been diluted or had its trajectory changed before proceeding further downwind.

Because the Gaussian approach used in regulatory dispersion models assumes that the plume has a normal or Gaussian distribution in both the cross-wind and vertical directions, the maximum concentration at any downwind distance would be predicted to be at plume centerline. Introducing receptor elevations for elevated releases can, therefore, increase predicted concentrations by effectively bringing the receptor closer to plume centerline. Whether the maximum concentration for a given analysis will be due to plume impaction will depend on the proximity of the terrain to the source location. Although the phenomenon of plume impaction can produce high concentrations, it may not produce the maximum predicted concentration for an analysis, since sufficient dilution of the plume may have occurred by the time the plume impacts the terrain feature (i.e., the concentration at plume centerline at a given downwind distance may be less than an off-centerline concentration predicted much closer to the source).

The need to incorporate terrain elevations is a common occurrence in point source modeling analyses conducted for regulatory compliance. Over the last few years, much attention has been focused on this aspect of air dispersion modeling within EPA. The term "complex terrain" modeling has evolved, with complex terrain generally defined as terrain exceeding the height of the stack being modeled. Another common term, "rolling terrain," pertains to terrain elevations above stack base elevation, but below stack top elevation. Receptor terrain elevations should be included in any point source analysis, even if the terrain elevations do not exceed that of stack top (as mentioned, elevating a receptor brings it closer to plume centerline, for elevated releases).

As stated in the Guideline on Air Quality Models (Revised)[1] there are currently five complex terrain screening techniques that are acceptable for estimating concentrations due to plume impaction. (1) the Valley Screening Technique (for 24-hour impacts); (2) CTSCREEN, (3) COMPLEX I; (4) SHORTZ/LONGZ; and (5) Rough Terrain Dispersion Model (RTDM). The Valley Screening technique is incorporated in the complex terrain dispersion estimates made by the SCREEN2 and TSCREEN models

The Valley model, COMPLEX I, SHORTZ/LONGZ, and RTDM should only be used to estimate concentrations at receptors whose elevations are greater than or equal to plume, rather than stack height. For receptors whose elevations are at or below stack height (i.e., simple terrain receptors), a simple terrain model should be used. For receptors whose elevations are between stack height and plume height (commonly referred to as intermediate terrain receptors), the estimation of concentrations should be considered on a case-by-case basis with the EPA Regional Modeler.

One technique that is generally acceptable, but not necessarily preferred for any specific application, involves applying both a complex terrain model (except for the Valley model) and a simple terrain model. For each receptor between stack height and plume height, an hour-by-hour comparison of the concentration estimates from both models is made. The higher of the two modeled concentrations should be chosen to represent the impact at that receptor for that hour, and then used to compute the concentration for the appropriate averaging time(s)

The CTSCREEN model presents another technique[28]. CTSCREEN may be used to estimate concentrations at all receptors located on terrain above the stack-top elevation (i.e., in both intermediate and complex terrain, where "intermediate" terrain refers to terrain above stack top, but below plume centerline). CTSCREEN is the screening version of the refined complex terrain model referred to as Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS). No meteorological data are required to execute SCREEN2, TSCREEN, Valley, or CTSCREEN, as these models assume worst-case meteorological conditions. RTDM and SHORTZ/LONGZ require site-specific meteorological data. COMPLEX I requires site-specific meteorological data unless the Valley option is chosen for its simulation. See the Guideline on Air Quality Models (Revised)[1].

For refined complex terrain analyses, the CTDMPLUS model is preferred[29]. CTDMPLUS is applicable to all receptors on terrain elevations above that of stack-top. A simple terrain model and a complex terrain model may also be used in concert to produce the required intermediate terrain concentrations. Meteorological data that are spatially and temporally representative must be used when conducting a refined complex terrain analysis. This essentially requires that the data be collected on site. Where site-specific data are used for either screening or refined complex terrain models, a database of at least one full year of meteorological data is preferred. If more than one year of data is available, it should be used to verify that maximum concentrations have been predicted.

RECEPTOR DEFINITION

In dispersion modeling, receptors are locations where impacts are predicted. A receptor grid or network for a Superfund analysis defines the locations of predicted air concentrations that are used as a part of the APA to assess the effect of contaminant air releases on human health and the environment under various Superfund site activities.

The receptor grid for a Superfund APA should be developed on a case-by-case basis in consultation with the Remedial Program Manager and should be a function of the goals outlined by the Superfund data quality objectives. Various types of receptor grids can be used. Input of the receptor grid is facilitated by some refined models through an option to automatically generate a grid based on some user specifications, such as desired interval spacing. In general, receptor grids are based on either a polar coordinate or Cartesian coordinate system, or a combination of both systems. In the Cartesian system, the X-axis is positive to the east and the Y-axis is positive to the north of a user-defined origin. Specified in this manner, the coordinates are relative to the grid origin. The X and Y coordinates may also be specified in terms of Universal Transverse Mercator (UTM) Coordinates, which effectively removes the concept of a grid origin and allows for each receptor to be readily mapped or identified. The polar receptor grid is based on radial distances measured from the grid origin and an azimuth bearing (angle) measured clockwise from true north

In the polar coordinate system, receptors are usually spaced at 10-degree intervals on concentric rings. Radial distances from the origin are user-selected and are generally set equal to the distances to the expected maximum concentrations of the sources modeled. In the Cartesian system, the X and Y coordinates of the receptors are specified by the user. The spacing of the grid points is not required to be uniform, so that the density of grid points can be greatest in the area of expected maximum concentrations. Examples of a Cartesian and polar receptor grid are shown in Figure 5-2.

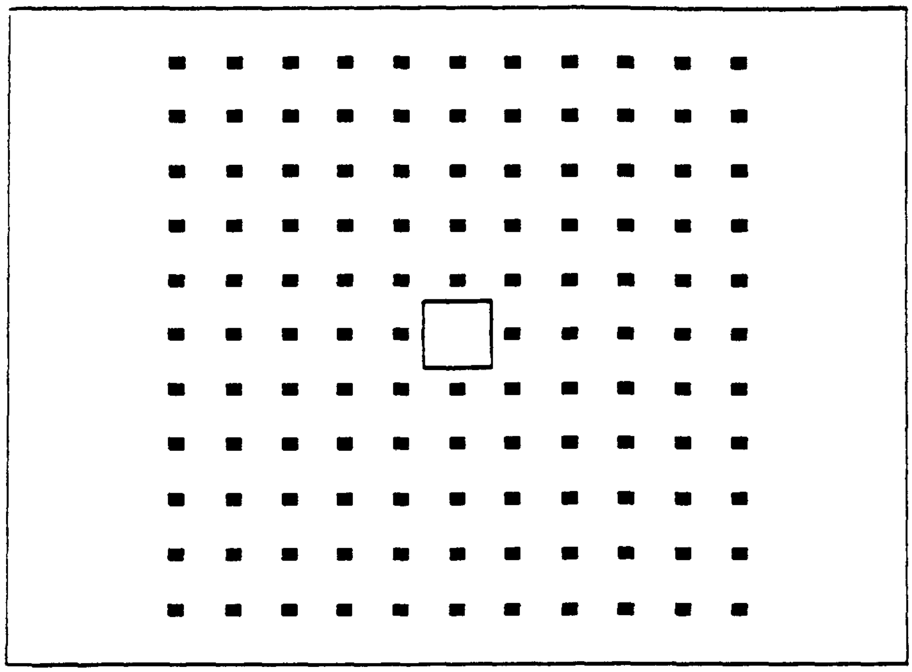
To establish the location of maximum concentration, two levels of receptor grids are commonly used in a refined modeling analysis. A first-level, or "screening-level," grid generally comprises a moderate number of receptors located uniformly in all directions from the source. Typically, this screening-level grid is centered on a prominent source or feature (e.g., a water tower) located within the site boundary. A second-level, or "refined," grid comprising receptors more densely located, is then modeled to pinpoint maximum concentrations based on the results obtained by using the screening-level grid. This refined grid is typically centered on areas of maximum impact defined by the screening-level grid.

From a geographical perspective, receptors should be located along the site boundary and in the surrounding area off site. The minimum distance to off-site receptors is usually defined by the property boundary or fence line. Receptors should be located at, and within, a far enough distance from the source to ensure that the maximum concentration is identified. A receptor network extends an adequate distance from the source if one can observe, from the model results, that impacts reach a maximum at some distance and then diminish with further distance from the source. To isolate maximum impacts, the emphasis should be placed on receptor resolution and location, and not on the total number of receptors modeled.

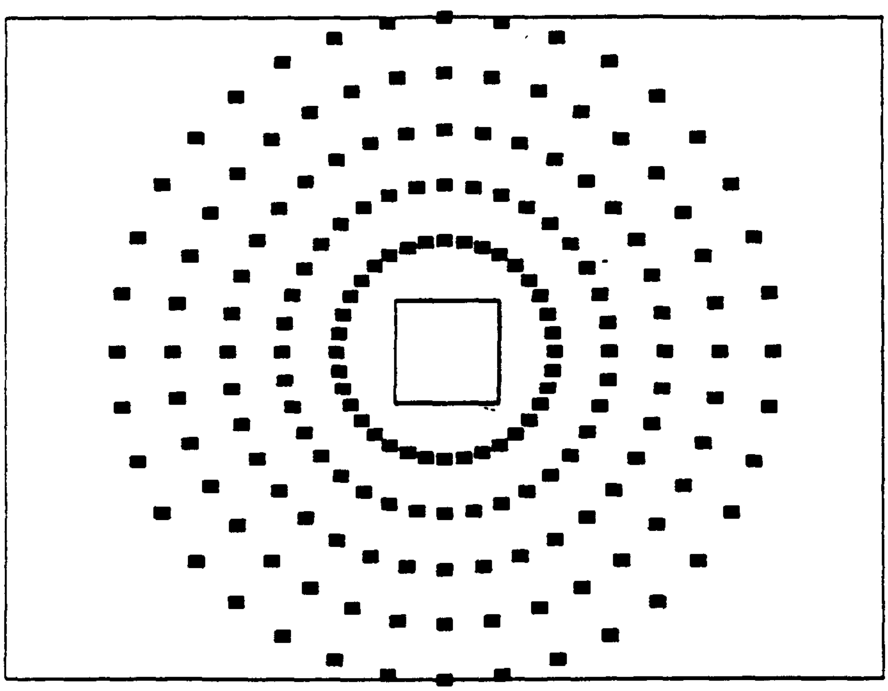
For the purposes of conducting a Superfund APA, specific receptor locations are also of interest. All "sensitive" receptor locations within a given distance (e.g., 10 kilometers [km]) of the site, and individual residences and other habitations near the site (e.g., within 1 km) should be identified. Sensitive receptor locations include schools, work areas, and hospitals associated with sensitive population segments, as well as locations where sensitive environmental flora and fauna exist, including parks, monuments, and forests. Receptors may also be placed at the work areas on the site and at the locations of air monitoring stations, so that comparison of predicted and monitored concentrations can be made. For input to a risk assessment, it may also be necessary to place receptors within areas relating to specific exposure pathways, such as waterbodies, dairy farms, playgrounds, and so forth.

Receptor placement requires special attention when modeling in complex terrain. In such cases, highest pollutant concentrations are often predicted to occur under very stable atmospheric conditions, when the plume is near, or impinges on, the terrain. Under these conditions, the plume may be quite narrow in the vertical, so that even relatively small changes in a receptor's elevation may make a substantial change in the predicted air pollutant concentrations. Terrain heights should be entered for each receptor and, as described below, each receptor distance should be entered, if the site is located in an area of rolling or complex terrain.

Certain screening-level models, such as TSCREEN, estimate the maximum impacts irrespective of direction from the source. Therefore, receptors are simply expressed in terms of distances considered to be downwind of the source. At a minimum, the user must specify the nearest and farthest receptor distances at which air pollutant concentrations are to be predicted. The model will then automatically calculate impacts at distances within that range, and will interpolate to find the maximum value and associated distance. The farthest distance should be set sufficiently large to ensure that the maximum concentration is identified.



A. Cartesian Receptor Grid



B. Polar Receptor Grid

Figure 5-2. Examples of Cartesian and Polar Receptor Grids

From a practical standpoint, most Superfund sources involve ground-level releases. Only a few sources are elevated, and even these can be classified as low-level, elevated sources. Examples include on-site treatment facilities involving incinerators and/or air strippers. This implies that, for most Superfund releases, the highest pollutant concentrations will occur at short distances from the source. Depending on the source configuration and the release height, such concentrations will occur very close to the source (i.e. 1 to 2 km).

In determining what terrain height to enter into the model for each downwind distance, the user should be sensitive to the source plume height. (A quick determination of plume height can be made by executing the SCREEN2 or TSCREEN models with a hypothetical receptor above stack top. The final stable plume height is then provided in the complex terrain portion of the model output for SCREEN2, or in a data entry screen for TSCREEN.) At each downwind distance, the terrain height closest to the plume height should be entered to estimate worst-case impacts.

Concentration averaging times should be a factor in establishing the receptor grid, based on APA objectives. For short-term averaging times (up to 24 hours), the selection of receptors should be based on the objective of protecting public health and the environment at all publicly accessible areas around the Superfund site. In this respect, the receptor grid should include locations of anticipated maximum concentrations off site. For long-term averaging times (e.g., monthly, seasonally, annually, 70 years), concentrations should be predicted at actual receptor locations (i.e., in areas surrounding residences and work places, and at locations with environmentally sensitive species).

URBAN/RURAL CLASSIFICATION

For the purpose of dispersion modeling, sites are classified as being in a predominantly "urban" or "rural" area. This determination is typically based on the land use in the area surrounding the site to be modeled. The Guideline on Air Quality Models (Revised)[1] and Auer[30] provide guidance on appropriate land use classification procedures. In general, the determination of whether the area should be classified as urban or rural begins by estimating the percentages of urban and rural land use types that occur within 3 km of the site Table 5-2 lists common land use types and their urban or rural designation. Zoning maps, U S Geological Survey (USGS) topographic maps (1:24,000 scale), or aerial photographs of the area surrounding the site typically provide the basis for distinguishing what land use types exist As stated in the Guideline on Air Quality Models (Revised)[1], if land use types I1, I2, C1, R2, and R3 account for 50 percent or more of the total area (within 3 km of the source), then the site is classified as urban for modeling purposes, otherwise, it is classified as rural Table 5-2 provides classification of land use types

Delineation of urban and rural land use types can be difficult for the residential-type areas listed in Table 5-2 The degree of resolution for residential areas can often not be identified without conducting an inspection of the site area. This process can be greatly streamlined for many applications, without lessening confidence in the selection of the appropriate classification. The fundamental simplifying assumption is that many applications will have a definite urban or rural designation based on review of the relevant USGS topographic maps, zoning maps, or aerial photographs.

Sources located in an area classified as urban should be modeled using urban dispersion coefficients, while sources located in an area classified as rural should be modeled using rural dispersion coefficients The general effect of an *urban* area is to create enough additional turbulence, due to the buildings and urban "heat island," to enhance plume dispersion. Some models, such as SCREEN2, TSCREEN, and the Industrial Source Complex Models (ISC2), incorporate both urban and rural dispersion coefficients (the model user simply specifies which applies). Other models, particularly those addressing complex terrain, generally accommodate one land use classification or the other.

PLUME DOWNWASH

Air quality modeling of point sources with stack heights that are less than good engineering practice (GEP) stack height should consider the impacts associated with building wake effects. Building wake effects are not considered for area or volume sources. Incorporating building downwash for stacks with heights less than GEP will increase model-predicted concentrations As defined by Title 40 of the Code of Federal Regulations (CFR) Section 51.100, GEP height is calculated as:

$$GEP = H_b + 1.5L$$

where H_b is the building height and L is the lesser of the building height or maximum projected width. This formula defines the stack height at which building wake effects on the stack gas exhaust may be considered insignificant.

A building or structure is considered sufficiently close to a stack to cause wake effects when the minimum distance between the stack and the building is less than or equal to five times the lesser of the height or projected width of the building (5L). This distance is commonly referred to as the building's "region of influence." If the source, for example an air stripper, is located near more than one building, each building/stack configuration must be assessed separately.

Note that building projected width is required. This means that the apparent width of building must be determined. The apparent width is the width as seen from the source looking towards either the wind direction or the direction of interest. For example, ISC requires the apparent building widths (and heights) for up to every 10 degrees of azimuth around each source.

TABLE 5-2 CLASSIFICATION OF LAND USE TYPES.

Type	Description	Urban or Rural Designation
I1	Heavy Industrial	Urban
I2	Light/Moderate Industrial	Urban
C1	Commercial	Urban
R1	Common Residential (Normal Easements)	Rural
R2	Compact Residential (Single Family)	Urban
R3	Compact Residential (Multi-Family)	Urban
R4	Estate Residential (Multi-Acre Plots)	Rural
A1	Metropolitan Natural	Rural
A2	Agricultural	Rural
A3	Undeveloped (Grasses/Weeds)	Rural
A4	Undeveloped (Heavily Wooded)	Rural
A5	Water Surfaces	Rural

References:

EPA. Guideline on Air Quality Models (Revised). EPA-450/2-78-027. Office of Air Quality Planning and Standards. Research Triangle Park. North Carolina. July 1986

Auer. August H. Jr.. "Correlation of Use and Cover with Meteorological Anomalies." Journal of Applied Meteorology. pp. 636-643. 1978.

To account for downwash, the SCREEN2 and TSCREEN models require input of a building (structure) height and the respective maximum and minimum horizontal dimensions. Generally, to evaluate the greatest downwash effects for each source, the building with dimensions that result in the highest GEP stack height for that source should be modeled.

The ISC2 models also contain algorithms for determining the impact of plume downwash on ambient concentration, and should be used for determining refined concentration estimates. Methods and procedures for determining the appropriate inputs to account for downwash are discussed in the Guidelines for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations) (Revised).[31] Due to the complexity of GEP guidance, the EPA has developed a computer program for calculating downwash related inputs for the ISC models. This program, called Building Profile Input Program (BPIP) is available from the SCRAM BBS. BPIP helps clarify GEP and building downwash guidance and should be applied in consultation with the EPA Regional Modeler.

AVERAGING TIME CONSIDERATIONS

Superfund sites often contain a complex mixture of contaminants. The potential adverse health effects vary from compound to compound, and the health-based action levels may vary by orders of magnitude between compounds with relatively similar structures and physical properties. Therefore, the most significant compounds at the site, from a health risk standpoint, may not necessarily be those compounds present in the highest concentrations in the soil or water.

Action levels are based on health or environmental risk values. The averaging-time periods that the action levels should address depend on a number of factors. Action levels associated with the work areas are designed to protect the health of on-site workers, whereas action levels associated with the exclusion area or fence line and beyond are designed to protect the surrounding populace and environment.

Several averaging periods may be of interest for any given analysis, including instantaneous, 15-minute, 1-hour, 24-hour, monthly, and annual. The averaging periods to evaluate will depend on the time periods of the applicable action levels. The choice of time periods will also depend on the specific compounds present and their associated health effects. The compounds addressed by the action levels will typically be a subset of the contaminants present at the site. Risk assessments for the air pathway usually indicate that relatively few compounds account for the great majority of the risk. The compounds requiring action levels are those compounds, present in significant quantities, that have high toxicity or a high degree of hazard, and that are capable of being released to the atmosphere.

Several categories of action levels may be necessary, depending on the compounds of interest, the operating life of the source, the type of emission sources, and the potentially exposed population. Categories of action levels used most often are long-term (annual) action levels for carcinogens and non-carcinogens, and short-term action levels for acute toxins The EPA Regional Toxicologist is the best source of technical guidance on determining the appropriate averaging periods for the contaminants at a particular site

Many hazardous air pollutant release models are designed to provide concentration predictions for unit averaging times ranging from 1 second (instantaneous) to 1 hour. This is because the concern for hazardous air pollutants may be explosions (where an instantaneous concentration may be sufficient for ignition) or short term exposures which can lead to acute effects. By contrast, the regulatory models typically used for air quality analyses have a basic averaging time of 1 hour for concentration estimates.

To derive impacts for other averaging periods such as 3-hour, 8-hour, 24-hour and annual, screening-level models such as TSCREEN and SCREEN2, use time scaling factors. These time scaling factors account for the variability in meteorological conditions that may occur over the longer time period. Concentrations for various averaging periods can be automatically calculated with refined models, given their use of site-specific meteorological data.

WORST-CASE IMPACT DETERMINATION

Establishing the characteristics of a release that maximize the predicted concentration is what is commonly referred to as determining the "worst-case" impact. It is important to characterize the worst case impact in order to establish the upper bound of potential exposure Further, since accidental releases, such as the puncture of a buried drum or gas cylinder, can occur at any time, it is important to have an understanding of what the worst impact of these releases could be in order to be as prepared as possible in the event such a release occurs.

