

TECHNICAL REPORT DATA
(Please read instructions on the reverse before completing)

1. REPORT NO. EPA-450/1-89-002a	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Air/Superfund National Technical Guidance Study Series. Volume II - Estimation Of Baseline Air Emissions At Superfund Sites.	5. REPORT DATE August 1990	
	6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S) Bart Eklund and Charles Schmidt	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. 68-02-4392	
12. SPONSORING AGENCY NAME AND ADDRESS U.S. Environmental Protection Agency OAR, OAQPS Research Triangle Park, NC 27711	13. TYPE OF REPORT AND PERIOD COVERED Interim Final	
	14. SPONSORING AGENCY CODE	

15. SUPPLEMENTARY NOTES
EPA Project Officer: Anne A. Pope

16. ABSTRACT

This report presents available methods for estimating air emissions at Superfund hazardous waste sites prior to any remedial action. Methods described include direct emission measurement techniques, indirect measurements and predictive emissions modeling. Information is provided on selecting from among the range of methods available given the associated range of costs and uncertainties. This report revises and expands an earlier report, Procedures For Conducting Air Pathway Analyses For Superfund Activities, Volume II, Estimation Of Baseline Air Emissions At Superfund Sites, EPA-450/1-89-002. It is one in a series of reports that provide guidance on conducting air pathway analysis at Superfund hazardous waste sites.

The purpose of this report is to assist EPA Air and Superfund staff, State Air Superfund program staff, Federal and State remedial and removal contractors, potentially responsible parties and others in designing, conducting, and reviewing air pathway analyses at undisturbed hazardous waste sites.

17. KEY WORDS AND DOCUMENT ANALYSIS		
2. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Superfund Hazardous Waste Sites Air Pathway Analysis Emissions		
18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 390
	20. SECURITY CLASS (This page) Unclassified	22. PRICE

EPA-450/1-89-002a

August 1990

**AIR/SUPERFUND NATIONAL TECHNICAL GUIDANCE
STUDY SERIES. VOLUME II - ESTIMATION OF
BASELINE AIR EMISSIONS AT SUPERFUND SITES**

*** This document revises earlier edition, EPA-450/1-89-002.**

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U. S. ENVIRONMENTAL PROTECTION AGENCY

Office Of Air and Radiation

Office Of Air Quality Planning And Standards

Research Triangle Park, North Carolina 27711

PREFACE

This report revises and expands an earlier report, Procedures For Conducting Air Pathway Analyses For Superfund Activities, Volume II, Estimation Of Baseline Air Emissions At Superfund Sites, EPA 450/1-89-002. It is one in a series of reports that provide guidance on conducting air pathway analysis at Superfund hazardous waste sites. It was developed for the Office of Air Quality Planning and Standards in cooperation with the Office of Emergency and Remedial Response (Superfund).

This report have been reviewed by the National Technical Guidance Study Technical Advisory Committee, State agencies, various groups within the U.S. Environmental Protection Agency, and the private sector. It provides technical guidance for use by a diverse audience including EPA Air and Superfund Regional and Headquarters staff, State Air Superfund program staff, Federal and State remedial and removal contractors, and potentially responsible parties in analyzing air pathways at hazardous waste sites. This report is written to serve the needs of individuals having different levels of scientific training and experience in designing, conducting and reviewing air pathway analyses. Remedial Project Managers, On Scene Coordinators, and the Regional Air program staff, supported by the technical expertise of their contractors, will use this volume when developing baseline emission estimates for undisturbed hazardous waste sites.

Because assumptions and judgments are required in many parts of an air pathway analysis, an analysis requires a strong technical background in air emission estimation methods, measurements, modeling and monitoring. Air pathway analyses cannot be reduced to simple "cookbook" procedures. Therefore, this volume is designed to be flexible, allowing the use of professional judgment. The procedures presented in this report are intended solely for technical guidance. They 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.