It is also important to understand that what constitutes worst-case conditions is really a function of the impact of concern Conditions producing the maximum concentration may not necessarily be the same conditions causing the most people to be exposed. This is because maximum impacts will result from minimal spatial dispersion of the released pollutant.

To determine a worst-case impact, one should consider situations that provide the most effective emissions release rate and the meteorological conditions that produce the worst dispersion. For most releases, the most effective release rate is equal to the maximum release rate. The maximum release rate should be defined for each source and for each averaging period modeled. Often the maximum, annualized emission rate for a source will be less than the maximum short-term rate, reflecting the fact that emissions are not occurring continuously over the long-term. The more continuous, as opposed to intermittent, the emissions are, or can be assumed to be, the higher the rate that should be modeled to predict worst-case impacts. For fugitive sources, emissions are a function of the spatial extent of the source. Characterizing worst-case impacts for these sources would involve modeling the maximum area that may be exposed at any given time, especially for determining all short-term impacts.

Meteorological conditions that produce the worst dispersion for ground-level releases are those associated with very stable atmospheric conditions and low wind speeds (on the order of 2 meters per second [m/s]); these conditions normally give poor dispersion. For elevated, buoyant eleases, an unstable atmosphere may result in the maximum concentration predictions, because an unstable atmosphere can mix the plume to the ground at higher concentrations than would a stable atmosphere. For other releases, multiple stability classes and wind speeds need to be modeled to determine the meteorological conditions producing the worst dispersion

Specifying the worst-case conditions is not a simple matter because the same variable can have conflicting influences For example, high wind speeds can lead to high fugitive dust emission rates and high evaporative rates from surface lagoons. However, high wind speeds are also associated with enhanced dispersion (for models that take wind speed into account in determining dispersion, but are executed with a "fixed" emission rate, concentration impacts can be lower during high winds, and higher during low winds). The relationship between ambient temperature and worst-case predicted impact is more straightforward, as higher ambient temperatures tend to result in higher emission rates of volatiles and an increase in the difference between ambient and release temperatures (leading to a tendency for the release to behave as a denser-than-air release). A denser-than-air release can lead to higher ground-level concentrations, especially at near field receptors. If a higher ground level temperature is given but the model uses it to increase the vertical temperature gradient, the turbulence and therefore dispersion will increase. These are only a few examples of counteracting effects for single parameters which must be taken into consideration when determining worst-case conditions.

For models executed with a complete year of meteorological data, establishing the worst-case impact is usually a matter of evaluating and executing different source characterizations, because the presumption is that the meteorological data set will contain conditions producing the worst dispersion. To ensure that meteorological conditions producing the worst dispersion are adequately represented, as many years of representative meteorological data as are available should be modeled (generally a five-year period should be adequate).

BACKGROUND CONCENTRATIONS

It is not uncommon for Superfund sites to be located in industrial areas. In such cases, it is important to assess the cumulative impact of toxic air pollutants that the site and existing industry have in common. Establishing the "background" pollutant concentrations due to other existing sources allows for the incremental impact of the Superfund site activities to be determined. Background concentrations may also be important when considering ARARs such as PSD or NSR.

Implementing an air monitoring program in the vicinity of a Superfund site could provide the necessary information on existing background air quality levels if:

1) the air monitoring network was designed and implemented following procedures similar to the guidelines provided in Volume IV of this series[6]; and

2) the network monitored the pollutants of interest at the Superfund site.

Background air quality data could be obtained from previous air monitoring programs conducted in the site vicinity. In areas where there are large sources of toxic air pollutants close to the Superfund site, a estimation of background concentrations can be obtained through dispersion modeling of these sources. The Guideline on Air Quality Models (Revised)[1] provides guidance on determining background concentrations.

SECTION 6

ASSESSMENT OF MODEL RESULTS

Modeling results need to be summarized and evaluated to provide input to the site-specific Air Pathway Assessment (APA) and the Superfund decision-making process. The output of the dispersion modeling should be summarized together with the pertinent source and meteorological data to serve as a basis for evaluating the results. In addition, interpretation of dispersion modeling results should account for other factors such as complex terrain, multiple sources, and noncontinuous releases. This process is invaluable, because examining the output will help reveal whether the model was executed properly, and whether the results make sense compared to the inputs used and the model's simulation of reality. The ideas presented in this section will help the modeler to understand the model results, and to view the results from a more learned perspective. Risk assessment philosophy or considerations are not addressed in this manual; the reader should refer to other Superfund documents that deal specifically with that subject.

SUMMARIZING MODEL INPUT AND OUTPUT

To understand the model results, it is useful to make some initial summaries of the output. The output from dispersion models is given in tabular form. These data must be summarized in a format that is useful both for data evaluation and for presenting the conclusions of the modeling for the specific APA application. Examples of recommended tabular data summaries include:

- Maximum short-term and long-term average concentrations predicted off site;
- Maximum concentrations at any sensitive receptor locations;
- Source-specific contributions to the maximum predicted values (for sites with multiple air release sources);
- Maximum deposition, if modeled, to soil and water bodies;
- Summaries of any predicted model versus measured values; and
- Chemical-specific applicable or relevant and appropriate requirements (ARARs) and health effects data.

An example of a simple summary table is shown in Table 6-1. This same format could be applied to show individual source maximum impacts and their corresponding locations. A column could also be added to show the percent contributions of the individual sources to the maximum predicted concentrations for the total site.

TABLE 6-1.

EXAMPLE SUMMARY TABLE OF MAXIMUM PREDICTED IMPACTS

Pollutant	Averaging Period	Maximum Impact ($\mu g/m^3$)	Maximum Impact Location		Action Levels ($\mu g/m^3$)
			UTM-E (m)	UTM-N (m)	
Chloroform	1-hour Annual	1,050 0.040	696000 696200	5068000 5068000	98 0.043
1,1,1-Trichloroethane	1-hour Annual	11,600 25	696100 696300	5068100 5068100	19,000 1,000
Trichloroethylene	1-hour Annual	2,100 0.420	696100 696300	5068100 5068100	2,690 0.59

Note: All values shown are for illustration only

It is also extremely useful to present the results graphically. This is easily accomplished by plotting concentration contours (i.e., isopleths) for the various pollutant averaging periods modeled. Since each contour represents a user-specified concentration (or deposition flux), each contour demarcates the spatial extent of that impact. Plots can be generated using specialized mapping software or an integrated modeling/plotting software package. In particular, contour plots of annual average concentration should show a correlation with the annual wind rose of the meteorological data modeled (it would be easy to match for example, the respective contour plots with the wind roses shown in Section 5).

Summaries of the meteorological data should also be made. The following present useful information:

- Annual wind rose;
- Daytime wind rose (atmospheric stability classes A-D),
- Nighttime wind rose (atmospheric stability classes E and F);
- Tabular summaries of means, minimums, and maximums of the variables modeled; and
- Summaries of percent data capture for each variable.

Statistical summaries for the meteorological data should be presented on a monthly, seasonal, and annual basis, as well as for the entire period modeled. For sites with diurnal wind patterns (e.g., mountain valley or coastal areas), the modeling should include separate wind roses for daytime and nighttime conditions.

Summaries of the source input, together with those of the meteorological data, are useful in interpreting the magnitude and locations of maximum impact. The following illustrations and tables are suggested:

- Map showing source locations and locations of maximum exposed individuals (MEIs);
- Source roster, categorized by pollutant; and
- Source physical characteristics modeled.

TOPICS FOR CONSIDERATION

In situations where multiple sources are being modeled, it is important to consider the source-specific contributions to the predicted concentrations. For example, remediation sources may involve soil-handling activities and an air stripper, with maximum impacts dominated by the soil-handling operations. This information is important to determining which emission controls will be most effective in reducing maximum concentrations to acceptable levels.

In the event predicted concentrations exceed acceptable levels, it is important to first ensure that the model inputs were correctly determined, and that the model options selected were appropriate. Further, any previously made assumptions should be reconsidered, particularly with respect to source emission rates or release parameters, as well as the determination of model selection. The merit of having prepared, and received approval for a modeling plan will manifest itself at this point, as it will narrow the range of potential modeling aspects to investigate.

Predicted concentrations may also be compared with ambient air monitoring data to assess the accuracy of the model predictions. This would involve executing the model with the actual meteorological conditions occurring during the air quality sampling. The short-term monitored concentrations could then be compared with the short-term model predictions for the same time period. Statistical measures to use in comparing the monitored and modeled data sets can be established through consultation with the Regional Modeler.

The results of the modeling analysis should be tailored to the needs and requirements of the APA. The level of required detail in the model output will certainly be a function of the pollutants involved, the magnitude of emissions, and other site-specific concerns. Understanding the model uncertainties will provide a good basis for developing the appropriate model output.

MODEL UNCERTAINTY

The accuracy of model estimates varies with the model used, the type of application, and site-specific characteristics. According to the Guideline on Air Quality Models (Revised)[1], studies of model accuracy have confirmed that (1) models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and (2) the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of ± 10 to 40 percent are typical (i.e., well within the factor-of-two accuracy that has long been reported for these models). However, estimates of concentrations that occur at a specific time and site are poorly correlated with actually observed concentrations, and are much less reliable.

Poor correlations between paired concentrations at fixed stations may be due to "reducible" uncertainties in knowledge of the precise plume location, and to unquantified, inherent uncertainties. For example, apart from data input errors, maximum ground-level concentrations at a given hour for a point source in flat terrain could be in error by 50 percent due to these uncertainties. Uncertainty of five to ten degrees in the measured wind direction, which transports the plume, can result in concentration errors of twenty to seventy percent for a particular time and location, depending on stability and station location Such uncertainties do not indicate that an estimated concentration does not occur, only that the precise time and locations are in doubt.

In light of model uncertainties, the recommended approach is to consider maximum concentrations predicted off site as controlling concentrations irrespective of whether the maximum receptor coincides with an inhabited location This is particularly important for short-term (i.e., 24-hour or less) concentrations. For long-term concentrations, the location of maximum impact in relation to residences or inhabited areas can be considered on a case-by-case basis as a factor in evaluating model results. For predicting impacts in specific areas of interest (e.g., waterways, residential communities) use of multiple receptors to characterize impact is recommended.

Because the technical information on measures of model uncertainty most relevant in decision making is incomplete, no specific guidance on the consideration of model uncertainty in decision making is presently issued. As procedures for considering uncertainty develop and are implemented, this guidance will be revised. In the meantime, it is acceptable to consider model results as a "best estimate."

SECTION 7

REFERENCES

1. U.S Environmental Protection Agency, 1986. Guideline on Air Quality Models. (Revised) EPA-450/2-78-027R, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina

2. U.S Environmental Protection Agency, 1989 Procedures for Conducting Air Pathway Analyses for Superfund Activities, Interim Final Document: Volume IV - Procedures for Dispersion Modeling and Air Monitoring for Superfund Air Pathway Analyses. EPA-450/1-89-004 (NTIS PB90-113382/AS)

3. Air/Superfund National Technical Guidance Study Series, 1992. Procedures for Conducting Air Pathway Analyses for Superfund Activities, Interim Final Document: Volume I - Overview of Air Pathway Assessments for Superfund Sites (Revised). EPA-450/1-89-001a.

4. Air/Superfund National Technical Guidance Study Series, 1990. Procedures for Conducting Air Pathway Analyses for Superfund Activities, Interim Final Document: Volume II - Estimation of Baseline Air Emissions at Superfund Sites (Revised). EPA-450/1-89-002a (NTIS PB90-270588).

5. Air/Superfund National Technical Guidance Study Series, 1989. Procedures for Conducting Air Pathway Analyses for Superfund Activities, Interim Final Document: Volume III - Estimation of Air Emissions from Cleanup Activities at Superfund Sites. EPA-450/1-89-003 (NTIS PB89-180061/AS).

6. Air/Superfund National Technical Guidance Study Series, 1993. Procedures for Conducting Air Pathway Analyses for Superfund Activities, Interim Final Document: Volume IV - Guidance for Ambient Air Monitoring at Superfund Sites. EPA-451/R-93-007 (NTIS PB93-199214).

7 Air/Superfund National Technical Guidance Study Series, 1993. *Models for Estimating Air Emission Rates from Superfund Remedial Actions*. EPA-451/R-93-001 Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

8. U.S. Environmental Protection Agency, 1989. *Review and Evaluation of Area Source Dispersion Algorithms for Emission Sources at Superfund Sites*. EPA-450/4-89-020. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina

9. U.S. Environmental Protection Agency, 1992 *User's Guide for the Industrial Source Complex (ISC2) Dispersion Models, Volume I - User Instructions* EPA-450/4-92-008a Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

10. U.S Environmental Protection Agency, 1994. *User's Guide to TSCREEN, A Model for Screening Toxic Air Pollutant Concentrations (Revised).* EPA-454/3-94-023. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

11. U.S. Environmental Protection Agency, 1993. *Contingency Analysis Modeling for Superfund Sites and Other Sources* EPA-454/R-93-001 Office of Air Quality Planning and Standards, Office of Air and Radiation, Research Triangle Park, North Carolina.

12. U.S. Environmental Protection Agency, 1993. *Guidance on the Application of Refined Dispersion Models to Hazardous/Toxic Air Pollutant Releases*. EPA-454/R-93-002. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina

13. U.S. Environmental Protection Agency, 1992. *SCREEN2 Model User's Guide*. EPA-450/4-92-006. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

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

15 U.S Environmental Protection Agency, 1992 Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants (Revised). EPA-454/R-92-024. Office of Air Quality Planning and Standards, Office of Air and Radiation, Research Triangle Park, North Carolina.

16. U.S Environmental Protection Agency, 1993. A Tiered Modeling Approach For Assessing the Risks Due to Sources of Hazardous Air Pollutants. EPA-450/4-92-001 Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina

17 U S. Environmental Protection Agency, 1992. Guideline for Predictive Baseline Emissions Estimation Procedures for Superfund Sites EPA-450/1-92-002.

18. F. Pasquill and F.B. Smith. Atmospheric Diffusion. Third Edition John Wiley and Sons, New York, NY., 1983.

19 U.S Environmental Protection Agency, 1978 User's Guide for RAM. EPA-600/8-78-016, Volumes A, B, and C. Research Triangle Park, North Carolina.

20. U.S. Environmental Protection Agency, 1993. Air/Superfund National Technical Guidance Study Series. Estimation of Air Impacts from Area Sources of Particulate Matter Emissions at Superfund Sites. EPA-451/R-93-004. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

21. U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, Volume 1. Stationary Point and Area Sources, Fourth Edition. EPA AP-42. Chapter 11 2 Fugitive Sources. Research Triangle Park, NC

22. Winges, K., et al. User's Guide for the Fugitive Dust Model (FDM) (Revised). EPA-910/9-88-202R, 1992.

23. U.S. Environmental Protection Agency, 1992. Estimation of Air Impacts for the Excavation of Contaminated Soil. EPA-450/1-92-004.

24. U.S. Department of Energy, 1984 Atmospheric Science and Power Production DOE/TIC-27601. (DE84005177).

25. U S. Environmental Protection Agency, 1993. On-Site Meteorological Program Guidance for Regulatory Modeling Applications. EPA-450/4-87-013. Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina

26 U S. Environmental Protection Agency, 1988. Meteorological Processor for Regulatory Models (MPRM 1 2) User's Guide. EPA-600/3-88/043R. Research Triangle Park, NC (NTIS No PB 89-127526)

27 U.S.Envir nmental Protection Agency, 1972. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States Office of Air Programs, Research Triangle Park, North Carolina.

28. U.S. Environmental Protection Agency, 1990. User's Guide to CTDMPLUS: Volume 2 The Screening Mode (CTSCREEN). EPA-600/8-90-087. Research Triangle Park, NC. (NTIS No. PB 91-136564).

29. U.S. Environmental Protection Agency, 1989. User's Guide to the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS) Volume 1: Model Description and User Instructions. EPA-600/8-89-041. Research Triangle Park, NC. (NTIS No. PB 89-181424).

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

31. U.S. Environmental Protection Agency, 1985 Guidelines for Determination of Good Engineering Practice Stack Height (Technical Support Documentation for the Stack Height Regulations) (Revised). EPA-450/4-80-023R.

32. U.S. Environmental Protection Agency, 1989. Quality Assurance for Air Pollution Measurement Systems, Volume IV - Meteorological Measurements. EPA 600/4-82-060R. Office of Research and Development. Research Triangle Park, NC.

33. U S. Environmental Protection Agency. 1987. Ambient Air Monitoring Guidelines for Prevention of Significant Deterioration (PSD). EPA 450/4-87-007. Office of Air Quality Planning and Standards. Research Triangle Park, NC. (NTIS No. PB 90-168030).

34 U S Environmental Protection Agency. 1989. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) EPA 540/1-89/002 Office of Emergency and Remdial Response. Washington DC.

35. U.S Environmental Protection Agency. 1991. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part B. Development of Risk-based Preliminary Goals) - Interim EPA 9285 7-01B Office of Emergency and Remdial Response. Washington DC

36. U.S. Environmental Protection Agency. 1991. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part C. Risk Evaluation of Remedial Alternatives) - Interim. EPA 9285 7-01C Office of Emergency and Remedial Response. Washington DC

37. U S Environmental Protection Agency. 1990. National Oil and Hazardous Substances Pollution Contingency Plan (NCP). 40 CFR Part 300. Volume 55. No. 46.

38. 40 CFR Part 302. Table 302 4 or U.S. Environmental Protection Agency. 1991. Title III List of Lists. EPA 560/4-91-011

39. U.S. Environmental Protection Agency, 1992. Guideline for Predictive Baseline Emissions Estimation Procedures for Superfund Sites. EPA-450/1-92-002. Office of Air Quality Planning and Standards. Research Triangle Park, NC.

APPENDIX A

CASE EXAMPLE

APPENDIX A
CASE EXAMPLE

This case example illustrates how the concepts presented in this manual can be implemented to fulfill an air dispersion modeling analysis at a Superfund site. For easy reference, it is organized to parallel the flow of the manual. This example is meant to emphasize, in a systematic manner, modeling methodology and input development. Any final determination on the acceptability of predicted impacts is, therefore, beyond the scope of this discussion. Finally, because the case described is hypothetical, the example is naturally not applicable to all situations. This case example draws from the case example published in the Air/Superfund NTGS document Screening Procedures for Estimating the Air Impacts of Incineration at Superfund Sites, EPA-450/1-92-003, NTIS PB92-171917.

SITE DESCRIPTION

The hypothetical Superfund site in this example is a 15-acre abandoned waste site once used by local industries The site is located on the outskirts of an urban area, and is within 3 kilometers (km) to the west of a small recreational lake that is a popular local fishing spot. Terrain within the site is relatively flat, and becomes more gently rolling in the surrounding area. Low foothills of a distant mountain range are a significant feature of the landscape within 10 km to the north of the site.

General site activities planned during the pre-remediation phase of the project included collection of historical operations data that might shed light on the nature and spatial distribution of the contamination, followed by soil sampling during the site inspection to establish what compounds were actually present. To support dispersion modeling, a meteorological monitoring program was also initiated.

Air dispersion modeling conducted during the pre-remediation phase was used to support the siting of an ambient air monitoring (AAM) stations. AAM data was collected prior to the start of remediation activities to provide baseline air quality information for the site.

During the remediation phase, further modeling was conducted to support the development of the Record of Decision (ROD) and remedial design (RD). AAM monitoring was continued through the remedial action (RA) to provide direct exposure assessment, and to provide data for comparison with the dispersion modeling results.

NATURE OF CONTAMINATION

In the past, the site was used to bury, dump, and store industrial wastes such as paint sludges, solvents, oils and greases, phenols, and heavy metals. The area requiring remediation consisted of a dry surface impoundment containing approximately 60,000 tons of soil contaminated primarily with polychlorinated biphenyls (PCBs) and lead. Sampling data collected during the site inspection indicated the presence of the compounds listed in Table A-1. The concentrations are in ppm by weight. The value of ppm-wt is the same as $\mu g/g$. The organic compounds were split into three groups for modeling. These groups were PCBs, Dioxins (TCDD and TCDF), and Total Hydrocarbons (THC) (all other organics). Potential exposure to each of these groups during the RA was addressed in the modeling analysis. In addition, the impact of particulate matter emissions was also determined, since particulate matter with a diameter less than 10 micrometers (PM_{10}) is a criteria pollutant.

TABLE A-1 CONTAMINANTS PRESENT IN SOIL SAMPLE.

Organics	
COMPOUND	**CONCENTRATION (ppm-wt)**
Acetone	37
Benzene	5
Bis(2-ethylhexyl)phthalate	50
Carbon Disulfide	3
Methyl Ethyl Ketone	47
Methylene Chloride	160
Polychlorinated Biphenyls (PCBs)	272
Phenol	28
Tetrachlorodibenzo-p-dioxin (TCDD)	0.06
Tetrachlorodibenzofuran (TCDF)	0.005
Tetrachloroethane	50
Toluene	11
Trichloroethene	50
Total Xylenes	3
Inorganics	
COMPOUND	**CONCENTRATION (ppm-wt)**
Arsenic	2
Barium	591
Cadmium	20
Chromium	85
Lead	778
Zinc	301

SOURCE DEFINITION

Given the amount of metals that were present in the soil, a dual remedial action was planned. Because most of the lead was concentrated in one portion of the impoundment, it was removed and sent to a nearby hazardous waste landfill. (Impacts due to lead contamination throughout the waste site were addressed in the modeling analysis.)

The proposed RA was to incinerate the contaminated soil on site. Therefore, as part of the risk determination conducted during the RD, air dispersion modeling was performed to assess the potential impact of this remedial activity. A rotary-kiln incinerator was proposed, with a maximum waste (soil) feed rate of 10 tons per hour (tons/hr). The conversion factor for tons/hr to kg/hr is 907.2. No free liquids were incinerated. The air pollution control system consisted of cyclones to remove large particulate matter, a packed-tower scrubber for primary removal of acid gases, and an ejector scrubber for removal of fine particulate matter and additional acid gases before release of the gas from the stack The point source parameters required for modeling the incinerator are shown in Table A-2. The incinerator was located approximately 30 meters (m) from the nearest site property boundary.

TABLE A-2. INCINERATOR STACK PARAMETERS

Stack Height (meters)	Stack Inner Diameter (meters)	Exit Gas Velocity (meters/second)	Exit Gas Temperature (Kelvin)
20	1.0	20	344

During remediation, the incinerator was operated 24 hours per day, 7 days per week to avoid start-ups and shut-downs. At this rate, it took 250 days to incinerate the 60,000 tons of contaminated soil. The incinerator was fueled with propane, which did not contribute significantly to the emissions of compounds present in the waste soil.

Aside from the incinerator stack, air emissions also occurred from soil handling operations upstream of the incinerator. These emissions included fugitive emissions from the soil excavation, transportation to the incinerator, and the temporary storage piles created near the incinerator. Soil excavation from the surface impoundment proceeded such that the total surface area exposed for the pit at any given time was no more than 1,000 square meters (m^2). A paved roadway was constructed and used for transporting the contaminated soil to the incinerator. The dimensions associated with the fugitive sources are shown in Table A-3. A general diagram of the site is shown in Figure A-1.

TABLE A-3 FUGITIVE SOURCE DIMENSIONS

Source	Dimensions (meters)	Area (square meters)	Release Height (meters)
Excavation Pit	25 x 40 x 3	1,000	0
Single Storage Pile	5 x 10 x 3	140	1.5
Transport	250[a]	--	1.5

[a] Maximum, single round-trip distance.

For dispersion modeling, these fugitive sources were represented as square area and volume sources (rectangular areas were not allowed by the model selected). As illustrated in Figure A-2, the excavation pit was modeled as five square area sources, each storage pile was modeled as two square areas, and the roadway was modeled as a series of square volume sources spaced at equal intervals So defined, the spatial extent of each fugitive source was matched exactly with the source dimensions Depending on the distance to the nearest receptor, an alternative technique might have been to assign a single square area source to both the excavation pit and to the storage piles, each such area source having a square area equivalent to the total area of the actual source

The actual location of the excavation pit varied as the RA progressed. Therefore, for dispersion modeling, this source was located within the impoundment such that predicted impacts would be conservative. Specifically, this source was located a minimal distance to the property boundary, and located near the storage pile area, allowing the location of the excavation pit impacts off site to more nearly coincide with those of the storage piles.

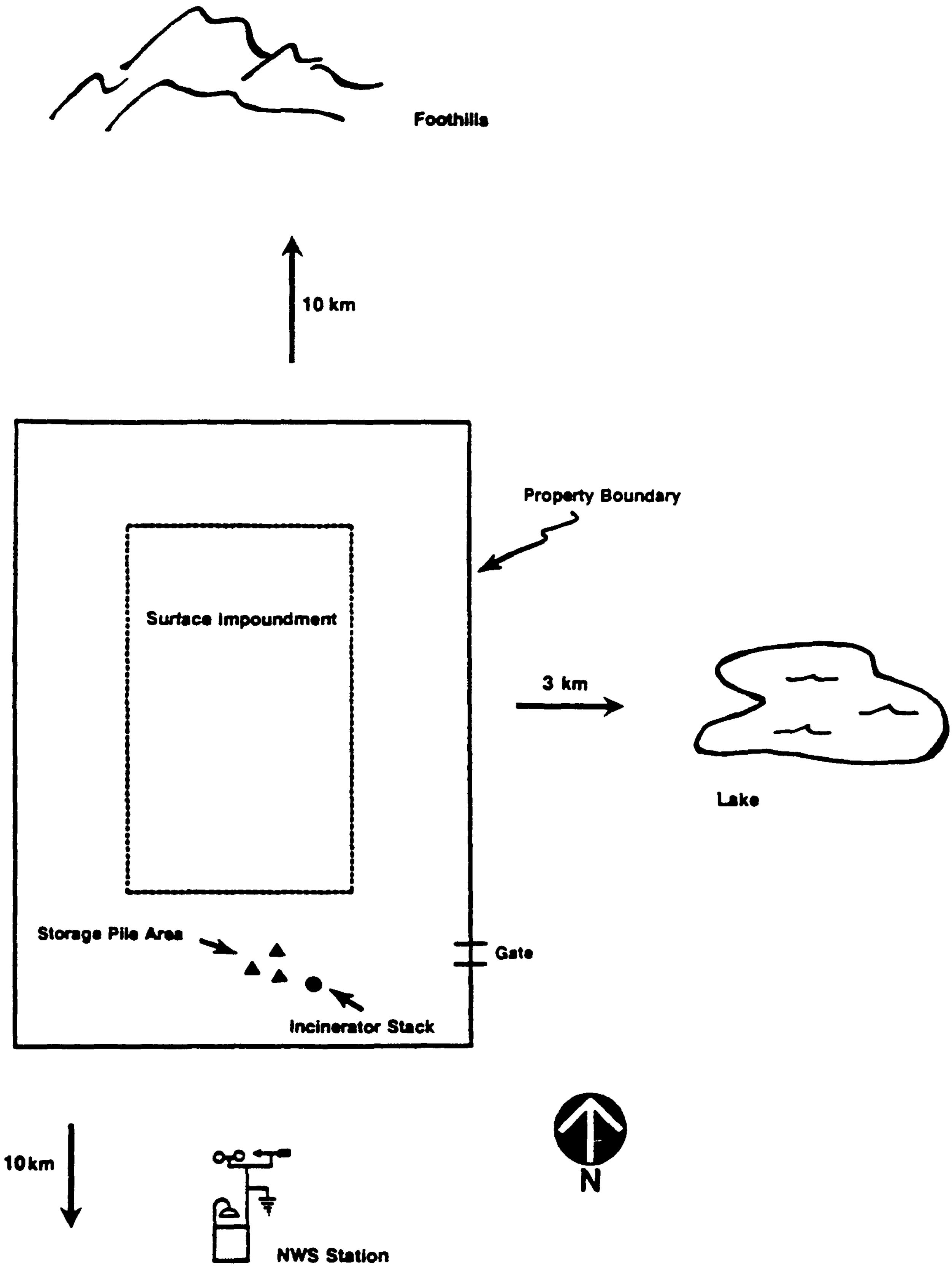


Figure A-1 Example Site Plan.

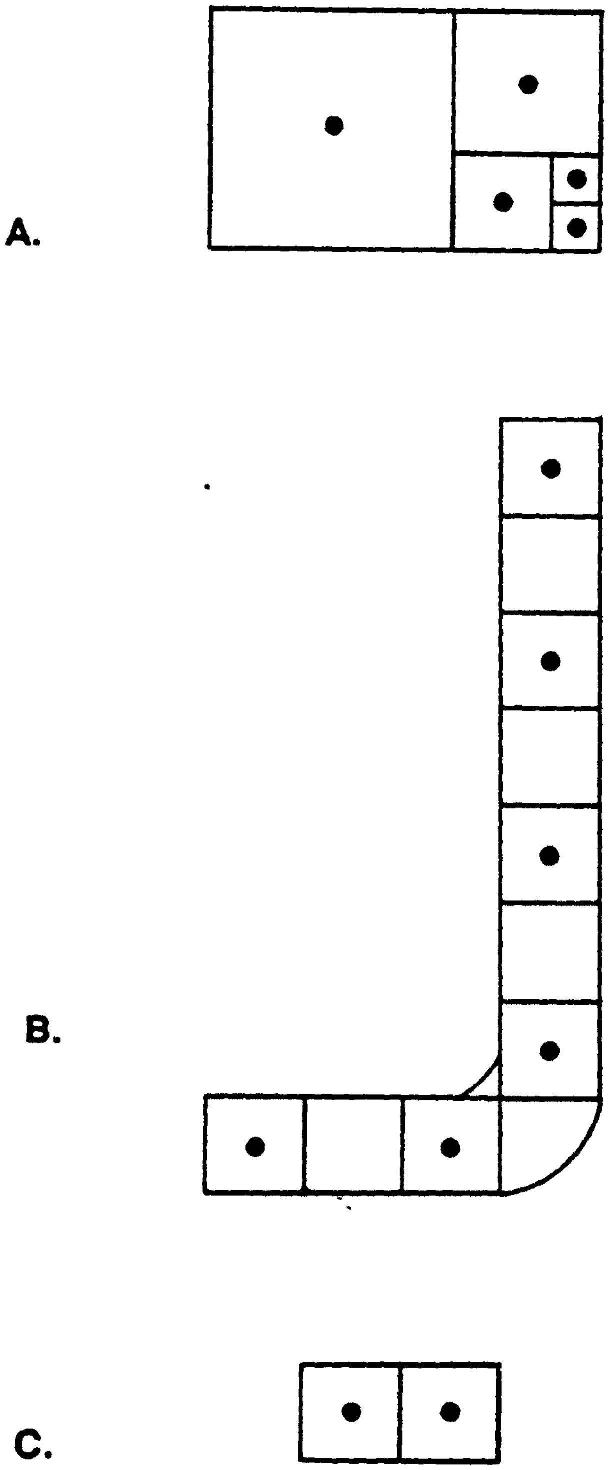


Figure A-2 Area and Volume Source Representations of the Fugitive Sources. (A) Area source breakout of the excavation pit. (B) Volume source delineation of the roadway. (C) Area source breakout of a single storage pile. Relative dimensions are not drawn to scale.

EMISSION ESTIMATION

In order to assess applicable or relevant and appropriate requirements (ARARs) and health effects, it was necessary to model both long-term and short-term impacts. Therefore, both long-term and maximum short-term emission rates were determined for each source. Individual pollutant emission rates per source were defined once the averaging periods of concern had been determined for each pollutant, based on consultation with the U.S. Environmental Protection Agency (EPA) Regional Toxicologist. In estimating emission rates from the incinerator, the planned air pollution control equipment was taken into account.

Emission rates were determined for the incinerator, soil excavation and handling, transport, and storage piles according to procedures outlined in the following documents:

- U.S. Environmental Protection Agency, 1989. Air/Superfund National Technical Guidance Study Series. Volume III - Estimation of Air Emissions from Cleanup Activities at Superfund Sites. EPA Publication No. 450/1-89-003. Office of Air Quality Planning and Standards. Research Triangle Park, NC;

- U.S. Environmental Protection Agency, 1993. Air/Superfund National Technical Guidance Study Series. Models for Estimating Air Emission Rates from Superfund Remedial Actions. EPA Publication No. 451/R-93-001. Office of Air Quality Planning and Standards. Research Triangle Park, NC.

- U.S. Environmental Protection Agency, 1992. Air/Superfund National Technical Guidance Study Series. Screening Procedures for Estimating the Air Impacts of Incineration at Superfund Sites. EPA Publication No. 450/1-92-003. Office of Air Quality Planning and Standards. Research Triangle Park, NC; and

- U.S. Environmental Protection Agency, 1992. Air/Superfund National Technical Guidance Study Series. Estimation of Air Impacts for the Excavation of Contaminated Soil. EPA Publication No. 450/1-92-004. Office of Air Quality Planning and Standards. Research Triangle Park, NC.

The TSCREEN model has the capability of doing many of the emission estimation calculations for a Superfund site. For the incinerator emission rate use the Superfund Release Type (Thermal incineration). For this example the total feed rate was given as 9072 kg/hr (10 tons/hr) The TSCREEN default efficiency of 99 99 percent was assumed. For the PCB concentration of 272 µg/g the emission rate is 6.9 x 10^{-5} g/s.

For the excavation site and pile TSCREEN can calculate the emission rate by using Superfund Release Type (Soil Excavation) Using a default vapor pressure of 35 mm Hg (4666 Pa) for PCB from Estimation of Air Impacts for the Excavation of Contaminated Soil. TSCREEN gives an emission rate of 0 06542 g/s for PCB from both the pit and a pile. Both the pit and pile are assumed to be made of the same material. A schematic illustration of the site is given in Figure A-3 The following assumptions were made (these are the defaults in TSCREEN):

- Soil excavated for 50 min/hour:
- Each scoop contains 2 m^3 of soil:
- 75 scoops per hour:
- Pit becomes 10m x 15m x 1m after 1 hour:
- Pile becomes 5m x 10m x 3m after 1 hour:
- Total exposed area of the pit is 150 m^2:
- Total exposed area of the pile is 140 m^2:
- Density of soil is 1.5 g/m^3: and
- Soil and air temperature is assumed to be 25 °C.

In ISC the pile should be treated as a volume source since it extends in the vertical (emission rate to be given in g/s). The pit should be treated as an area source (emission rate to be given in g/s-m^2). The total surface area exposed is 290 m^2 (150 m^2 + 140 m^2).

These assumptions imply that the PCB emission rate for the pile is 0.03158 g/s ((140 m^2 / 290 m^2) x 0.06542 g/s). Only three piles will be assumed to be uncovered during the day. At night the piles will be assumed to be covered with no emission. This can be handled explicitly in the ISC input by the use of Emission Factors (EMISFACT input in Table A-4) Each pile is broken down into two volume sources (see Figure A-2(c)) so the emission rate must be halved for each source. The PCB area emission rate for the pit is 2.256 x 10^{-4} g/s-m^2 (0.06542 g/s / 290 m^2).

The same area emission rate (E) can be used to estimate the transport emission rate In this example assume:

- Exposed soil surface area (A) on truck is 10 m^2;
- Round trip travel time (T) is 60 seconds; and
- There are 6 trips per hour (N), 8 hours per day

On an hourly basis the emission would be N x E x A x T. In this example the emission for PCB over an hour is 0.8122 g (6 x 2.256 x 10^{-4} g/s-m^2 x 10 m^2 x 60 s). This means the average emission rate is 2.256 x 10^{-4} g/s. This emission rate is for the entire road. The road is split into 10 volume sources so the emission rate for each road source is one tenth this rate

MODEL METHODOLOGY AND SELECTION

Both screening-level and refined dispersion models were used for the analysis. The screening level analysis was used to determine potential complex terrain impacts from the incinerator. To determine the collective impact from all sources, the decision was made to conduct a refined modeling analysis, rather than solely a screening-level analysis, because of the nature and number of sources involved. (Given the differing dispersion characteristics involved, the location of maximum impacts from the fugitive sources would not be collocated with those from the incinerator. Further, as mentioned later in Section A.13, the total number of sources involved in the analysis also reflected sources from a nearby manufacturing facility.)

Complex Terrain Screening Analysis

Because of the point source (incinerator) and the presence of complex terrain, it was necessary to address the potential for plume impaction on an elevated terrain feature. To determine whether complex terrain impacts would be significant in the analysis, the screening model TSCREEN[1] was executed.

A receptor grid comprised of discrete downwind distances was used for running the TSCREEN model. Discrete receptors were defined in order to account for unique terrain heights at each downwind distance (see Section A.8 for definition of the terrain heights). The receptor grid included both simple and complex terrain receptors. The model was executed to see whether the maximum impact predicted was from the simple terrain algorithm or the complex terrain algorithm. This analysis determined whether additional complex terrain modeling would be needed to identify the maximum exposed individual (MEI). If the maximum complex terrain impact was found to be "significantly lower" than the maximum simple terrain impact, then it would be determined that simple terrain impacts were controlling, and the identification of the MEI could be adequately addressed with a simple terrain model. (There is no set criterion on what percentage of the simple terrain impact the complex terrain impact should be to constitute an impact that is "significantly lower." Such determination can be made on a case-by-case basis in consultation with the EPA Regional Modeler.)

Refined Analysis

Based on the screening analysis, it was determined that identification of the MEI could be adequately addressed with a simple terrain model. (The maximum complex terrain impact from the incinerator was found to be less than 15 percent of the maximum simple terrain impact.) Therefore, the Industrial Source Complex Short-Term (ISCST2) model[2] was selected for predicting both short-term and long-term impacts for all sources at the site. The ISCST2 model was selected based on the following requirements:

- Model multiple sources;
- Account for rolling terrain;
- Model various averaging times;
- Model time-varying emission rate(s);
- Model with rural dispersion coefficients; and
- Model both point and fugitive sources.

Since the remedial activity was not continuous at the site on an annual basis, the modeling analysis was designed such that long-term averages would be based on emissions occurring only during the time period activities were being performed. In this example, the soil excavation and incineration occurred continuously for 250 days, during the time period from the first of March through the first week of November. The emissions due to transport and piles were limited during the day. Therefore, ISCST2 emission factors (EMISFACT in the ISC input in Table A-5) were assigned to the transport and pile sources for the time of day. Emissions from these sources only took place between 8 AM to 5PM. The only meteorological data used was from March 1 through November 5 To extrapolate the period average concentrations given in the model output, multiply the averages by the factor (250 days / 365 days).

Other Analysis

To determine whether any of the organic emissions could form a dense gas and, therefore, require use of a specialized model, specific calculations were made for selected compounds in accordance with procedures documented in Guidance on the Application of Refined Dispersion Models to Hazardous/Toxic Air Pollutant Releases.[3] The same type of calculation can be done in TSCREEN through the use of the "Initial Form of Release Menu." Under that menu use the option "Stacks, Vents, Conventional Point Sources." The next screen allows a gas density check to be done. Entering "Y" for the gas density check brings up a new screen requesting emission density. The emission density can be calculated for you by entering a molecular weight and emission temperature. The calculation assumes that the emission is 100% emitted species. To have the calculation done correctly an emission molecular weight (M_e) is needed. The emission molecular weight can be determined from:

$$M_e = \left(\Sigma \frac{w_i}{M_i} \right)^{-1}$$

where w_i is the weight fraction of component i and M_i is the molecular weight of component i. For this case no dense-gas modeling was determined to be necessary.

Particle emissions from the point and fugitive sources were also investigated to determine the need to conduct deposition modeling that would provide input to a multipathway risk assessment for the site. No site-specific particle size distribution data had been collected, however, representative data were available from another Superfund site at which the same remedial activity had been undertaken Based on this data, it was determined that particulate matter from the excavation, transport, and storage activities would principally be deposited within the property boundary.

Particulate emissions from the incinerator and subsequent transport off site were a potential concern. Screening modeling indicated that maximum impacts from the incinerator were likely occur within 1 km Sensitive receptors of interest, such as the nearby recreational lake, were located further away (greater than 2.5 km from the source). From a risk standpoint it was determined, through discussion with the EPA Regional Toxicologist and toxicologist for the Potentially Responsible Parties (PRPs), that exposure throughout the inhalation pathway would be the most significant. Therefore, for this analysis, it was decided to estimate only particulate matter concentrations.

METEOROLOGICAL DATA

An on-site meteorological monitoring program had been initiated at the site three months prior to the analysis. The primary meteorological variables recorded on the 10-meter tower were wind speed, wind direction, and temperature. The data were used to evaluate the applicability of meteorological data available from the National Weather Service (NWS) Station at the local airport, located about 10 km south of the site.

For each meteorological variable, correlation coefficients between the two data sets were computed, as well as the variable means, ranges from minimum to maximum, and standard deviations. These statistics were calculated for the entire data set and for smaller time periods within the larger data set (i.e., for weeks and months). In general, if the correlation coefficients were found to be much less than 0.8 or 0.9, then the representativeness of the off-site data would be questionable. The evaluation resulted in the following information:

- For the same time period, the off-site meteorological data correlated reasonably well with the on-site data (correlation coefficients were greater than 0.9). Wind direction data for the airport showed the same pattern as the data collected on site, with an apparent small shift of about 10 to 15 degrees. The frequency distribution of wind speed and direction by stability class was within 10 to 20 percent.

- No significant topographic features or water bodies existed between the NWS station and the site (The recreational lake to the east of the site is too small to influence the meteorology at the site.)