This edition of Volume II will be periodically updated to incorporate new data and information on air pathway analysis procedures. The Agency reserves the right to act at variance with these procedures and to change them as new information and technical tools become available on air pathway analyses without formal public notice. The Agency will, however, attempt to make any revised or updated manual available to those who currently have a copy through the registration form included with the report.

Copies of this report are available as supplies permit, through the Library Services Office (MD-35), U.S. EPA, MD-35, Research Triangle Park, NC 27711 or from the National Technical Information Services, 5285 Port Royal Road, Springfield, VA 22161.

This report has been reviewed by the Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, and has been approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

EPA 450/1-89-002a

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GLOSSARY OF FREQUENTLY USED TERMS AND ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists, 6500 Glenway Ave., Building D-5, Cincinnati, OH 45211.
Adsorption	A physical process in which molecules of gas, dissolved substances, or liquids adhere in an extremely thin layer to the surfaces of solid bodies with which they are in contact.
Air Monitoring	A gas phase sampling technique where ambient air is sampled. It can be used to develop emission rate estimates and is similar to indirect emission measurement except measurements usually are taken at greater distances from the waste site.
APA	Air Pathway Analyses. APA are designed to assess the potential for air emissions from a hazardous waste site.
BEEs	Baseline Emission Estimates. These are estimates of baseline emission rates from a hazardous waste site in its undisturbed conditions.
Calibration	Establishment of a relationship between the response of a measurement system obtained by introducing various calibration standards into the system. The calibration levels should bracket the range of levels for which actual measurements are to be made.
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980. Modified by SARA in 1986. The Acts created a special tax that goes into a trust fund, commonly known as Superfund, to investigate and clean up abandoned or uncontrolled hazardous waste sites.
Co-disposal Site	A waste site that has received and mixed municipal and hazardous wastes.
Detection Limit	The minimum quantity of a compound which yields a "measurable response." Measurable response has many statistical definitions. Be careful to differentiate "instrumental detection limit," which refers to the minimum quantity of material introducible into a measurement system that can be detected, from "method detection limit," which means the minimum concentration of a compound in a sample which, when put through the entire sampling and analysis process, can be detected.
Direct Emissions Measurement	A measurement made directly on or above the waste to determine the emission rate of volatile species from a liquid or solid surface.

Disturbed Condition	Changes in a hazardous waste site as remediation takes place that usually involve increasing the emission rate of volatile species and particulate matter.
Emissions	The total of substances discharged into the air from a discrete source.
EPA	U.S. Environmental Protection Agency.
FS	Feasibility Study. Analysis and selection of alternative remedial actions for hazardous waste sites.
Fugitive Dust	Atmospheric dust arising from disturbance of granular matter exposed to the air; called "fugitive" because it is not released to the atmosphere in a confined flow stream.
Hazardous	Those wastes that are regulated or "listed" under RCRA (40 CFR Part 261) or wastes that are ignitable, corrosive, reactive, or toxic.
In-depth Technologies	Very detailed methods for measuring emissions. These technologies produce detailed, reliable data.
Indicator Species	Species found in hazardous waste that can be used to represent a group of species in determining emissions from a site.
Indirect Emissions Measurement	A gas phase sampling technology that measures ambient air concentrations at short distances down-wind of a hazardous waste site. Data are collected to satisfy specific needs of specialized models used to estimate air emissions.
Lagoon	In this manual, lagoon encompasses surface impoundments or impoundments designed to hold liquid wastes or wastes containing free liquids.
Landfill	For purposes of this manual, a landfill is a facility, usually an excavated pit, into which wastes are placed for permanent disposal.
mg/m ³	Milligrams per cubic meter. This is a measure of mass per unit volume. The units mg/m ³ are commonly used to describe concentrations of particulates, dusts, fumes, and mists.
NIOSH	National Institute for Occupation Safety and Health, Centers for Disease Control, Public Health Service, U.S Department of Health and Human Services.
NPL	National Priorities List. A list of waste sites for which EPA has assessed the relative threat of site contamination on soil, air, surface water, ground water, and the population at risk. Site listing is found under CERCLA (Section 105) and is updated three times a year.