Based on the evaluation and consultation with the EPA Regional Modeling contact, it was decided to use the meteorological data from the NWS station. The most recent five-year data set was obtained from the Support Center for Regulatory Air Models (SCRAM) Bulletin Board System (BBS) for use in the analysis. This data set included both surface and mixing height data. Although required for some models, it was not necessary to determine the site's surface roughness for this analysis. Examples of surface roughness values are given in Table 5-1.

TERRAIN CONSIDERATIONS

The base elevation of the site is 1,200 feet (ft) mean sea level (msl). The height of the incinerator stack was 20 m (65.6 ft msl) above base elevation (1,266 ft msl). The closest terrain above 1,266 ft occurs approximately 8,700 m to the north of the site. The presence of rolling terrain and nearby terrain above stack top required the inclusion of terrain heights (and complex terrain modeling, as discussed previously in Section A.5) in the modeling analysis. The closest rolling terrain reached about 15 m above stack base at 400 m to the west.

RECEPTOR GRID

Screening--Two types of receptor grids were established for the analysis. The first receptor grid was developed for screening incinerator impacts using the TSCREEN model. This grid was comprised of downwind distances from the incinerator stack, starting with the nearest distance to the property boundary. Terrain heights were included in this receptor array by selecting the "worst-case" terrain feature for each distance. The "worst-case" terrain feature was defined as the terrain height closest to plume centerline height located at each receptor distance, regardless of the terrain orientation relative to the site. The plume centerline height was obtained from executing TSCREEN in the complex terrain mode and noting the value from a data input screen

Refined--For the refined modeling, a Cartesian grid was developed. A Cartesian coordinate system was selected for the refined modeling, as opposed to a polar coordinate system, because of an interest in having uniform spacing between receptor points. The grid was centered on the location of the incinerator stack. Receptors were placed every 100 m out to a distance of 1 km from the property boundary. From 1 km out to a distance of 3 km, a 500-meter receptor grid spacing was used In addition, discrete receptors were placed at 100-meter intervals along the site property boundary. To address potential impacts from the incinerator, a coarse array of discrete receptors was also placed over the low foothills region to the north of the site.

The initial receptor spacing beyond 1 km from the site boundary was coarse because preliminary screening with TSCREEN indicated that maximum impacts from the incinerator would likely fall within 1 km Further, because the other sources were ground-level fugitive sources, their maximum impacts were anticipated to occur at the property boundary. Although the emphasis of the analysis was on identifying the MEI, there was a concern for specifically estimating impacts at the nearby recreational lake. Therefore, a set of sensitive receptors was placed within the recreational lake area.

In the event the maximum impact occurred in the coarse-grid region (including the contribution from the nearby facility mentioned in Section A.13 to follow), the maximum impacts would be refined with a 100-meter interval grid centered on the location of maximum impacts predicted with the coarse grid. Terrain height elevations for all receptors were determined from 1:24,000 scale U.S. Geological Survey (USGS) topographic maps of the area.

LAND USE CLASSIFICATION

The selection of the appropriate dispersion coefficients was dependent upon the land use within 3 km of the site. According to the guidance in Guideline on Air Quality Models (Revised)[4], the land use typing scheme of Auer was used to determine the proper land use classification. Specifically, the total area circumscribed by a 3-kilometer radius about the site was identified on the pertinent USGS 1:24,000 scale topographic maps. If the Auer land use types of heavy industrial, light-to-moderate industrial, commercial, and compact residential account for 50 percent or more of the total area, Guideline on Air Quality Models (Revised)[4] recommends use of urban dispersion coefficients; otherwise, the appropriate rural coefficients are used.

Although on the outskirts of town, visual inspection of the topographic maps indicated that the area surrounding the site is predominantly agricultural, recreational, and low-density residential (i.e., rural designations visually accounted for greater than 70 percent of the area). Therefore, rural dispersion coefficients were selected for use in the analysis.

PLUME DOWNWASH

A good engineering practice (GEP) stack height evaluation was conducted to determine whether inclusion of building wake effects would be required in the modeling analysis. The procedures used in this analysis were in accordance with those described in Guidelines for Determination of Good Engineering Practice Stack Height (Technical Support Documentation for the Stack Height Regulations--Revised).[5]

Operation of the proposed incinerator involved the installation of a temporary trailer located within 10 m. The dimensions of the trailer were 6.1 m x 4.5 m, with a height of 3 m. GEP formula height is expressed as: $GEP = H_b + 1.5L$, where H_b is the building height and L is the lesser of the building height or maximum projected width. A building or structure is considered sufficiently close to a stack to cause wake effects when the minimum distance between the stack and the building is less than or equal to five times the lesser of the height or projected width of the building (5L). Because the trailer was within 5L of the incinerator [5L = (5 x 3) = 15 m], it was necessary to see whether the potential for wake effects existed. Based on the trailer dimensions, the GEP formula height for the stack was 7.5 m [3 + (1 5 x 3) = 7.5]. Since the incinerator stack height was greater than 7.5 m, no building wake effects due to the trailer were anticipated, and therefore, no building dimension inputs were used in the analysis.

AVERAGING PERIOD CONSIDERATIONS

To address requirements for the health risk assessment, averaging periods of 1 hour, 24 hours, and annually were predicted In addition, to address the National Ambient Air Quality Standard for lead, calendar quarterly averages were estimated.

WORST-CASE IMPACT DETERMINATION

To determine the highest potential, or "worst-case" impacts that could occur for each averaging period, special attention was paid to how the source emission rates were defined. It was considered important to characterize worst case impacts in order to estimate the upper bound of potential human exposure to the ambient pollutant concentrations resulting from the remedial activities at the site.

Since emissions from the incinerator were continuous, pollutant emission rates were based on a maximum feed rate to the unit. For the fugitive sources, a worst-case, short-term emission rate was determined by assuming an emitting area of three piles and a single pit. This emission rate was also used for determining worst-case, long-term impacts. Worst case dispersion conditions were assumed to be reflected in the five-year meteorological data set modeled.

BACKGROUND CONCENTRATIONS

Adjacent to the site on the eastern perimeter is a small manufacturing facility. Air permit information for the facility indicated that it emits two pollutants addressed in the Superfund site inventory: methyl ethyl ketone and toluene. To account for the cumulative impacts of these pollutants, and to identify the incremental change due to the Superfund remedial activities, the relevant sources from this facility were included in the analysis. All necessary input data for modeling were obtained from the facility's state air permit application.

MODEL RESULTS

Screening--An example output from TSCREEN for the PCB emissions from the incinerator is given in Table A-4. The results of the model runs were used to verify that complex terrain modeling was not required. In the case in Table A-4 the maximum simple terrain impact was 3.231×10^{-3} $\mu g/m^3$, the maximum complex terrain impact was 3.591×10^{-4} $\mu g/m^3$. The complex terrain concentration was only 11 percent of the simple terrain impact.

In this example, the results of all other pollutants from the incinerator could be determined by scaling their emission rates to that used for the PCB simulation. The emission rate can be calculated in TSCREEN just as done for PCB. The predicted concentrations would then be those given for PCB multiplied by a factor. The factor would be the pollutant emission rate divided by the PCB emission rate.

The emissions from the excavation area needs to be modeled separately from the incinerator scenario since it is a different form of source type. Each contaminant has a different vapor pressure and concentration and needs to be modeled as shown in A.4.

Refined--An example ISCST2 output for the PCB sources is given in Table A-5. The output is from a run for a single year. Similar runs are needed for each of the five years.

The emission rate for each species is proportional to its concentration in the contaminated soil The concentration of each species in the soil is constant. This means that the relative source strengths of the incinerator, pit, pile, and transport sources are the same for all the species. This, in turn, means that impacts from the other species can be determined by multiplying the PCB concentrations by the ratio of the concentration of the species of interest by the concentration of the PCB (272 ppm-wt).

Over the five years of meteorological data modeled, maximum impacts for the complete emissions inventory were found to occur at the site boundary. Since the maximum impacts occurred in the portion of the receptor grid that was resolved to a 100-meter spacing, a refined-grid model run was not necessary Impacts from just the Superfund site were also reported (separately from those combined with the adjacent manufacturing facility) to isolate the predicted impact of the RA. The modeling results indicated that the location of the MEI was not in an inhabited area In all cases, model results were analyzed to ensure that no errors were made in the input preparation or model execution.

CONFIRMATORY AIR MEASUREMENTS

An AAM program was performed to validate the dispersion modeling predictions and to make a direct assessment of exposure at receptors of interest. A network of five monitoring stations was established around the facility. The preliminary dispersion modeling output was used to site the monitoring stations to ensure that they would be within the emission plume. At each monitoring location, canisters were collected and analyzed off site by EPA Method TO-14 to determine volatile organic compounds (VOCs). Also at each location, PM_{10} samples were collected. The PM_{10} loading was determined from air flow measurements and gravimetric analysis of the filter catch. A portion of the filter was analyzed off site for the six metals thought to be present at the site. Sampling was conducted over two 12-hour periods each day, during each day that the incinerator was in operation or soils/waste handling operations were underway. In addition, two weeks of baseline AAM data were collected prior to the start of the remediation activities.

The AAM data collected during remediation were compared to short-term model predictions developed from the on-site meteorological data for that same time period. The model predictions were found to be slightly conservative, but of the same magnitude as the actual AAM results. This outcome was more likely and desirable than the alternative (the model underpredicts the observed concentration). If the air quality monitor were only a few degrees off from the exact centerline location of the plume, the maximum concentrations reported by the monitor could be substantially underestimated.

REFERENCES

1. U S. Environmental Protection Agency, 1990· User's Guide to TSCREEN, A Model for Screening Toxic Air Pollutant Concentrations. EPA-450/ 4-90-013. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.

2. U.S. Environmental Protection Agency, 1992: User's Guide for the Industrial Source Complex (ISC2) Dispersion Models, Volume I - User Instructions. EPA-450/4-92-008a. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.

3. U.S. Environmental Protection Agency, 1993. Guidance on the Application of Refined Dispersion Models to Hazardous/Toxic Air Pollutant Releases. EPA-454/R-93-002. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

4. U.S. Environmental Protection Agency, 1986. Guideline on Air Quality Models. (Revised). EPA-4502-78-027R, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

5. U.S. Environmental Protection Agency, 1985. Guidelines for Determination of Good Engineering Practice Stack Height (Technical Support Documentation for the Stack Height Regulations--Revised) EPA-450/4-80-023R.

TABLE A-4. EXAMPLE TSCREEN OUTPUT

```
                                                                 10/11/94
                                                                 10:12.22
 ***  SCREEN2 MODEL RUN  ***
 *** VERSION DATED 92245 ***

Example PCB release from incinerator

SIMPLE TERRAIN INPUTS
   SOURCE TYPE             =      POINT
   EMISSION RATE (G/S)     =     690000E-04
   STACK HEIGHT (M)        =    20.0000
   STK INSIDE DIAM (M)     =     1 0000
   STK EXIT VELOCITY (M/S)=     20 0000
   STK GAS EXIT TEMP (K)   =   344.0000
   AMBIENT AIR TEMP (K)    =   293.0000
   RECEPTOR HEIGHT (M)     =      .0000
   URBAN/RURAL OPTION      =      RURAL
   BUILDING HEIGHT (M)     =      .0000
   MIN HORIZ BLDG DIM (M) =       0000
   MAX HORIZ BLDG DIM (M) =       0000


     ***************************************
     *** SUMMARY OF SCREEN MODEL RESULTS ***
     ***************************************

 CALCULATION        MAX CONC    DIST TO   TERRAIN
  PROCEDURE        (UG/M**3)    MAX (M)    HT (M)
--------------    -----------   -------   -------
SIMPLE TERRAIN      .3231E-02     400.       15.

COMPLEX TERRAIN     .3591E-03    8700.       55. (24-HR CONC)


***************************************************
** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
***************************************************


BUOY. FLUX =    7 269 M**4/S**3;  MOM. FLUX =   85.174 M**4/S**2.


FINAL STABLE PLUME HEIGHT (M) =  55.2
DISTANCE TO FINAL RISE (M)    =  151.3

                        *VALLEY 24-HR CALCS*  **SIMPLE TERRAIN 24-HR CALCS**
 TERR        MAX 24-HR             PLUME HT               PLUME HT
  HT   DIST    CONC         CONC   ABOVE STK    CONC    ABOVE STK     U10M USTK
 (M)    (M)  (UG/M**3)  (UG/M**3)  BASE (M)  (UG/M**3)  HGT (M)  SC   (M/S)
----- ------- ---------- ---------- ------   ---------- ------  -- ---- ----
```

55. 8700. .3591E-03 .3500E-04 55.2 .3591E-03 42.1 6 1.0 1.5

BUOY. FLUX = 7.269 M**4/S**3; MOM. FLUX = 85.174 M**4/S**2.

. *** FULL METEOROLOGY ***

****
*** SCREEN AUTOMATED DISTANCES ***
****

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
30.	.4057E-14	6	1.0	1.5	10000 0	62 08	7.86	7.79	NO
100.	.7292E-04	1	3.0	3 1	960.0	50.12	27.53	15.21	NO
200.	.1172E-02	1	3.0	3.1	960.0	50.12	50.71	30.54	NO
300.	.1242E-02	2	4.0	4.2	1280.0	42.59	52.60	30.83	NO
400.	.1276E-02	3	4.5	4.8	1440.0	39.67	45.00	27.04	NO

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 30. M:

414.	.1278E-02	3	4.5	4.8	1440.0	39.67	46.52	27.92	NO

****
*** SCREEN AUTOMATED DISTANCES ***
****

*** TERRAIN HEIGHT OF 15. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
400.	.3231E-02	4	8.0	8.9	2560.0	15.69	29.61	15.57	NO
500.	.2902E-02	4	5.0	5.5	1600.0	22.10	36.47	18.94	NO
600.	.2559E-02	4	4.5	5.0	1440.0	24.00	43.06	21.89	NO
700.	.2287E-02	4	4.0	4.4	1280.0	26.37	49.57	24.80	NO
800.	.2073E-02	4	3.5	3.9	1120.0	29.42	56.01	27.68	NO
900.	.1897E-02	4	3.0	3.3	960.0	33.49	62.42	30.57	NO
1000.	.1741E-02	4	3.0	3.3	960.0	33.49	68.61	33.11	NO
1100.	.1618E-02	4	2.5	2.8	800.0	39.19	74.95	35.50	NO
1200.	.1509E-02	4	2.5	2.8	800.0	39.19	81.03	37.39	NO
1300.	.1407E-02	4	2.5	2.8	800.0	39.19	87.07	39.24	NO
1400.	.1326E-02	5	1.0	1.3	10000.0	58.10	70.86	30.75	NO
1500.	.1355E-02	5	1.0	1.3	10000.0	58.10	75.24	31.79	NO
1600.	.1375E-02	5	1.0	1.3	10000.0	58.10	79.61	32.81	NO
1700.	.1412E-02	6	1.0	1.5	10000 0	47.08	56.24	22.92	NO
1800.	.1459E-02	6	1.0	1.5	10000.0	47.08	59.10	23.54	NO
1900	.1498E-02	6	1 0	1.5	10000.0	47.08	61.96	24.14	NO
2000.	.1531E-02	6	1.0	1.5	10000.0	47.08	64.80	24.74	NO
2100.	.1546E-02	6	1.0	1.5	10000.0	47.08	67.63	25.26	NO
2200.	.1556E-02	6	1.0	1.5	10000.0	47.08	70.46	25.76	NO
2300.	.1562E-02	6	1.0	1.5	10000.0	47.08	73.27	26.25	NO

2400	1566E-02	6	1 0	1.5	10000.0	47.08	76.07	26.74	NO
2500	1566E-02	6	1.0	1.5	10000.0	47.08	78.87	27.22	NO
2600	1565E-02	6	1.0	1 5	10000.0	47.08	81.65	27.70	NO
2700.	.1561E-02	6	1.0	1.5	10000.0	47.08	84.43	28.17	NO
2800	1555E-02	6	1.0	1.5	10000.0	47.08	87.20	28.63	NO
2900	1547E-02	6	1 0	1.5	10000.0	47.08	89.96	29 08	NO
3000.	1538E-02	6	1.0	1.5	10000 0	47.08	92.71	29.53	NO
3500.	.1459E-02	6	1 0	1.5	10000.0	47.08	106.33	31.37	NO
4000	.1376E-02	6	1 0	1.5	10000.0	47.08	119.77	33.10	NO
4500.	.1295E-02	6	1 0	1.5	10000 0	47.08	133 05	34.72	NO
5000	.1218E-02	6	1 0	1 5	10000.0	47.08	146.17	36.26	NO
5500.	.1147E-02	6	1.0	1 5	10000 0	47.08	159.15	37.72	NO
6000	.1081E-02	6	1 0	1 5	10000.0	47 08	172.00	39.13	NO
6500.	.1020E-02	6	1.0	1 5	10000.0	47.08	184.73	40.47	NO
7000	.9642E-03	6	1.0	1.5	10000 0	47.08	197.36	41.77	NO
7500.	.9124E-03	6	1 0	1.5	10000 0	47.08	209.88	42 88	NO
8000.	.8651E-03	6	1.0	1.5	10000.0	47.08	222.31	43.96	NO
8500	.8219E-03	6	1.0	1.5	10000.0	47.08	234.65	44.99	NO
9000.	.7824E-03	6	1.0	1.5	10000.0	47.08	246.90	46.00	NO
9500.	.7460E-03	6	1 0	1.5	10000.0	47.08	259.07	46.97	NO
10000	.7125E-03	6	1 0	1.5	10000 0	47.08	271.17	47.92	NO
15000	4837E-03	6	1.0	1.5	10000.0	47.08	388 61	56.19	NO
20000.	.3632E-03	6	1.0	1.5	10000.0	47.08	501.09	61.48	NO
25000.	.2891E-03	6	1.0	1.5	10000.0	47.08	609.87	65.96	NO
30000.	.2391E-03	6	1 0	1.5	10000 0	47.08	715.69	69.88	NO
40000	.1778E-03	6	1 0	1.5	10000.0	47.08	920 30	75.45	NO
50000.	1410E-03	6	1.0	1.5	10000.0	47.08	1117.49	80.10	NO

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 400. M:

400.	.3231E-02	4	8.0	8 9	2560.0	15.69	29.61	15.57	NO

DIST = DISTANCE FROM CENTER OF THE AREA SOURCE
CONC = MAXIMUM GROUND LEVEL CONCENTRATION
STAB = ATMOSPHERIC STABILITY CLASS (1=A, 2=B, 3=C, 4=D, 5=E, 6=F)
U10M = WIND SPEED AT THE 10-M LEVEL
USTK = WIND SPEED AT STACK HEIGHT
MIX HT = MIXING HEIGHT
PLUME HT= PLUME CENTERLINE HEIGHT
SIGMA Y = LATERAL DISPERSION PARAMETER
SIGMA Z = VERTICAL DISPERSION PARAMETER
DWASH = BUILDING DOWNWASH:
DWASH= MEANS NO CALC MADE (CONC = 0.0)
DWASH=NO MEANS NO BUILDING DOWNWASH USED
DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

```
*********************************************
 *  SUMMARY OF TERRAIN HEIGHTS ENTERED FOR  *
 *    SIMPLE ELEVATED TERRAIN PROCEDURE      *
*********************************************

      TERRAIN        DISTANCE RANGE (M)
       HT (M)       MINIMUM     MAXIMUM
      -------      --------    --------
          0.           30         400.
         15           400.       50000

***************************************
*** USER SPECIFIED AVERAGING TIMES ***
***************************************

ESTIMATED MAXIMUM CONCENTRATION FOR 24 HR AVERAGING TIME:
0.001292 (+/- 0.000646) UG/M**3

ESTIMATED MAXIMUM CONCENTRATION FOR ANNUAL AVERAGING TIME:
0.000258 (+/- 0.000065) UG/M**3


***********************************
*** END OF SCREEN MODEL OUTPUT ***
***********************************
```