OSHA	Occupational Safety and Health Administration, U.S. Department of Labor.
OVA	Organic vapor analyzer.
Particulate Matter	Airborne solid or liquid matter.
PEL	OSHA permissible exposure limit, expressed as ppm or mg/m ³ of substance in air.
ppb	Parts per billion.
ppm	Parts per million.
Probe	A tube used for gas phase concentration sampling or for measuring pressures at a distance from the actual collection or measuring apparatus.
Quality Assurance	A system of activities designed to assure that the quality control system is performing adequately.
Quality Control	A system of specific efforts designed to test and control the quality of data obtained.
RI	Remedial Investigation. Field investigations of hazardous waste sites to determine pathways and nature and extent of contamination.
RPM	Remedial Project Manager, equivalent to a site manager at non-NPL sites.
Sampling	The process of withdrawing or isolating a fractional part of the whole. In air or gas analysis, it is the separation or a portion of an ambient atmosphere with or without the simultaneous isolation of selected components.
SARA	Superfund Amendments and Reauthorization Act. Modifications of CERCLA enacted on October 17, 1986.
Screening Technologies	Quick and simple methods for estimating baseline emissions.
Undisturbed Condition	The condition in which a hazardous waste site is discovered or may be left if a no-action remedial alternative is selected.
VOCs	Volatile organic compounds. An organic compound (containing carbon) that evaporates (volatilizes) readily at room temperature.

ACKNOWLEDGEMENTS

This manual was prepared for the U.S. Environmental Protection Agency by Radian Corporation. Mr. Leigh Hayes (project manager) and Ms. Susan Fernandes (contract manager) managed the project. Dr. Charles E. Schmidt served as the original project director and author of several sections. Other contributors included Mr. John Clark, Mr. Mark Galloway, Ms. Susan Penner, and Mr. Bart Eklund. Revisions to the document were made by Mr. Bart Eklund and Mr. Doug Orr.

Mr. Joe Padgett and his staff at the Office of Air Quality Planning and Standards (OAQPS), U.S. Environmental Protection Agency, provided overall program direction. Ms. Margaret McDonough and Mr. Tom D'Avanzo, of the U.S. EPA Air Management Division, Region I, along with Ms. Anne Pope of EPA-OAQPS directed efforts on this particular manual.

Other support was provided by the program's Technical Advisory Committee, the members of which include:

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- Mr. Wayne Kaiser, U.S. EPA Region VII
- Mr. Tom Pritchett, U.S. EPA Emergency Response Team
- Mr. David Dunbar, PEI Associates, Inc.
- Mr. Bart Eklund, Radian Corporation

This program also received support from the Regional Air Superfund Program and its participants.

SECTION 1 INTRODUCTION

1.1 BACKGROUND

The United States Environmental Protection Agency (EPA) is responsible for the assessment and cleanup of the National Priority List (NPL) sites under CERCLA and SARA. EPA's Remedial Program Managers (RPMs) are required to assess the potential for air emissions and air quality impacts caused by NPL sites prior to and during cleanup. To date, no standard approach for assessing the air pathway at NPL or other hazardous waste sites has been available. As a result, performing air pathway analyses (APA) has been less straightforward than evaluating other pathways such as the impacts on ground water or surface water quality. This manual assists RPMs in determining if an uncontrolled site has the potential for significant air emissions and, if so, how to characterize the baseline air emissions potential from the site.

This volume is one in a series of manuals prepared for EPA to assist its RPMs in the assessment of the air contaminant pathway and developing input data for risk assessment. Volume I (1) of the series provides generalized guidance for addressing air issues throughout the overall Superfund process. This manual (Volume II) provides guidance on developing baseline emission estimates for hazardous waste sites. Baseline emission estimates (BEEs) are defined as emission rates estimated for a site in its undisturbed state. Volume III (2) provides guidance on estimating emissions from cleanup activities, and Volume IV (3) provides guidance on ambient air monitoring and on dispersion modeling. Together these four manuals provide a complete treatment of air issues for superfund applications.

CERCLA and SARA mandate the characterization of all contaminant migration pathways from the waste or hazardous material to the environment and evaluation of the resulting environmental impacts. However, air pathway analyses are often overlooked because many sites have little or no perceptible air emissions in their baseline or undisturbed state. Even low level emissions, however, may be significant if toxic or carcinogenic compounds are present. Also, emissions during clean-up may be much higher than baseline emissions. Emissions of potential concern include volatile and semi-volatile organics, acid gases, particulate matter, and toxics associated with windblown particulate matter such as metals, PCBs and dioxins.

A remedial investigation is typically necessary to provide data on air emissions from the site. These emission can be measured directly, or estimated indirectly from chemical and physical data collected during the RI and used as inputs to predictive models. Remedial investigations (RIs) often include ambient air monitoring to assess baseline air quality impacts from the site, but measurements of emission rates or soil-gas concentrations are less widely employed. An introduction to these techniques is a major emphasis of this manual. Emission rate or soil-gas data can be useful for: 1) identifying "hot spots" e.g. areas of higher than average waste content or pockets of subsurface gases, 2) serving as model inputs (source terms) to estimate ambient air concentrations under meteorological conditions other than those encountered during the RI, and 3) estimating emissions during remediation. For this last use, the air emissions investigation during the RI stage would include emission measurements of both the undisturbed wastes and the exposed or disturbed wastes.

While not strictly part of baseline emission estimates, measurements of emissions from exposed or disturbed wastes can generally be performed during the RI using the same techniques presented in this manual for performing baseline emission measurements. These data along with the BEEs can be used in the procedures outlined in Volume III of this series to help evaluate remediation options, design an engineering approach to the site mitigation, and determine whether air emission control technologies or an air monitoring program may be necessary as part of the remedial alternatives.

1.2 OBJECTIVES

The overall objective of this manual is to assist RPMs or site managers in assessing the impacts on air quality from undisturbed sites. Specifically the manual is intended to:

- Present a protocol for selecting the appropriate level of effort to characterize baseline air emissions.
- Assist site managers in designing an approach for estimating baseline emissions.
- Identify available methods for developing site-specific baseline emission estimates (BEEs).

1.3 APPROACH

To meet the objectives of this program, three steps were undertaken to compile and assess existing information: 1) Conduct a literature search, 2) Perform a survey of key researchers, and 3) Review and evaluate the collected information. This work served as the basis for developing the protocol for estimating air emission factors for remediation presented herein. Each step of the approach is discussed below.

A computer-assisted search of 15 databases was performed to identify published literature of potential interest. Keywords were formulated into a search strategy to identify abstracts related to both baseline and remedial emissions. Approximately 1400 abstracts were reviewed, and over one hundred publications were identified as pertinent and obtained by staff librarians.

The literature search was augmented by a telephone survey to locate and access unpublished data or research in progress. A list of contacts was developed that included regional EPA personnel, employees of EPA research offices, EPA contractors, university researchers, and referrals from those initially contacted. A set of questionnaires was used to put the responses obtained during the phone survey in a standard format.

The collected information was reviewed and evaluated with respect to its applicability to estimating baseline air emissions from NPL and other hazardous waste sites.

1.4 RECOMMENDED USES OF THIS MANUAL

This manual is, to the extent possible, a complete, stand-alone document. It is, however, intended to complement existing guidance manuals for the Superfund program.

This manual has certain limitations:

- The manual is a decision making tool but it is not intended to relieve the site managers of their decision making responsibility.
- The protocol is not a "cookbook" for designing air pathway investigations or for determining BEEs.
- The determination of BEEs for a site will not by itself, yield an assessment of actual or potential air impacts, but it is a useful part of that evaluation process.