TABLE A-5. EXAMPLE ISCST2 OUTPUT

```
CO STARTING
   TITLEONE An Example Superfund Site for the ISCST2 Model
   MODELOPT  DFAULT  RURAL  CONC
   TERRHGTS  ELEV
   AVERTIME  1  24  PERIOD
   POLLUTID  PCB
   RUNORNOT  RUN
   EVENTFIL  EVENTEXP.INP
   ERRORFIL  ERRORS.OUT
CO FINISHED

SO STARTING
   LOCATION  INCIN1  POINT  0 0    0 0    0.0
** Point Source       QS        HS     TS     VS    DS
** Parameters:        ----      ----   ----   ----  ---
   SRCPARAM  INCIN1  6.9E-5   20.0   344    20.0  1.0

   LOCATION  PIT1  AREA    0.0 105 0    0 0
   LOCATION  PIT2  AREA   25.0 115.0    0.0
   LOCATION  PIT3  AREA   25.0 105.0    0.0
   LOCATION  PIT4  AREA   35.0 110 0    0 0
   LOCATION  PIT5  AREA   35 0 105.0    0 0
** Area Source       QS          HS    DX
** Parameters:       ----        ----  ----
   SRCPARAM  PIT1  2.256E-4   0.0  25.0
   SRCPARAM  PIT2  2.256E-4   0.0  15.0
   SRCPARAM  PIT3  2.256E-4   0.0  10.0
   SRCPARAM  PIT4  2.256E-4   0.0   5.0
   SRCPARAM  PIT5  2.256E-4   0.0   5.0

   LOCATION  ROAD1  VOLUME   27.5  85.0   0.0
   LOCATION  ROAD2  VOLUME   27.5  72.5   0 0
   LOCATION  ROAD3  VOLUME   27.5  60.0   0.0
   LOCATION  ROAD4  VOLUME   27.5  47.5   0.0
   LOCATION  ROAD5  VOLUME   27.5  35.0   0 0
   LOCATION  ROAD6  VOLUME   27.5  22 5   0.0
   LOCATION  ROAD7  VOLUME   27.5  10 0   0.0
   LOCATION  ROAD8  VOLUME   15.0  10.0   0.0
   LOCATION  ROAD9  VOLUME    2.5  10.0   0.0
   LOCATION  ROAD0  VOLUME  -10.0  10.0   0.0
** Volume Source       QS        HS    DY    DZ
** Parameters·         ----      ----  ----  ----
   SRCPARAM  ROAD1  2.256E-5  1.5   5.81  0.698
   SRCPARAM  ROAD2  2.256E-5  1.5   5.81  0 698
   SRCPARAM  ROAD3  2.256E-5  1.5   5.81  0 698
   SRCPARAM  ROAD4  2.256E-5  1.5   5 81  0.698
   SRCPARAM  ROAD5  2.256E-5  1.5   5.81  0 698
   SRCPARAM  ROAD6  2.256E-5  1.5   5.81  0 698
   SRCPARAM  ROAD7  2.256E-5  1.5   5.81  0 698
```

```
   SRCPARAM  ROAD8  2.256E-5  1.5   5.81  0.698
   SRCPARAM  ROAD9  2.256E-5  1.5   5.81  0.698
   SRCPARAM  ROAD0  2.256E-5  1.5   5.81  0.698

   EMISFACT ROAD0-ROAD9   HROFDY 7*0.0 4*1 0 0.0 4*1.0 8*0.0

   LOCATION  PILE1A  VOLUME  -30.0  10.0   0.0
   LOCATION  PILE1B  VOLUME  -25.0  10.0   0.0
   LOCATION  PILE2A  VOLUME  -45.0  25 0   0.0
   LOCATION  PILE2B  VOLUME  -40.0  25.0   0.0
   LOCATION  PILE3A  VOLUME  -45 0  -5.0   0.0
   LOCATION  PILE3B  VOLUME  -40.0  -5.0   0.0
** Volume Source        QS      HS    DY    DZ
** Parameters.         ----    ----  ----  ----
   SRCPARAM  PILE1A  0 01579  1 5   2.33  0 698
   SRCPARAM  PILE1B  0 01579  1 5   2.33  0 698
   SRCPARAM  PILE2A  0.01579  1.5   2.33  0.698
   SRCPARAM  PILE2B  0.01579  1.5   2.33  0.698
   SRCPARAM  PILE3A  0.01579  1.5   2.33  0.698
   SRCPARAM  PILE3B  0.01579  1.5   2.33  0.698

   EMISFACT PILE1A-PILE3B HROFDY 7*0.0 9*1.0 8*0.0

   SRCGROUP  ALL
SO FINISHED

RE STARTING
   GRIDCART  GRID1  STA
                    XYINC -1000.0 21 100.0 -1000.0 21 100.0
                    ELEV 1 315*0.0 126*15.0
             GRID1  END
   GRIDCART  GRID2  STA
                    XYINC -3000.0 13 500.0 -3000.0 13 500.0
                    ELEV 1 91*0.0 78*15.0
             GRID2  END

** Site boundary points
   DISCCART  -150. -30. 0.0
   DISCCART   -50. -30. 0.0
   DISCCART    50. -30. 0.0
   DISCCART    50.  70. 0.0
   DISCCART    50. 170. 0.0
   DISCCART    50. 270. 0.0
   DISCCART    50. 370. 0.0
   DISCCART   -50. 370. 0.0
   DISCCART  -150. 370. 0.0
   DISCCART  -150. 270. 0.0
   DISCCART  -150. 170. 0.0
   DISCCART  -150.  70. 0.0

** High elevation points
   DISCCART  -2000.  8700.  55.2
   DISCCART  -1500.  8700.  55.2
```

```
   DISCCART  -1000   8700.  55.2
   DISCCART   -500.  8700.  55.2
   DISCCART      0   8700.  55.2
   DISCCART    500.  8700   55.2
   DISCCART   1000.  8700.  55.2
   DISCCART   1500   8700.  55 2
   DISCCART   2000.  8700.  55.2

RE FINISHED

ME STARTING
   INPUTFIL  METDATA\METDATA INP
   ANEMHGHT  10 METERS
   SURFDATA  12960  1991
   UAIRDATA  3937  1991
   STARTEND  91 03 01 91 11 05
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE  FIRST-SECOND
   MAXTABLE  ALLAVE  50
OU FINISHED

************************************
*** SETUP Finishes Successfully ***
************************************
```

```
*** ISCST2 - VERSION 93109 ***    *** An Example Superfund Site for the ISCST2 Model
          ***          10/12/94          ***
          ***          07:59:09
                                          PAGE   1
*** MODELING OPTIONS USED:  CONC   RURAL  ELEV          DFAULT


                                          ***     MODEL SETUP OPTIONS SUMMARY       ***
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - -

**Model Is Setup For Calculation of Average CONCentration Values.

**Model Uses RURAL Dispersion.

**Model Uses Regulatory DEFAULT Options:
          1. Final Plume Rise.
          2. Stack-tip Downwash.
          3. Buoyancy-induced Dispersion.
          4. Use Calms Processing Routine.
          5. Not Use Missing Data Processing Routine.
          6. Default Wind Profile Exponents.
          7. Default Vertical Potential Temperature Gradients.
          8. "Upper Bound" Values for Supersquat Buildings.
          9. No Exponential Decay for RURAL Mode

**Model Accepts Receptors on ELEV Terrain.

**Model Assumes No FLAGPOLE Receptor Heights.

**Model Calculates  2 Short Term Average(s) of:   1-HR  24-HR
    and Calculates PERIOD Averages

**This Run Includes:   22 Source(s);      1 Source Group(s); and    631 Receptor(s)

**The Model Assumes A Pollutant Type of:  PCB

**Model Set To Continue RUNning After the Setup Testing.

**Output Options Selected:
         Model Outputs Tables of PERIOD Averages by Receptor
         Model Outputs Tables of Highest Short Term Values by Receptor (RECTABLE Keyword)
         Model Outputs Tables of Overall Maximum Short Term Values (MAXTABLE Keyword)

**NOTE:  The Following Flags May Appear Following CONC Values:  c for Calm Hours
                                                                m for Missing Hours
                                                                b for Both Calm and Missing
Hours

**Misc. Inputs:  Anem. Hgt. (m) =    10.00 ;    Decay Coef. =   0.0000     ;    Rot. Angle =
   0.0
                 Emission Units = GRAMS/SEC                                ;  Emission Rate
Unit Factor =   0.10000E+07
```

Output Units = MICROGRAMS/M**3

**Input Runstream File. exam1 inp ; **Output Print File: exam1.out
**File Created for Event Model: EVENTEXP.INP
**Detailed Error/Message File: ERRORS.OUT

```
*** ISCST2 - VERSION 93109 ***     *** An Example Superfund Site for the ISCST2 Model
             ***          10/12/94
                                   ***
             ***          07:59:09

                          PAGE   2
*** MODELING OPTIONS USED:  CONC    RURAL  ELEV           DFAULT



                                                    *** POINT SOURCE DATA ***


             NUMBER EMISSION RATE                         BASE     STACK    STACK     STACK
STACK    BUILDING EMISSION RATE
   SOURCE      PART.  (GRAMS/SEC)     X         Y        ELEV.     HEIGHT   TEMP.    EXIT VEL.
DIAMETER   EXISTS   SCALAR VARY
     ID        CATS.                (METERS) (METERS) (METERS) (METERS) (DEG.K)  (M/SEC)
(METERS)                  BY
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - -

  INCIN1         0   0.69000E-04       0.0        0.0       0.0     20.00   344.00     20.00
1.00       NO
```

*** MODELING OPTIONS USED: CONC RURAL ELEV DFAULT

*** VOLUME SOURCE DATA ***

SOURCE ID	NUMBER PART. CATS	EMISSION RATE (GRAMS/SEC)	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	RELEASE HEIGHT (METERS)	INIT. SY (METERS)	INIT. SZ (METERS)	EMISSION RATE SCALAR VARY BY
ROAD1	0	0.22560E-04	27.5	85.0	0.0	1.50	5.81	0.70	HROFDY
ROAD2	0	0.22560E-04	27.5	72.5	0.0	1.50	5.81	0.70	HROFDY
ROAD3	0	0.22560E-04	27 5	60.0	0.0	1.50	5.81	0.70	HROFDY
ROAD4	0	0 22560E-04	27.5	47.5	0.0	1.50	5.81	0.70	HROFDY
ROAD5	0	0.22560E-04	27 5	35.0	0.0	1.50	5.81	0.70	HROFDY
ROAD6	0	0 22560E-04	27.5	22.5	0.0	1.50	5.81	0.70	HROFDY
ROAD7	0	0 22560E-04	27.5	10.0	0.0	1.50	5.81	0.70	HROFDY
ROAD8	0	0.22560E-04	15 0	10.0	0.0	1.50	5.81	0.70	HROFDY
ROAD9	0	0.22560E-04	2.5	10.0	0.0	1.50	5.81	0.70	HROFDY
ROAD0	0	0.22560E-04	-10.0	10.0	0.0	1.50	5.81	0.70	HROFDY
PILE1A	0	0.15790E-01	-30 0	10.0	0.0	1.50	2.33	0.70	HROFDY
PILE1B	0	0.15790E-01	-25.0	10.0	0.0	1.50	2.33	0.70	HROFDY
PILE2A	0	0.15790E-01	-45 0	25.0	0.0	1.50	2.33	0.70	HROFDY
PILE2B	0	0.15790E-01	-40.0	25 0	0.0	1.50	2.33	0.70	HROFDY
PILE3A	0	0.15790E-01	-45.0	-5.0	0.0	1.50	2.33	0.70	HROFDY

PILE3B	0	0.15790E-01	-40.0	-5.0	0.0	1.50	2 33	0.70

HROFDY

*** ISCST2 - VERSION 93109 ***   *** An Example Superfund Site for the ISCST2 Model
*** 10/12/94
***
*** 07.59:09

PAGE 4
*** MODELING OPTIONS USED. CONC RURAL ELEV DFAULT

*** AREA SOURCE DATA ***

SOURCE ID	NUMBER PART. CATS.	EMISSION RATE (GRAMS/SEC /METER**2)	COORD (SW CORNER) X (METERS)	Y (METERS)	BASE ELEV. (METERS)	RELEASE HEIGHT (METERS)	WIDTH OF AREA (METERS)	EMISSION RATE SCALAR VARY BY
PIT1	0	0.22560E-03	0.0	105.0	0.0	0.00	25.00	
PIT2	0	0.22560E-03	25.0	115.0	0.0	0.00	15.00	
PIT3	0	0.22560E-03	25.0	105.0	0.0	0.00	10.00	
PIT4	0	0 22560E-03	35.0	110.0	0 0	0.00	5.00	
PIT5	0	0 22560E-03	35.0	105 0	0.0	0.00	5.00	

*** ISCST2 - VERSION 93109 ***   *** An Example Superfund Site for the ISCST2 Model
*** 10/12/94
***
*** 07:59:09

PAGE 5
*** MODELING OPTIONS USED: CONC RURAL ELEV DFAULT

*** SOURCE IDs DEFINING SOURCE GROUPS ***

GROUP ID   SOURCE IDs

ALL INCIN1 , PIT1 , PIT2 , PIT3 , PIT4 , PIT5 , ROAD1 , ROAD2 ,
ROAD3 , ROAD4 , ROAD5 , ROAD6 ,

ROAD7 , ROAD8 , ROAD9 , ROAD0 , PILE1A , PILE1B , PILE2A , PILE2B ,
PILE3A , PILE3B ,

```
 *** ISCST2 - VERSION 93109 ***    *** An Example Superfund Site for the ISCST2 Model
             ***        10/12/94
                                   ***
             ***        07 59:09

                        PAGE   6
 *** MODELING OPTIONS USED·  CONC   RURAL  ELEV         DFAULT


                          * SOURCE EMISSION RATE SCALARS WHICH VARY FOR EACH HOUR OF THE
DAY *


    HOUR    SCALAR      HOUR    SCALAR      HOUR    SCALAR      HOUR    SCALAR      HOUR
SCALAR      HOUR    SCALAR
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - -


SOURCE ID = ROAD1     ;  SOURCE TYPE =   VOLUME :
     1   .00000E+00      2    00000E+00      3   .00000E+00      4   .00000E+00      5
.00000E+00      6   .00000E+00
     7   .00000E+00      8   .10000E+01      9   .10000E+01     10   .10000E+01     11
.10000E+01     12   .00000E+00
    13   .10000E+01     14   .10000E+01     15   .10000E+01     16   .10000E+01     17
.00000E+00     18   .00000E+00
    19   .00000E+00     20   .00000E+00     21   .00000E+00     22   .00000E+00     23
.00000E+00     24   .00000E+00


SOURCE ID = ROAD2     ;  SOURCE TYPE =   VOLUME :
     1   .00000E+00      2   .00000E+00      3   .00000E+00      4   .00000E+00      5
.00000E+00      6   .00000E+00
     7   .00000E+00      8   .10000E+01      9   .10000E+01     10   .10000E+01     11
.10000E+01     12   .00000E+00
    13   .10000E+01     14   .10000E+01     15   .10000E+01     16   .10000E+01     17
.00000E+00     18   .00000E+00
    19   .00000E+00     20   .00000E+00     21   .00000E+00     22   .00000E+00     23
.00000E+00     24   .00000E+00


SOURCE ID = ROAD3     ;  SOURCE TYPE =   VOLUME :
     1   .00000E+00      2   .00000E+00      3   .00000E+00      4   .00000E+00      5
.00000E+00      6   .00000E+00
     7   .00000E+00      8   .10000E+01      9   .10000E+01     10   .10000E+01     11
.10000E+01     12   .00000E+00
    13   .10000E+01     14   .10000E+01     15   .10000E+01     16   .10000E+01     17
.00000E+00     18   .00000E+00
    19   .00000E+00     20   .00000E+00     21   .00000E+00     22   .00000E+00     23
.00000E+00     24   .00000E+00


SOURCE ID = ROAD4     ;  SOURCE TYPE =   VOLUME .
```

1 .00000E+00 2 .00000E+00 3 .00000E+00 4 .00000E+00 5
.00000E+00 6 00000E+00
7 00000E+00 8 .10000E+01 9 .10000E+01 10 .10000E+01 11
.10000E+01 12 .00000E+00
13 .10000E+01 14 .10000E+01 15 .10000E+01 16 .10000E+01 17
.00000E+00 18 .00000E+00
19 .00000E+00 20 .00000E+00 21 .00000E+00 22 .00000E+00 23
.00000E+00 24 .00000E+00

SOURCE ID = ROAD5 : SOURCE TYPE = VOLUME
1 .00000E+00 2 .00000E+00 3 .00000E+00 4 .00000E+00 5
.00000E+00 6 .00000E+00
7 .00000E+00 8 .10000E+01 9 .10000E+01 10 .10000E+01 11
.10000E+01 12 .00000E+00
13 .10000E+01 14 .10000E+01 15 .10000E+01 16 .10000E+01 17
.00000E+00 18 .00000E+00
19 .00000E+00 20 .00000E+00 21 .00000E+00 22 .00000E+00 23
.00000E+00 24 .00000E+00

*** ISCST2 - VERSION 93109 *** *** An Example Superfund Site for the ISCST2 Model
*** 10/12/94
***
*** 07:59:09

PAGE 7
*** MODELING OPTIONS USED: CONC RURAL ELEV DFAULT

* SOURCE EMISSION RATE SCALARS WHICH VARY FOR EACH HOUR OF THE DAY *

HOUR SCALAR HOUR SCALAR HOUR SCALAR HOUR SCALAR HOUR SCALAR HOUR SCALAR
- -

SOURCE ID = ROAD6 ; SOURCE TYPE = VOLUME :
1 .00000E+00 2 .00000E+00 3 .00000E+00 4 .00000E+00 5 .00000E+00 6 .00000E+00
7 .00000E+00 8 .10000E+01 9 .10000E+01 10 .10000E+01 11 .10000E+01 12 .00000E+00
13 10000E+01 14 .10000E+01 15 .10000E+01 16 .10000E+01 17 .00000E+00 18 .00000E+00
19 .00000E+00 20 00000E+00 21 .00000E+00 22 .00000E+00 23 .00000E+00 24 .00000E+00

SOURCE ID = ROAD7 ; SOURCE TYPE = VOLUME :
1 .00000E+00 2 .00000E+00 3 .00000E+00 4 .00000E+00 5 .00000E+00 6 .00000E+00
7 .00000E+00 8 10000E+01 9 .10000E+01 10 .10000E+01 11 .10000E+01 12 .00000E+00
13 10000E+01 14 .10000E+01 15 .10000E+01 16 .10000E+01 17 .00000E+00 18 .00000E+00
19 .00000E+00 20 .00000E+00 21 .00000E+00 22 .00000E+00 23 .00000E+00 24 .00000E+00

SOURCE ID = ROAD8 ; SOURCE TYPE = VOLUME :
1 00000E+00 2 .00000E+00 3 .00000E+00 4 .00000E+00 5 .00000E+00 6 .00000E+00
7 00000E+00 8 .10000E+01 9 .10000E+01 10 .10000E+01 11 .10000E+01 12 .00000E+00
13 .10000E+01 14 .10000E+01 15 .10000E+01 16 .10000E+01 17 .00000E+00 18 .00000E+00
19 00000E+00 20 .00000E+00 21 .00000E+00 22 .00000E+00 23 .00000E+00 24 .00000E+00

SOURCE ID = ROAD9 ; SOURCE TYPE = VOLUME

```
      1   .00000E+00      2   .00000E+00      3   .00000E+00      4    00000E+00      5
.00000E+00      6   .00000E+00
      7   .00000E+00      8   .10000E+01      9   .10000E+01     10   .10000E+01     11
.10000E+01     12   .00000E+00
     13   .10000E+01     14   .10000E+01     15   .10000E+01     16   .10000E+01     17
.00000E+00     18   .00000E+00
     19   .00000E+00     20   .00000E+00     21   .00000E+00     22   .00000E+00     23
.00000E+00     24    00000E+00


SOURCE ID = ROAD0     :  SOURCE TYPE =   VOLUME
      1   .00000E+00      2   .00000E+00      3   .00000E+00      4    00000E+00      5
.00000E+00      6   .00000E+00
      7   .00000E+00      8   .10000E+01      9   .10000E+01     10   .10000E+01     11
.10000E+01     12   .00000E+00
     13    10000E+01     14   .10000E+01     15   .10000E+01     16    10000E+01     17
.00000E+00     18   .00000E+00
     19    00000E+00     20   .00000E+00     21   .00000E+00     22   .00000E+00     23
.00000E+00     24   .00000E+00
```

*** ISCST2 - VERSION 93109 *** *** An Example Superfund Site for the ISCST2 Model
*** 10/12/94
***
*** 07:59:09

PAGE 8
*** MODELING OPTIONS USED. CONC RURAL ELEV DFAULT

* SOURCE EMISSION RATE SCALARS WHICH VARY FOR EACH HOUR OF THE
DAY *

HOUR SCALAR HOUR SCALAR HOUR SCALAR HOUR SCALAR HOUR
SCALAR HOUR SCALAR
- -
- - - - - - - - - - - - - - - - - - -

SOURCE ID = PILE1A . SOURCE TYPE = VOLUME :
1 .00000E+00 2 .00000E+00 3 .00000E+00 4 .00000E+00 5
.00000E+00 6 .00000E+00
7 .00000E+00 8 .10000E+01 9 .10000E+01 10 .10000E+01 11
.10000E+01 12 .10000E+01
13 .10000E+01 14 .10000E+01 15 .10000E+01 16 .10000E+01 17
00000E+00 18 .00000E+00
19 .00000E+00 20 .00000E+00 21 .00000E+00 22 .00000E+00 23
.00000E+00 24 .00000E+00