The steps in the overall NPL site clean-up process are shown in Figure 1. The primary intended use for this manual (Volume II) is for estimating air impacts as part of the evaluation of the undisturbed site. Therefore the manual's guidance is input to the record of decision (ROD) step, as well as, the RI/FS step.

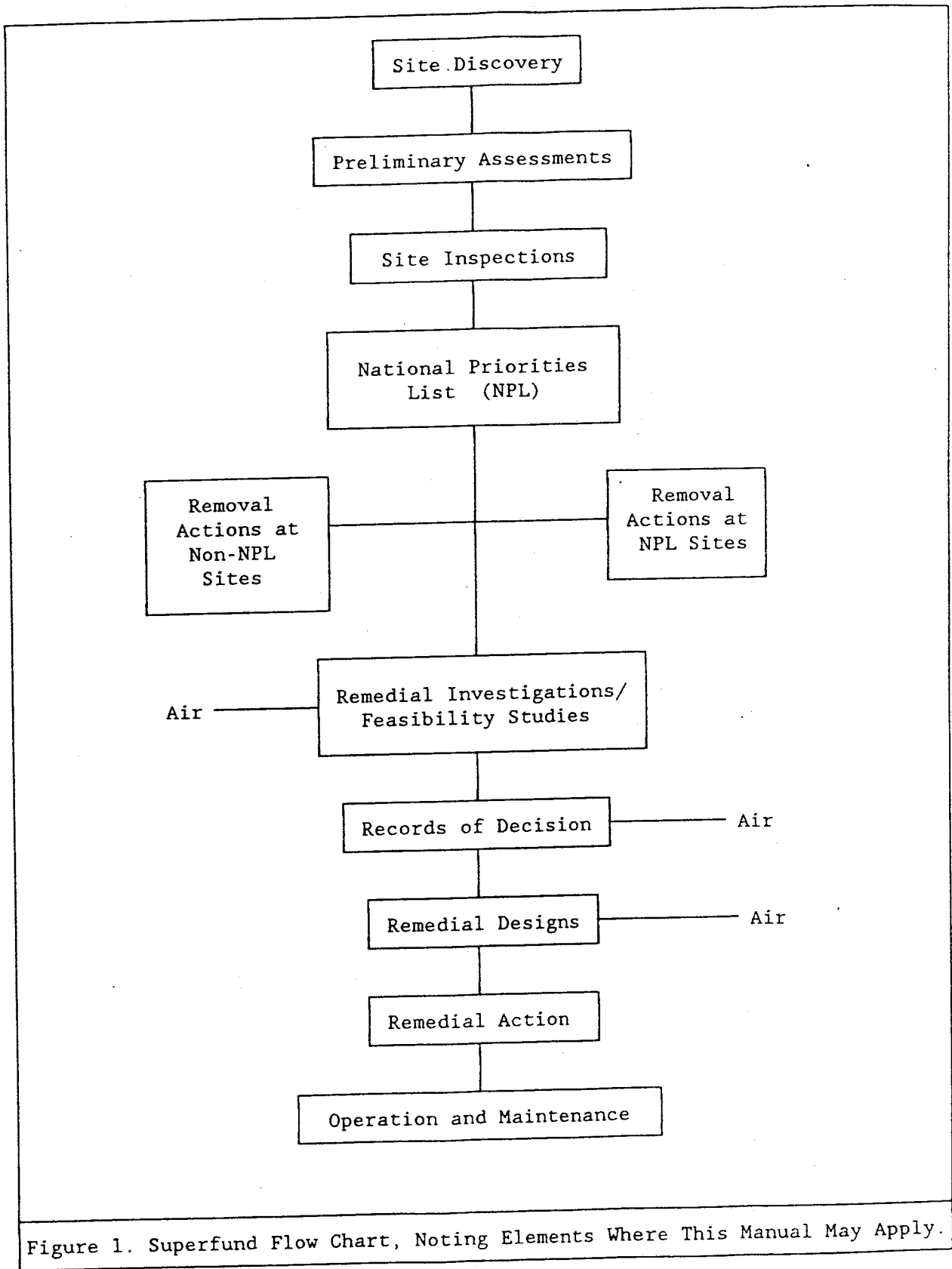


Figure 1. Superfund Flow Chart, Noting Elements Where This Manual May Apply.

Furthermore, this manual provides the important function of standardizing the air pathway analysis (APA) for baseline NPL sites, thereby ensuring that a uniform and systematic approach is followed for the diverse universe of NPL sites. The manual provides a protocol for estimating air quality impacts resulting from undisturbed sites. For each step, a three-tiered approach is presented. The approaches in order of preference are:

1. Use of site-specific field data;
2. Use of predictive models using site-specific inputs;
3. Use of tabulated default values when site-specific information is unavailable.

Therefore, emissions can be estimated regardless of the state of knowledge regarding a given site. Of course, the confidence of the emissions estimates depends on the associated confidence of the inputs to the estimation procedure.

Limitations of the emissions estimation procedures should be borne in mind. The primary limitation is that the data quality of any emissions estimate is dependent on the data quality of the inputs and on the quality of the assumptions that are made. The use of site-specific data as input to the estimation procedure is preferable to the use of predictive models, which in turn are preferable to the use of tabulated generic emission factors. Data of known quality (confidence) should be used whenever available. In many cases, the conceptual site model will be developed from a limited database. The resulting estimates of volume of contaminated material, the type of contaminants present, the concentration of the contaminants, etc. will have large associated uncertainties. Therefore any emissions derived from such data will have an even larger overall uncertainty.

1.5 DOCUMENT ORGANIZATION

There are five remaining sections to Volume II. General information on the potential for air contaminant emissions from hazardous waste sites is presented in Section 2. Section 3 offers a protocol for determining if BEEs are required and how to develop site-specific BEEs. Information on sampling methods that can be used to obtain BEEs is provided in Section 4. Section 5 describes case studies in which BEEs were needed and/or determined for hazardous waste sites. References are given in Section 6.

An annotated bibliography of the information reviewed for this project is included as Appendix A. Appendix B identifies chemical and physical properties of waste material that may affect its emissions potential. A guide to developing an overall emission rate from individual emission rate measurements is included as Appendix C. Information on databases containing potential input values for predictive models is given in Appendix D. Descriptions of remote sensing systems are contained in Appendix E.

SECTION 2

AIR EMISSIONS FROM HAZARDOUS WASTE SITES

This section presents information on landfills and lagoons, the two general types of sites used in this manual to demonstrate methods for estimating the potential for air emissions. For this manual, all types of uncontrolled solid waste sites, land disposal sites in particular, will be referred to as "landfills" and all types of uncontrolled liquid waste sites will be referred to as "lagoons." The estimation methods described for application to landfills and lagoons may generally be applied to solid and liquid hazardous waste, respectively.

This section addresses potential emission sources and potential air quality impacts. Discussion of potential air quality impacts covers the general types of air quality impacts by waste site category, and the basic transport mechanisms involved with the movement of contamination from lagoons and landfills. Where not otherwise specified, the general term hazardous waste site is used to refer to both landfills and lagoons that contain hazardous wastes and/or substances. Figures 2 and 3 depict these two types of sites in generalized schematic drawings.

The site and contaminant characteristics discussed below are general background information for working with the protocol presented in Section 3. The information provided will assist the site manager in developing conceptual models of landfills and lagoons. Based on this conceptual understanding, the site manager can then develop strategies for assessing the potential impacts and for estimating potential air emissions from these sites. The references cited in this section and those listed in the annotated bibliography contain further background material.