SOURCE ID = PILE1B : SOURCE TYPE = VOLUME :
1 .00000E+00 2 .00000E+00 3 .00000E+00 4 .00000E+00 5
.00000E+00 6 .00000E+00
7 00000E+00 8 .10000E+01 9 .10000E+01 10 .10000E+01 11
.10000E+01 12 .10000E+01
13 .10000E+01 14 .10000E+01 15 .10000E+01 16 .10000E+01 17
.00000E+00 18 .00000E+00
19 .00000E+00 20 .00000E+00 21 .00000E+00 22 .00000E+00 23
.00000E+00 24 .00000E+00

SOURCE ID = PILE2A . SOURCE TYPE = VOLUME :
1 .00000E+00 2 .00000E+00 3 .00000E+00 4 .00000E+00 5
.00000E+00 6 .00000E+00
7 .00000E+00 8 .10000E+01 9 .10000E+01 10 .10000E+01 11
.10000E+01 12 .10000E+01
13 .10000E+01 14 .10000E+01 15 .10000E+01 16 .10000E+01 17
.00000E+00 18 .00000E+00
19 .00000E+00 20 .00000E+00 21 .00000E+00 22 .00000E+00 23
.00000E+00 24 .00000E+00

SOURCE ID = PILE2B : SOURCE TYPE = VOLUME .

```
     1   .00000E+00      2   .00000E+00      3   .00000E+00      4   .00000E+00      5
.00000E+00      6   .00000E+00
     7   .00000E+00      8   .10000E+01      9   .10000E+01     10   .10000E+01     11
.10000E+01     12    10000E+01
    13    10000E+01     14   .10000E+01     15    10000E+01     16   .10000E+01     17
.00000E+00     18   .00000E+00
    19   .00000E+00     20   .00000E+00     21    00000E+00     22    00000E+00     23
.00000E+00     24   .00000E+00


SOURCE ID = PILE3A    :  SOURCE TYPE =   VOLUME :
     1   .00000E+00      2   .00000E+00      3   .00000E+00      4   .00000E+00      5
.00000E+00      6   .00000E+00
     7   .00000E+00      8   .10000E+01      9   .10000E+01     10   .10000E+01     11
.10000E+01     12   .10000E+01
    13    10000E+01     14   .10000E+01     15   .10000E+01     16   .10000E+01     17
.00000E+00     18   .00000E+00
    19   .00000E+00     20   .00000E+00     21   .00000E+00     22   .00000E+00     23
.00000E+00     24   .00000E+00
```

```
*** ISCST2 - VERSION 93109 ***    *** An Example Superfund Site for the ISCST2 Model
             ***         10/12/94
                                     ***
             ***         07:59.09

                         PAGE   9
*** MODELING OPTIONS USED.  CONC   RURAL  ELEV          DFAULT


                           * SOURCE EMISSION RATE SCALARS WHICH VARY FOR EACH HOUR OF THE
DAY *


    HOUR    SCALAR      HOUR    SCALAR      HOUR    SCALAR      HOUR    SCALAR      HOUR
SCALAR      HOUR    SCALAR
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - -


SOURCE ID = PILE3B   ;  SOURCE TYPE =   VOLUME :
     1   .00000E+00      2    00000E+00      3   .00000E+00      4   .00000E+00      5
.00000E+00      6    00000E+00
     7   .00000E+00      8   .10000E+01      9   .10000E+01     10   .10000E+01     11
.10000E+01     12   .10000E+01
    13   .10000E+01     14   .10000E+01     15   .10000E+01     16   .10000E+01     17
.00000E+00     18   .00000E+00
    19   .00000E+00     20   .00000E+00     21   .00000E+00     22   .00000E+00     23
.00000E+00     24   .00000E+00
```

*** MODELING OPTIONS USED. CONC   RURAL ELEV   DFAULT

*** GRIDDED RECEPTOR NETWORK SUMMARY ***

*** NETWORK ID: GRID1   ; NETWORK TYPE: GRIDCART ***

*** X-COORDINATES OF GRID ***
(METERS)

```
      -1000 0.    -900.0,    -800 0.    -700.0,    -600.0,    -500.0,    -400.0,    -300.0,
 -200.0,    -100.0,
         0.0,     100.0,     200.0,     300.0,     400.0,     500.0,     600.0,     700.0,
  800.0,     900.0,
      1000.0,
```

*** Y-COORDINATES OF GRID ***
(METERS)

```
      -1000.0,    -900.0,    -800 0.    -700 0.    -600.0,    -500.0,    -400.0,    -300.0,
 -200.0,    -100.0,
         0.0,     100.0,     200.0,     300 0,     400.0,     500.0,     600.0,     700.0,
  800.0,     900.0,
      1000.0,
```

*** ISCST2 - VERSION 93109 ***   *** An Example Superfund Site for the ISCST2 Model
*** 10/12/94
***
*** 07:59:09

PAGE 11

*** MODELING OPTIONS USED. CONC RURAL ELEV DFAULT

*** NETWORK ID. GRID1 : NETWORK TYPE: GRIDCART ***

* ELEVATION HEIGHTS IN METERS *

Y-COORD (METERS)	X-COORD (METERS) -1000.00	-900 00	-800.00	-700.00	-600.00	-500.00	-400.00	-300 00	-200.00
1000.00	15.00	15.00	15.00	15 00	15.00	15.00	15.00	15.00	15.00
900.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
800.00	15.00	15.00	15.00	15.00	15.00	15.00	15 00	15 00	15.00
700 00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
600.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15 00
500.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
400.00	0 00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
300.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00
100.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0 00	0 00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00
-100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00
-200.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-300.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-400.00	0 00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00
-500.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

-600.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0 00
-700.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00
-800.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-900.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-1000.00	0 00	0.00	0.00	0.00	0 00	0 00	0.00	0.00	0.00

*** ISCST2 - VERSION 93109 ***   *** An Example Superfund Site for the ISCST2 Model
*** 10/12/94
***
*** 07:59:09

PAGE 12

*** MODELING OPTIONS USED: CONC RURAL ELEV DFAULT

*** NETWORK ID: GRID1 ; NETWORK TYPE: GRIDCART ***

* ELEVATION HEIGHTS IN METERS *

Y-COORD (METERS)	X-COORD (METERS) -100 00	0.00	100.00	200 00	300.00	400 00	500.00	600.00	700.00
1000.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
900.00	15.00	15 00	15.00	15.00	15.00	15.00	15 00	15.00	15.00
800.00	15 00	15 00	15.00	15 00	15 00	15.00	15.00	15 00	15 00
700.00	15.00	15 00	15.00	15.00	15.00	15.00	15.00	15.00	15 00
600.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15 00
500.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
400.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00
300.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200.00	0.00	0.00	.0.00	0.00	0.00	0.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-200.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
-300.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-400.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-500.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

-600.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-700 00	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0 00	0.00
-800.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-900.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-1000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

*** MODELING OPTIONS USED   CONC   RURAL ELEV   DFAULT

*** NETWORK ID. GRID1   , NETWORK TYPE GRIDCART ***

* ELEVATION HEIGHTS IN METERS *

Y-COORD (METERS)	X-COORD (METERS) 800.00	900 00	1000 00
1000.00	15 00	15.00	15.00
900.00	15.00	15 00	15.00
800 00	15.00	15 00	15.00
700.00	15.00	15.00	15.00
600.00	15.00	15 00	15.00
500 00	15.00	15 00	15 00
400 00	0 00	0 00	0.00
300.00	0 00	0.00	0.00
200.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
0.00	0 00	0 00	0.00
-100.00	0.00	0.00	0.00
-200.00	0.00	0.00	0.00
-300.00	0.00	0 00	0.00
-400.00	0.00	0.00	0.00
-500.00	0.00	0.00	0.00
-600.00	0.00	0.00	0.00
-700.00	0 00	0.00	0.00
-800.00	0.00	0.00	0.00
-900 00	0 00	0 00	0.00
-1000.00	0.00	0.00	0.00

*** MODELING OPTIONS USED. CONC RURAL ELEV DFAULT

*** GRIDDED RECEPTOR NETWORK SUMMARY ***

*** NETWORK ID. GRID2 : NETWORK TYPE: GRIDCART ***

*** X-COORDINATES OF GRID ***
(METERS)

-3000.0, -2500.0, -2000 0, -1500 0, -1000.0, -500.0, 0.0, 500.0,
1000.0, 1500.0,
2000.0, 2500.0, 3000.0,

*** Y-COORDINATES OF GRID ***
(METERS)

-3000.0, -2500.0, -2000 0, -1500 0, -1000.0, -500.0, 0 0, 500.0,
1000 0, 1500 0,
2000.0, 2500.0, 3000.0,

*** MODELING OPTIONS USED: CONC RURAL ELEV DFAULT

*** NETWORK ID: GRID2 ; NETWORK TYPE. GRIDCART ***

* ELEVATION HEIGHTS IN METERS *

Y-COORD (METERS)	X-COORD (METERS) -3000 00	-2500 00	-2000 00	-1500.00	-1000.00	-500.00	0 00	500.00	1000.00
3000.00	15 00	15 00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
2500.00	15.00	15.00	15.00	15.00	15.00	15.00	15 00	15.00	15.00
2000.00	15 00	15 00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
1500.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
1000.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
500.00	15 00	15 00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00
-500.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-1000.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-1500.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-2000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-2500.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-3000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00

*** MODELING OPTIONS USED: CONC RURAL ELEV DFAULT

*** NETWORK ID: GRID2 ; NETWORK TYPE. GRIDCART ***

* ELEVATION HEIGHTS IN METERS *

Y-COORD (METERS)	X-COORD (METERS) 1500.00	2000.00	2500.00	3000.00
3000.00	15.00	15.00	15.00	15.00
2500.00	15.00	15.00	15.00	15.00
2000.00	15 00	15.00	15.00	15.00
1500.00	15.00	15 00	15.00	15.00
1000.00	15.00	15.00	15.00	15.00
500.00	15.00	15.00	15.00	15.00
0.00	0.00	0.00	0.00	0.00
-500.00	0.00	0.00	0.00	0.00
-1000.00	0.00	0.00	0.00	0.00
-1500.00	0.00	0.00	0.00	0.00
-2000.00	0.00	0 00	0.00	0.00
-2500.00	0.00	0.00	0.00	0.00
-3000.00	0.00	0.00	0.00	0.00

*** MODELING OPTIONS USED: CONC RURAL ELEV DFAULT

*** DISCRETE CARTESIAN RECEPTORS ***
(X-COORD, Y-COORD, ZELEV, ZFLAG)
(METERS)

(-150.0, -30.0, 0 0, 0 0), (-50 0, -30.0, 0 0, 0.0);

APPENDIX B

CHECKLIST OF MODELING CONSIDERATIONS

APPENDIX B

SUPERFUND AIR PATHWAY ANALYSIS

CHECKLIST OF MODELING INPUT REQUIREMENTS

I PHYSICAL CHARACTERISTICS OF THE SITE

- ☐ Has a plot plan of the site been acquired?
- ☐ Has the site boundary been identified on a topographic map?
- ☐ Have the topographic features and water bodies at the site and in the surrounding vicinity been identified?
- ☐ Have the soil and vegetation characteristics of the site and vicinity been identified?

II. SOURCE DEFINITION

A. Nature and Extent of Contamination

- ☐ Have the locations of the sources within the site boundary been identified?
- ☐ Have the contaminants from each source been identified?
- ☐ Has the emissions mode (continuous or instantaneous) been identified for each source?
- ☐ Has the physical state (gas or particle) of emissions to the atmosphere been identified?
- ☐ Have fugitive emission sources been identified?
- ☐ - Has the spatial extent of the source areas been well-defined?
- ☐ - Have sources been subdivided into appropriate line, volume, or area sources?
- ☐ Has the possibility of a dense-gas release been identified?
- ☐ Have any emissions control effects on source parameters been taken into account?
- ☐ Has the potential for building wake effects been addressed for point source emissions?

B. Emissions Estimation

CHECKLIST OF MODELING INPUT REQUIREMENTS (Continued)

- ☐ Have maximum emission rates for short-term impacts prediction been identified?
- ☐ Have average long-term emission rates been identified?
- ☐ Has the particle size distribution been estimated for deposition modeling?

III. METEOROLOGICAL DATA

- ☐ Have representative meteorological data for the site been identified?
- ☐ Do the meteorological data meet the U.S. Environmental Protection Agency (EPA) data quality and completeness requirements?
- ☐ Do climatological data for the site exist?
- ☐ Has worst-case meteorology been defined for models requiring a single set of meteorological variables?

IV. RECEPTOR DATA

- ☐ Have sensitive population receptors been identified?
- ☐ Have sensitive environmental areas (wildlife preserves, wilderness areas, etc.) been identified?
- ☐ If point sources are to be modeled, have elevated terrain receptors been considered?
- ☐ If exposure pathways other than inhalation are to be addressed, have adequate receptors been identified (e.g., receptors placed on nearby water bodies to account for potential exposure through the drinking water and fish consumption pathways)?

V. LAND USE CLASSIFICATION

- ☐ Has the land use within 3 kilometers of the site been classified as urban or rural, in accordance with EPA procedures?

VI. BACKGROUND CONCENTRATIONS

- ☐ Have any off-site contaminant sources been identified?
- ☐ Do background data exist from a past or existing air monitoring program in the vicinity of the site?

CHECKLIST OF MODELING INPUT REQUIREMENTS (Continued)

VII EXPOSURE ASSESSMENT

- ☐ Have all air-related local, state, and federal ambient applicable or relevant and appropriate requirements (ARARs) been identified?
- ☐ Does a population density map of the area exist?
- ☐ Have exposure pathways other than inhalation been considered?
- ☐ Have the uncertainties associated with the modeling technique been defined and their implications to the Air Pathway Assessment (APA) discussed?

APPENDIX C

BASIC REQUIREMENTS OF COMMONLY USED
DISPERSION MODELS FOR SUPERFUND APAs

APPENDIX C
BASIC REQUIREMENTS OF COMMONLY USED DISPERSION MODELS

Common Models	Principal Input	Principal Output	Major Assumptions
Screening			
TSCREEN SCREEN2 CTSCREEN[a]	Source • Emission rate • Height • Stack inner diameter (point source) • Gas exit velocity (point source) • Gas exit temperature (point source) • Building dimensions (point source) • Length of side of square (square area source) • Initial lateral dimension (volume source) • Initial vertical dimension (volume source) Receptor • Height (e.g., ground level or breathing zone) • Downwind distance from source • Terrain elevation (height above source elevation) Other • Urban/rural classification • Digitized terrain contours (CTSCREEN[a])	Maximum concentration and associated downwind distance (TSCREEN, SCREEN2) Maximum concentration over receptor grid (CTSCREEN[a])	Worst-case meteorology (TSCREEN, SCREEN2, CTSCREEN[a]) Short-term emissions occur simultaneously Maximum impacts are co-located

APPENDIX C
BASIC REQUIREMENTS OF COMMONLY USED DISPERSION MODELS
(Continued)

Common Models	Principal Input	Principal Output	Major Assumptions
Refined			
ISCST2 ISCLT2 COMPLEX I[b]	Source • Emission rate • Height • Location • Stack inner diameter (point source) • Gas exit velocity (point source) • Gas exit temperature (point source) • Building dimensions (point source) • Length of side of square (square area source) • Initial lateral dimension (volume source) • Initial vertical dimension (volume source) Meteorological Data • Hourly surface and mixing height data (ISCST2 and COMPLEX I[c]) • Joint frequencies of wind speed and stability class (STAR data) and average mixing heights and air temperature (ISCLT2) Receptor • Height (e.g., ground level or breathing zone) • Cartesian or Polar coordinates • Terrain elevation (height above source elevation) Other • Urban/rural classification	Concentrations at spatially distributed receptor points for varying averaging periods	Meteorological data reflect transport and dispersion conditions at the site (if data are not collected on site)

[a]Valid for receptors with terrain elevations above stack top.
[b]A complex terrain screening technique. Valid if used alone for receptors with terrain elevations above that of plume centerline. Otherwise, used in conjunction with a simple terrain model for receptors with terrain elevations above stack top, but below plume centerline (i.e., used for conducting an intermediate terrain analysis).
[c]Only on-site meteorological data should be used if this model is run outside of the VALLEY screening mode.

Notes:
ISCST2 = Industrial Source Complex Short-Term Model.
ISCLT2 = Industrial Source Complex Long-Term Model.

APPENDIX D

USEFUL CONTACTS AND TELEPHONE NUMBERS

APPENDIX D

USEFUL CONTACTS AND TELEPHONE NUMBERS

U S. ENVIRONMENTAL PROTECTION AGENCY (EPA) REGIONAL OFFICES

Each EPA regional office has the following staff positions:

- Air/Superfund Coordinator,
- Applicable or Relevant and Appropriate Requirements (ARARs) Coordinator; and
- Air Toxics Coordinator.

The Air/Superfund coordinator is the best single point of contact for air issues related to Superfund Sites The individuals in the staff positions listed above can be reached through the office switchboards at the following numbers:

Region	Location	Telephone
I	Boston	(617) 565-3420
II	New York	(212) 264-2657*
III	Philadelphia	(215) 597-9800
IV	Atlanta	(404) 347-2864
V	Chicago	(312) 353-2000
VI	Dallas	(214) 655-6444
VII	Kansas City	(913) 551-7000
VIII	Denver	(303) 293-1603
IX	San Francisco	(415) 744-1305
X	Seattle	(206) 442-1200

*Air Programs Branch x-2517

AIR/SUPERFUND PROGRAM CONTACT

The primary contact for the Air/Superfund program is Ms. Patricia Flores, Air/Superfund Coordinator of EPA Region III at (215) 597-9134.

DOCUMENT ORDERING INFORMATION

Documents can be obtained through the National Technical Information Service (NTIS) at (703) 487-4650. Information of Air/Superfund reports that are not yet in the NTIS system can be obtained from Environmental Quality Management at (919) 489-5299.

Other sources of documents include:

- EPA's Control Technology Center (CTC) at (919) 541-0800;
- EPA's Center for Environmental Research Information (CERI) at (513) 569-7562, and
- U S. Government Printing Office (USGPO) at (202) 783-3238.

OTHER USEFUL CONTACTS

Air and Waste Management Association (412) 232-3444.

APPENDIX E

BIBLIOGRAPHY OF NTGS DOCUMENTS

APPENDIX E

BIBLIOGRAPHY OF NATIONAL TECHNICAL GUIDANCE STUDY (NTGS) DOCUMENTS

ASF-1 Eklund. B Procedures for Conducting Air Pathway Analyses for Superfund Activities, Interim Final Document: Volume 1 - Overview of Air Pathway Assessments for Superfund Sites (Revised) EPA-450/1-89-001a. February 1993.

ASF-2 Schmidt, C., et al Procedures for Conducting Air Pathway Analyses for Superfund Activities, Interim Final Document, Volume 2 - Estimation of Baseline Air Emissions at Superfund Sites (Revised). EPA-450/1-89-002a (NTIS PB90-270588). August 1990.

ASF-3 Eklund, B., et al. Procedures for Conducting Air Pathway Analyses for Superfund Activities, Interim Final Document: Volume 3 - Estimation of Air Emissions From Clean-up Activities at Superfund Sites. EPA-450/1-89-003 (NTIS PB89-180061/AS). January 1989.

ASF-4 Hendler, A., et al. Procedures for Conducting Air Pathway Analyses for Superfund Activities, Interim Final Document: Volume 4 - Guidance for Ambient Air Monitoring at Superfund Sites. EPA-451/R-93-007 (NTIS PB93-199214). May 1993.

ASF-5 U.S. EPA. Procedures for Conducting Air Pathway Assessments for Superfund Sites, Interim Final Document: Volume 5 - Dispersion Modeling. [Proposed document]

ASF-6 TRC Environmental Consultants. A Workbook of Screening Techniques For Assessing Impacts of Toxic Air Pollutants. EPA-450/4-88-009 (NTIS PB89-134340) September 1988

ASF-7 Salmons, C., F. Smith, and M. Messner. Guidance on Applying the Data Quality Objectives For Ambient Air Monitoring Around Superfund Sites (Stages I & II). EPA-450/4-89-015 (NTIS PB90-204603/AS). August 1989.

ASF-8 Pacific Environmental Services. Soil Vapor Extraction VOC Control Technology Assessment. EPA-450/4-89-017 (NTIS PB90-216995). September 1989.

ASF-9 TRC Environmental Consultants. Review and Evaluation of Area Source Dispersion Algorithms for Emission Sources at Superfund Sites. EPA-450/4-89-020 (NTIS PB90-142753). November 1989.

ASF-10 Letkeman, J. Superfund Air Pathway Analysis Review Criteria Checklists. EPA-450/1-90-001 (NTIS PB90-182544/AS). January 1990.

ASF-11 Smith, F., C. Salmons, M. Messner, and R. Shores. Guidance on Applying the Data Quality Objectives For Ambient Air Monitoring Around Superfund Sites (Stage III). EPA-450/4-90-005 (NTIS PB90-204611/AS). March 1990.

ASF-12 Saunders, G. Comparisons of Air Stripper Simulations and Field Performance Data. EPA-450/1-90-002 (NTIS PB90-207317). March 1990.

ASF-13 Damle, A.S., and T.N. Rogers. Air/Superfund National Technical Guidance Study Series: Air Stripper Design Manual. EPA-450/1-90-003 (NTIS PB91-125997). May 1990.

ASF-14 Saunders, G. Development of Example Procedures for Evaluating the Air Impacts of Soil Excavation Associated with Superfund Remedial Actions. EPA-450/4-90-014 (NTIS PB90-255662/AS). July 1990.

ASF-15 Paul, R. Contingency Plans at Superfund Sites Using Air Monitoring. EPA-450/1-90-005 (NTIS PB91-102129). September 1990.

ASF-16 Stroupe, K., S Boone, and C. Thames. User's Guide to TSCREEN - A Model For Screening Toxic Air Pollutant Concentrations. EPA-450/4-90-013 (NTIS PB91-141820). December 1990.

ASF-17 Winges, K D . User's Guide for the Fugitive Dust Model (FDM)(Revised), User's Instructions. EPA-910/9-88-202R (NTIS PB90-215203, PB90-502410). January 1991.

ASF-18 Thompson, P., A. Ingles, and B. Eklund. Emission Factors For Superfund Remediation Technologies EPA-450/1-91-001 (NTIS PB91-190-975). March 1991.

ASF-19 Eklund, B., C. Petrinec, D. Ranum, and L. Howlett. Database of Emission Rate Measurement Projects -Draft Technical Note. EPA-450/1-91-003 (NTIS PB91-222059). June 1991.

ASF-20 Eklund, B., S. Smith, and M. Hunt. Estimation of Air Impacts For Air Stripping of Contaminated Water. EPA-450/1-91-002 (NTIS PB91-211888), May 1991 (Revised August 1991).

ASF-21 Mann, C. and J. Carroll. Guideline For Predictive Baseline Emissions Estimation Procedures For Superfund Sites. EPA-450/1-92-002 (NTIS PB92-171909). January 1992.

ASF-22 Eklund, B., S. Smith, P. Thompson, and A. Malik. Estimation of Air Impacts For Soil Vapor Extraction (SVE) Systems. EPA-450/1-92-001 (NTIS PB92-143676/AS). January 1992.

ASF-23 Carroll, J. Screening Procedures For Estimating the Air Impacts of Incineration a Superfund Sites. EPA-450/1-92-003 (NTIS PB92-171917). February 1992.

ASF-24 Eklund, B., S. Smith, and A. Hendler. Estimation of Air Impacts For the Excavation of Contaminated Soil. EPA-450/1-92-004 (NTIS PB92-171925), March 1992.

ASF-25 Draves, J. and B. Eklund. Applicability of Open Path Monitors for Superfund Site Cleanup. EPA-451/R-92-001 (NTIS PB93-138154). May 1992.

ASF-26 U S. EPA. Assessing Potential Air Impacts for Superfund Sites. EPA-451/R-92-002. September 1992.

ASF-27 Hueske, K., B. Eklund, and J. Barnett. Evaluation of Short-Term Air Action Levels for Superfund Sites. EPA-451/R-93-009. April 1993.

ASF-28 Ranum, D. and B. Eklund. Compilation of Information on Real-Time Air Monitors for Use at Superfund Sites. EPA-451/R-93-008. April 1993.

ASF-29 U.S. EPA. Air Emissions From Area Sources: Estimating Soil and Soil-Gas Sample Number Requirements. EPA-451/R-93-002. March 1993.

ASF-30 Eklund, B. and C. Albert. Models For Estimating Air Emission Rates From Superfund Remedial Actions. EPA-451/R-93-001. March 1993.

ASF-31 U.S. EPA. Contingency Analysis Modeling for Superfund Sites and Other Sources. EPA-454/R-93-001. 1993.

ASF-32 Eklund, B., C. Thompson, and S. Mischler. Estimation of Air Impacts From Area Sources of Particulate Matter Emissions at Superfund Sites. EPA-451/R-93-004. April 1993

ASF-33 Dulaney, W . B Eklund, C Thompson, and S. Mischler. Estimation of Air Impacts For Bioventing Systems Used at Superfund Sites. EPA-451/R-93-003. April 1993

ASF-34 Eklund, B . C. Thompson, and S Mischler. Estimation of Air Impacts For Solidification and Stabilization Processes Used at Superfund Sites. EPA-451/R-93-006. April 1993.

ASF-35 Dulaney, W . B. Eklund, C. Thompson, and S. Mischler. Estimation of Air Impacts For Thermal Desorption Systems Used at Superfund Sites. EPA-451/R93-005. April 1993

ASF-36 Options for Developing and Evaluating Mitigation Strategies for Indoor Air Impacts at CERCLA Sites. EPA-451/R-93-012 April 1993.

Affiliated Reports

Eklund, B , et al. Control of Air Emissions From Superfund Sites. Final Revised Report. EPA/625/R-92-012. U.S. EPA, Center for Environmental Research Information. November 1992

APPENDIX F

CONTAINER/ACUTE RELEASES

APPENDIX F

CONTAINER/ACUTE RELEASES

At some Superfund sites, buried drums containing liquid or cylinders containing gas liquified under pressure may be encountered. During remediation activities, these items may accidentally be punctured, causing a pollutant release. Characterizing the release in such cases may be complicated, requiring knowledge of the source conditions at the time of release and the thermodynamic properties of the released material. The source parameters such as emission rate, exit velocity, and exit temperature are highly dependent on release characterization. The remainder of this section discusses some of the main concepts involved with characterizing these types of releases.

For an air pathway assessment, it is ultimately the emissions to the atmosphere that drive the predicted impacts. For a punctured drum or cylinder, the pollutant may be initially released as a liquid that consequently evaporates and enters the atmosphere as a gas. Therefore, it is important to understand how the gas emission rate for this source may be determined.

Each source of emissions can be defined by its pre-release, at-release, and post-release conditions. The conditions prior to the release can determine the possible conditions at the time of release. In turn, the at-release conditions can determine the possible conditions occurring after the release. The primary pre-release conditions are:

- Phase (solid, liquid, or gas);
- Temperature; and
- Pressure.

Figure F-1 shows a flowchart describing the high-level partitioning of the release class by the pre-release phase state. The analysis cannot continue unless one of the state variables is known. If one or two state variables are known, the other variables can be estimated through the use of the flowcharts in Figures F-2, F-3, and F-4.

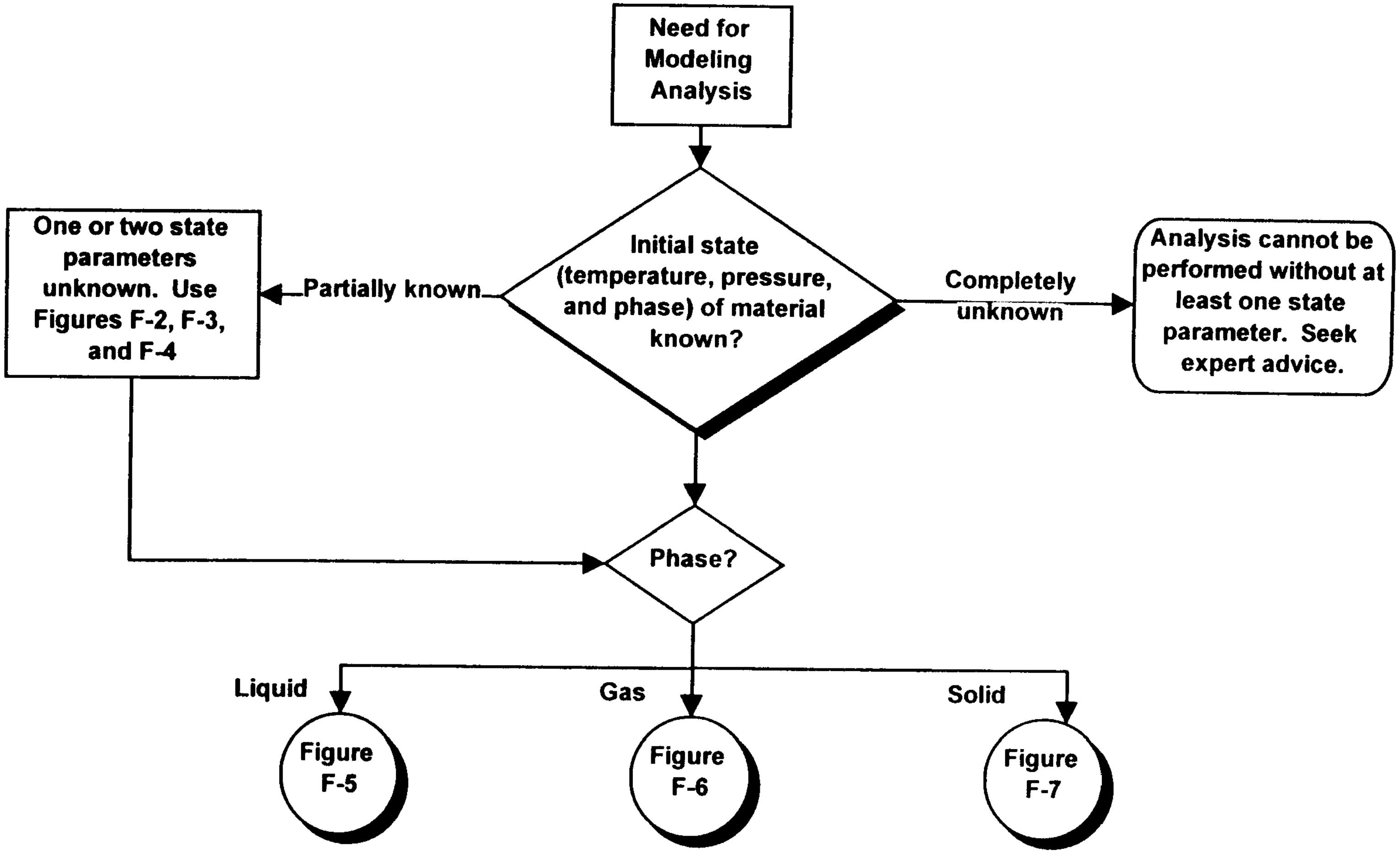


Figure F-1. Scenario/Release Class Identification

T = storage temperature
P = storage pressure
P3 = triple point pressure
T3 = triple point temperature

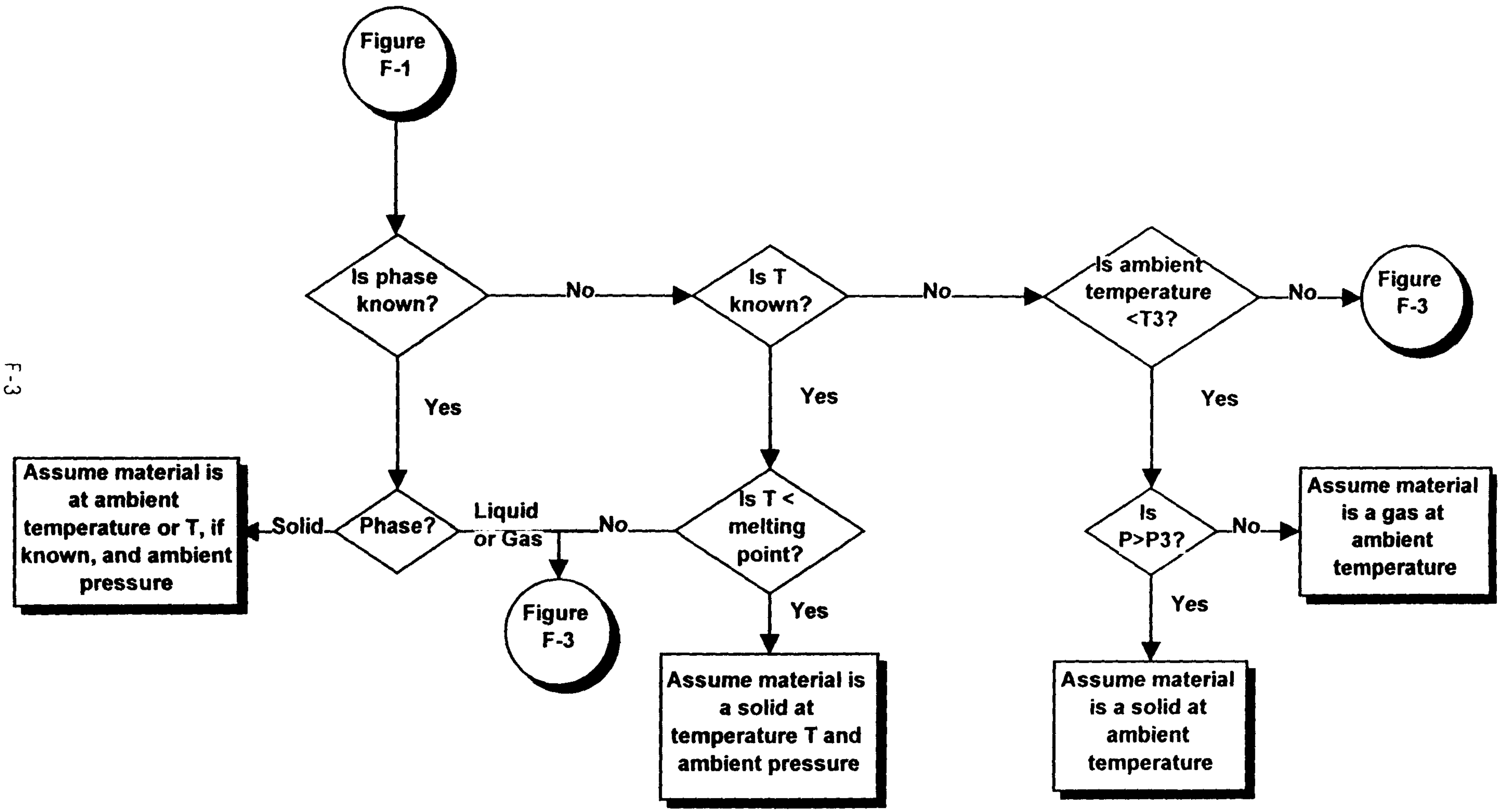


Figure F-2. Phase, temperature, and pressure determination for a solid (continue to Figure F-3 for liquid or gas)

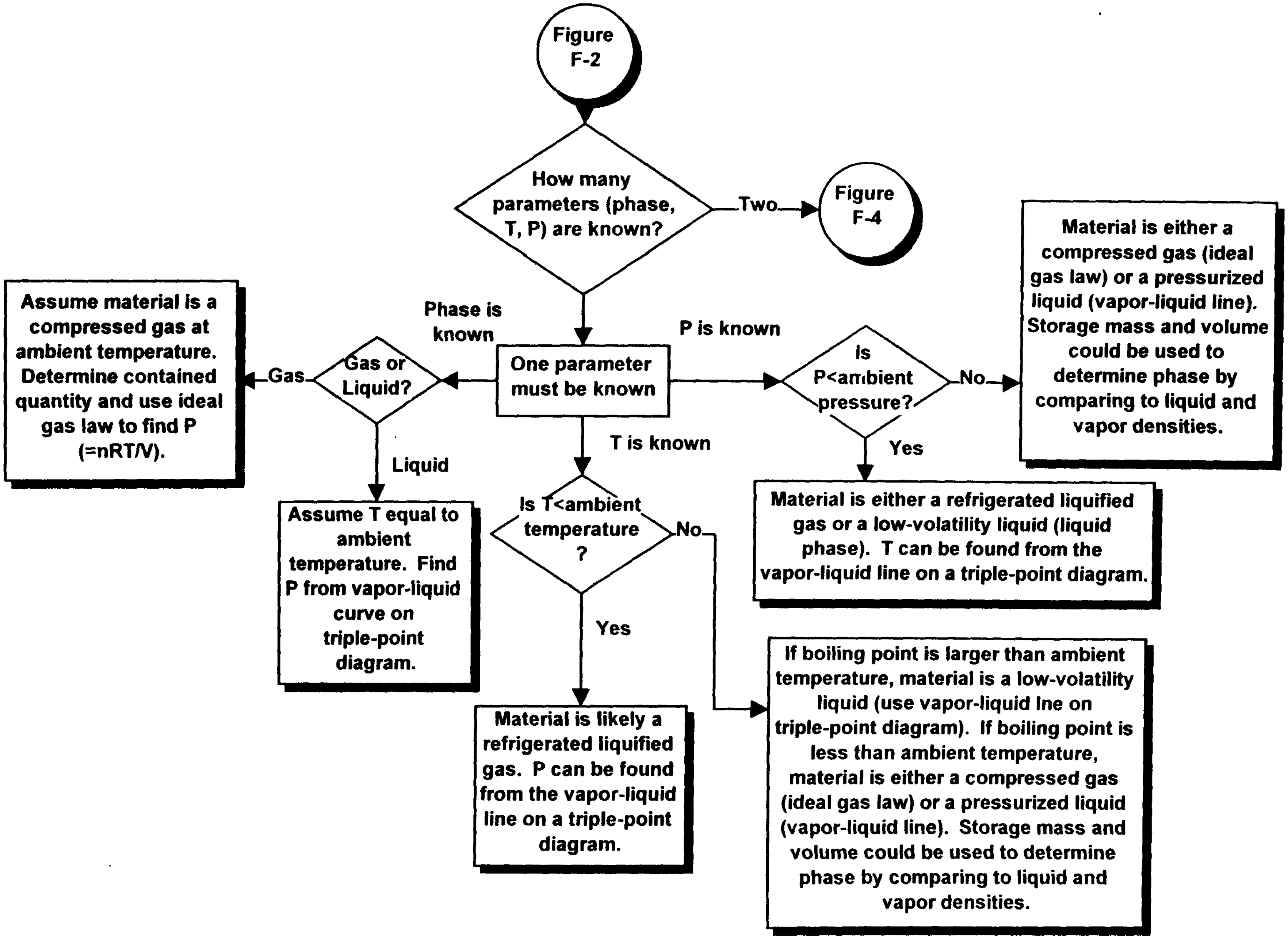


Figure F-3. Phase, temperature, and pressure determination for a stored liquid or gas with one parameter known

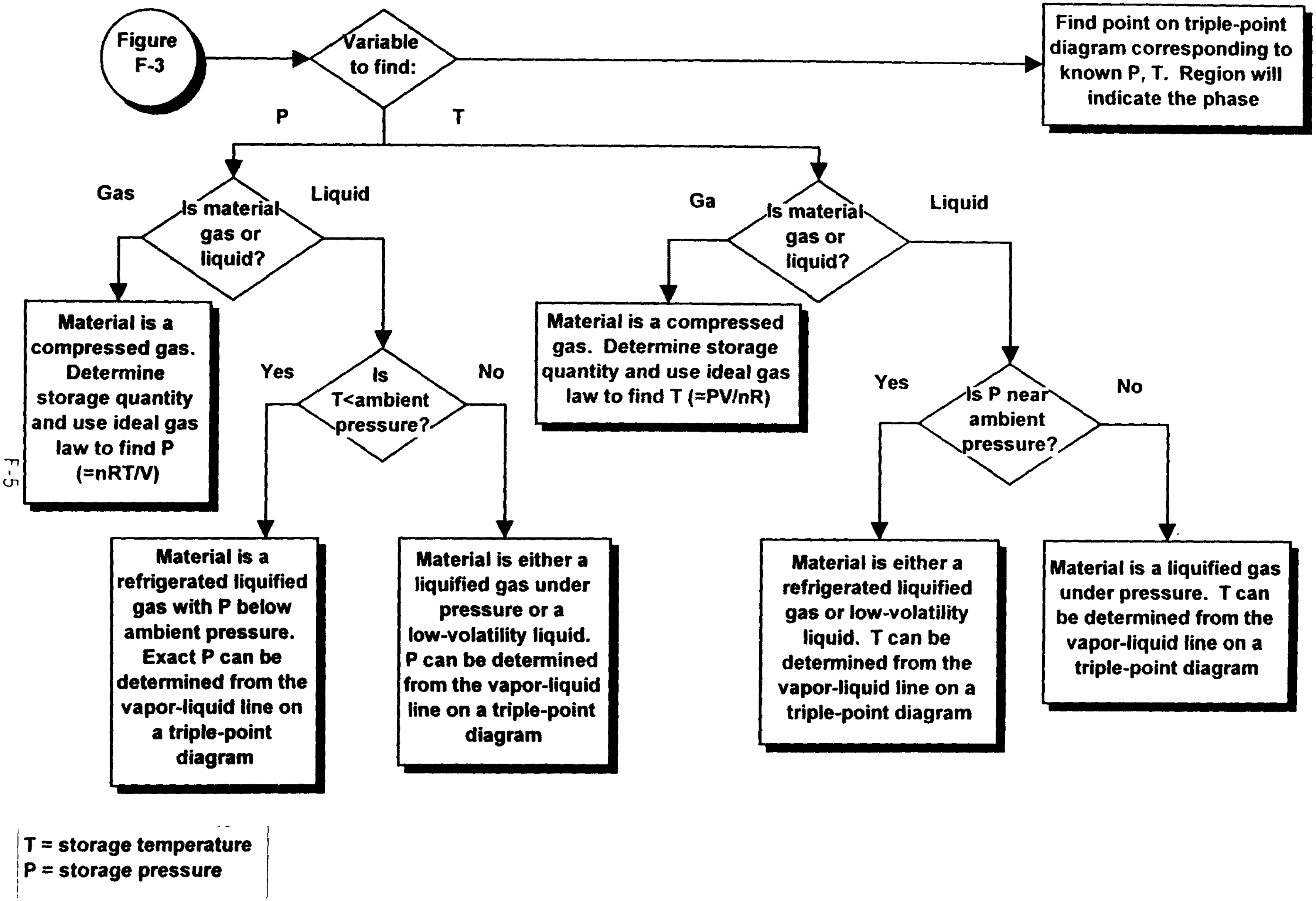


Figure F-4. Phase, temperature, and pressure determination for a stored liquid or gas with two parameters known

Figure F-2 attempts to determine whether the pre-release state is a solid. If it is a solid but no other state information is known, the material may be assumed to be at ambient temperature and pressure. If the temperature is known and phase is unknown, the temperature can be compared to the melting point of the material. If the temperature is below the melting point, it can be assumed that the material is a solid. If the material is not a solid, the flow passes to Figure F-3 for determining whether the pre-release state is liquid or gas. (Figures F-3 and F-4 refer to triple-point diagrams A triple-point diagram for a particular compound represents the equilibrium relationship between all three phases [liquid, gas, and solid] at any given pressure and temperature.)

Conditions at the time of a release can be determined given the pre-release conditions. The at-release conditions are those parameters normally supplied to an air dispersion model. The conditions at the time of release normally required or assumed include:

- Phase;
- Emission rate;
- Temperature; and
- Density.

Determining the at-release conditions requires calculation using the pre-release conditions and thermodynamic properties of the material being released.

The post-release conditions refer to what may happen to an emission as it leaves the source or after it has dispersed in the atmosphere. Normally, concentration impacts are the major concern at a Superfund site. However, if the emitted material is flammable and an ignition source is present, a fire or explosion may occur. If large quantities are released, the effects from thermal radiation and/or shockwaves associated with a fire or explosion may be of sufficient concern to be considered.

A release class is a combination of pre- and at-release conditions. The two primary guidance documents containing discussion and flowcharts for determining release classes are Contingency Analysis Modeling For Superfund Sites and Other Sources.[1] and Guidance on the Application of Refined Dispersion Models to Hazardous/Toxic Air Pollutant Releases.[2]

Once a release class has been determined, a model can be selected for simulation of the release. The calculations performed in the referenced documents are not designed for a specific model. Rather, the calculations provide a number of parameters, all or some of which may be needed by a specific model.

DETERMINING THE RELEASE CLASS OF A STORED LIQUID

For material stored in the liquid phase, the material's boiling point provides an indication of the types of release classes that can be expected to result from a given release scenario. Further determination of the release class, specifically the amount of flashing of a pressurized liquid release, can also be made. A "flash diagram" may be used to determine the approximate fraction of liquid that will flash to vapor during a release.

A flash diagram is constructed by use of the equation shown below.

$$F = \frac{C_{pl}(T_s - T_b)}{\lambda}$$

where:

F	=	flash fraction (dimensionless);
Cpl	=	liquid heat capacity at T_s (J/kg K);
T_s	=	storage temperature (K);
T_b	=	normal boiling point (K);
λ	=	heat of vaporization at T_b (J/kg);
J	=	Joule;
K	=	Kelvin; and
kg	=	kilogram.

When T_s is below T_b, the flash fraction is set to zero. The flash fraction cannot be larger than 1. When T_s is greater than the temperature given by the equation,

$$T_s = \frac{\lambda}{C_{pl}} + T_b$$

the flash fraction should be set to 1.

The value of the flash fraction can be used to indicate whether the release is two-phase (liquid and gas). Further, a comparison of the boiling point of the chemical with the ambient temperature can be made to determine whether the release is a high-volatility or low-volatility spill. If the boiling point is lower than the ambient temperature, the release should be considered one of high volatility. If the boiling point is higher than the ambient temperature, a low-volatility release is assumed. Determining whether the liquid release is two-phase, high-volatility or low-volatility allows the user to choose the appropriate liquid release option in TSCREEN[3] (i.e., the user must know what the release class is before proceeding with the screening analysis).

To be conservative, the two-phase release may be assumed to lead to a totally suspended mixture of gas and liquid droplets. No liquid pool is assumed to form and then evaporate. The high-volatility release may be assumed to have the liquid immediately vaporize into gas upon release. The low-volatility release may be assumed to form a pool that then evaporates. No flashing and no aerosol formation are assumed to occur. Figure F-5 illustrates the determination of a liquid release class from a container.

DETERMINING THE RELEASE CLASS OF A STORED GAS

For material stored in the gas phase, it must first be determined if there is choked flow. A calculation is made to define the critical pressure that is then compared to the ambient pressure.

The calculation for determining if there is choked flow is:

$$\frac{p_*}{p_s} = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{(\gamma-1)}}$$

where:

p_* = the critical pressure (Pa);

Pa = pascal (a unit of pressure)

γ = the ratio of the gas phase specific heat at constant pressure to that at constant volume; and

p_s = storage pressure (Pa).

Tb = Normal boiling point
F = Flash fraction

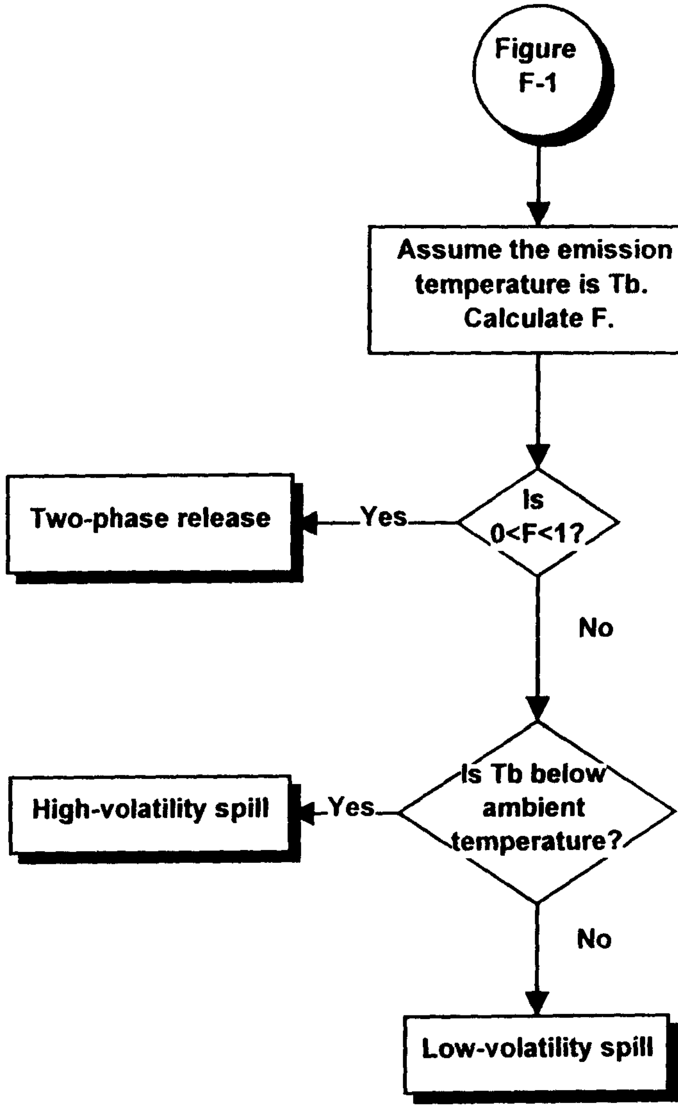


Figure F-5. Determination of a liquid release class from a container

If p_* is greater than or equal to the ambient pressure (p_a), then the flow should be considered choked. If p_* is less than p_a, then the flow is not choked.

The next step for determining the class for a stored gas release involves determination of a reference temperature (T_{ref}) and pressure (p_{ref}) indicative of the conditions at the hole. The assumption is made that the release is two-phase, so that these reference values can be checked against the chemical's properties for consistency. If all calculated values are internally consistent, the release is two-phase. If there is an inconsistency, the release is a single-phase gas release.

The method of determining the reference temperature and pressure depends on whether or not the flow is choked. If the flow is choked, then the reference pressure is equal to the critical pressure, and the temperature at choke conditions (T_*) must be determined. This calculation is derived from the Clausius-Clapeyron equation given as:

$$p_* = p_a \exp\left[\frac{\lambda M}{R}\left(\frac{1}{T_b} - \frac{1}{T_*}\right)\right]$$

where:

p_a	=	ambient pressure (Pa);
λ	=	heat of vaporization at T_b (J/kg);
J	=	joule
K	=	Kelvin
Kg	=	Kilogram
kmol	=	kilomole
Pa	=	pascal (unit of pressure)
M	=	molecular weight (kg/kmol);
R	=	gas constant = 8314 J/kmol K;
T_b	=	normal boiling point (K); and
T_*	=	temperature at choked conditions (K).

The above equation can be solved for T_*, which results in the following equation.

$$T_* = \left[\frac{1}{T_b} - \frac{R}{\lambda M}\ln\left(\frac{p_*}{p_a}\right)\right]^{-1}$$

The values of p_* and T_* could then be set to reference values p_{ref} and T_{ref}.

If the flow is unchoked, the reference pressure (p_{ref}) is equal to the ambient pressure (p_a). The reference temperature (T_{ref}), is set to the unchoked release temperature, (T_{rel}), which for unchoked flow is equal to T_b. The value of T_* is derived in the same manner as for the choked flow but the value of p_* is equal to p_a. With p_* equal to p_a, the above equation for T_* reduces to $T_* = T_b$.

Once the reference temperature and reference pressure have been determined, they can be used to determine whether the release is two-phase (i.e., whether any condensation occurs during the release). This is done by performing two checks to determine whether the release is single-phase. If both checks prove negative, the release is two-phase. The first check is to compare the reference temperature to the critical temperature of the chemical. If the reference temperature is greater than the critical temperature, the release is single-phase. If not, the second check must be performed. In this check, if the vapor pressure of the chemical (which must be externally calculated from the chemical data) at the reference temperature is greater than the reference pressure, then the release is single-phase. Otherwise, the release is two-phase. Figure F-6 illustrates the determination of a gas release class from a container.

DETERMINING THE RELEASE CLASS OF A SOLID

Figure F-7 describes the logic in determining the release class from a solid. There are only two classes considered here: vapor release from soil and from burning tires. The document Contingency Analysis Modeling For Superfund Sites and Other Sources[1] contains guidance on calculating emissions from these sources.

Tref = Reference temperature
Pref = Reference pressure
Tc = Critical temperature

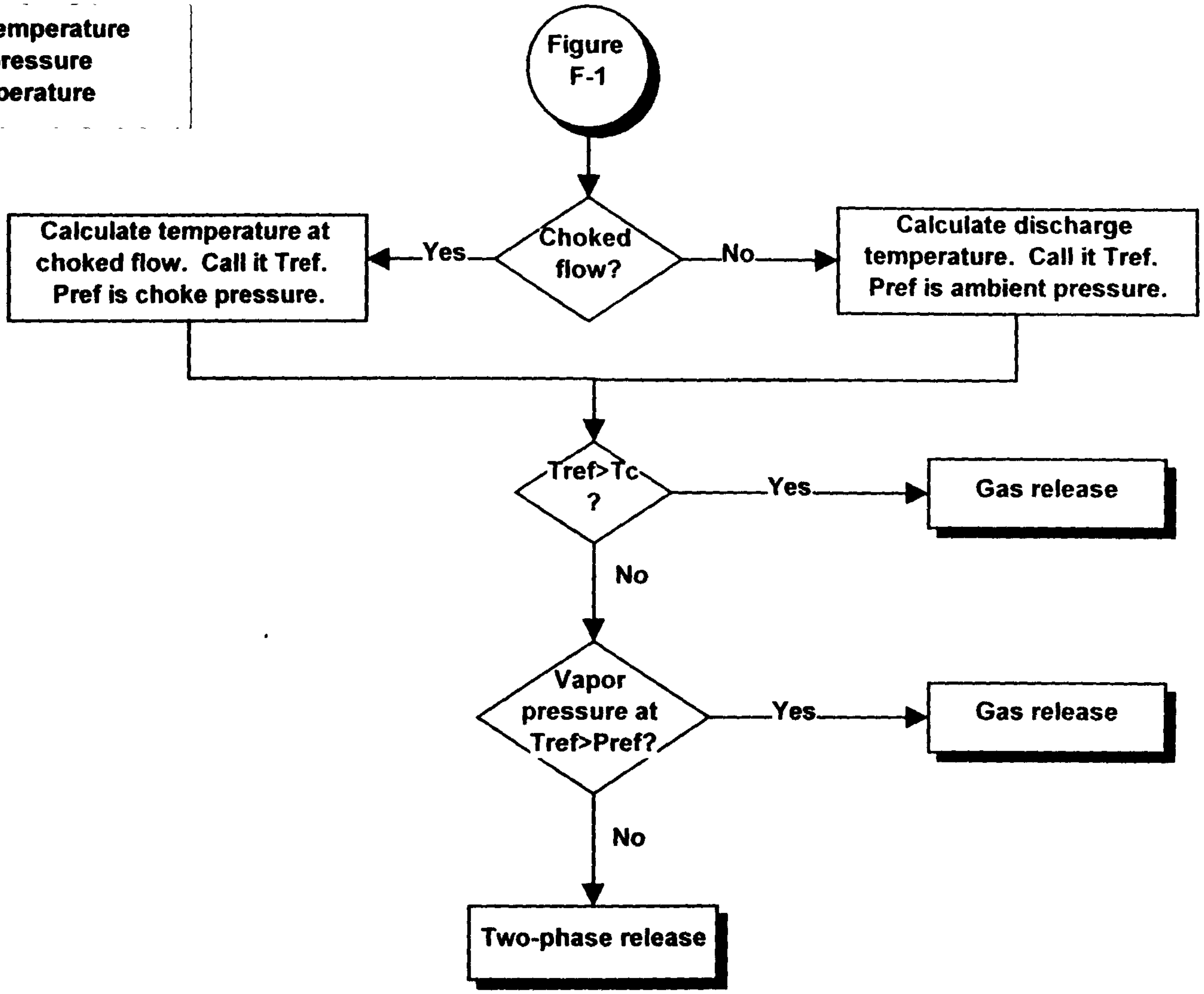


Figure F-6. Determination of a gas release class from a container

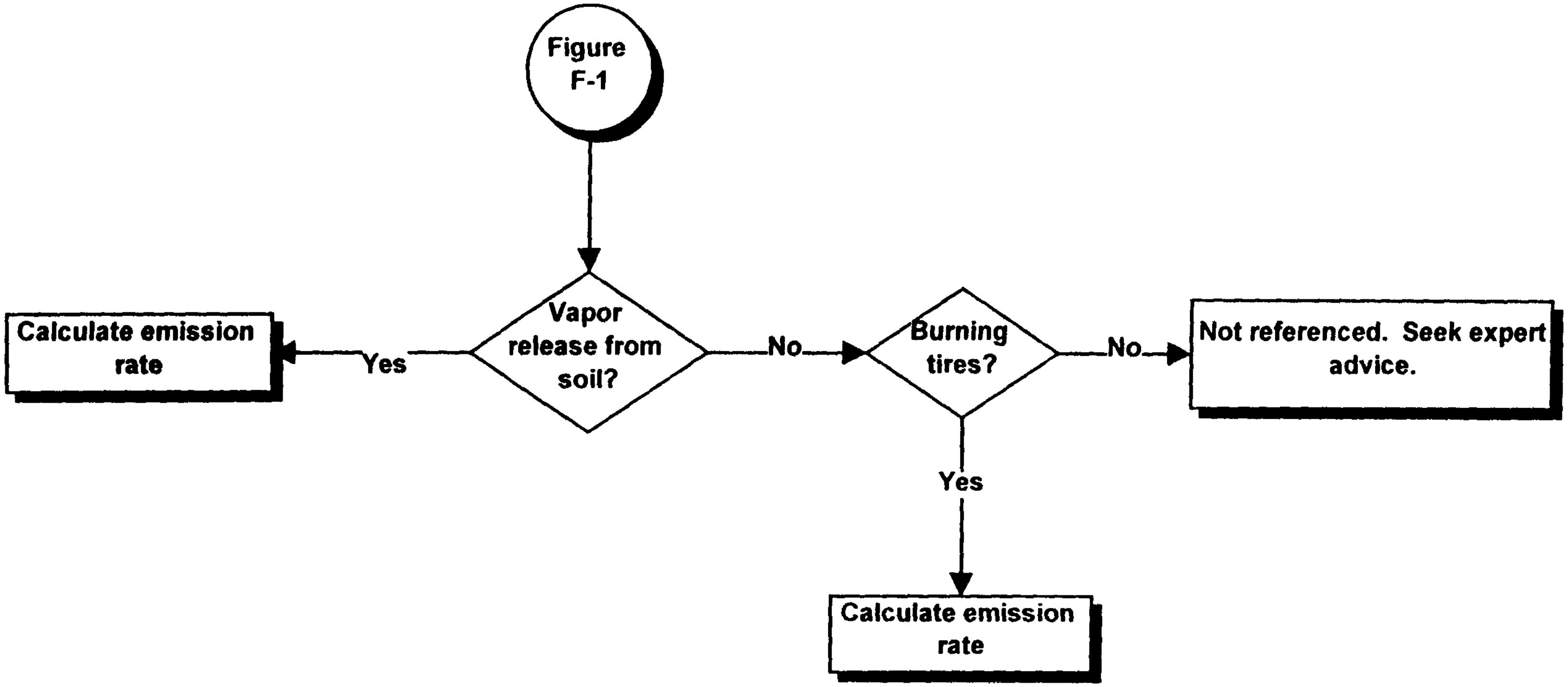


Figure F-7. Determination of a release class from a solid

REFERENCES

1. U.S. Environmental Protection Agency, 1993. Contingency Analysis Modeling for Superfund Sites and Other Sources. EPA-454/R-93-001. Office of Air Quality Planning and Standards, Office of Air and Radiation, Research Triangle Park, North Carolina.

2. U.S. Environmental Protection Agency, 1993. Guidance on the Application of Refined Dispersion Models to Hazardous/Toxic Air Pollutant Releases. EPA-454/R-93-002. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

3. U S. Environmental Protection Agency, 1994. User's Guide to TSCREEN, A Model for Screening Toxic Air Pollutant Concentrations (Revised). EPA-454/3-94-023. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

TECHNICAL REPORT DATA
(Please read Instructions on reverse before completing)

1. REPORT NO. EPA-454/R-95-003	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Air/Superfund National Technical Guidance Study Series - Volume V-Procedures for Air Dispersion Modeling At Superfund Sites		5. REPORT DATE February 1995
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Radian Corporation 8501 Mo-Pac Boulevard Austin, Texas 78759		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO. EPA Contract No. 68-D30033
12. SPONSORING AGENCY NAME AND ADDRESS U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Technical Support Division Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED Final Report
		14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES EPA Work Assignment Manager: Jawad S. Touma		

16. ABSTRACT

This manual is the fifth in a five-volume series dealing with air pathway assessments at hazardous waste sites. It is an update of the air dispersion modeling discussion in the original Volume IV of this series. Air pathway assessments involve complex procedures requiring the use of professional judgment. This manual provides for flexibility in tailoring the air pathway analysis to the specific conditions of each site. It offers technical guidance for use by a diverse audience including EPA Air and Superfund Regional and Headquarters staff, State Air and Superfund program staff, Federal and State remedial and removal contractors, and potentially responsible parties in analyzing air pathways at hazardous waste sites. It is written to serve the needs of individuals having different levels of scientific training and experience in designing, conducting, and reviewing air pathway analyses. Because assumptions and judgements are required in many parts of the analysis, the individuals conducting air pathway analyses need a strong technical background in air emission measurements, modeling, monitoring, and risk assessment. Remedial Project Managers, On-Scene Coordinators, and the Regional Air program staff, supported by the technical expertise of their contractors, should use this guide when establishing data quality objectives and the appropriate scientific approach to air pathway analysis.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Superfund Air Pathway Analysis Dispersion Modeling		
18. DISTRIBUTION STATEMENT Release Unlimited	19. SECURITY CLASS *(Report)* Unclassified	21. NO. OF PAGES 170
	20. SECURITY CLASS *(Page)* Unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE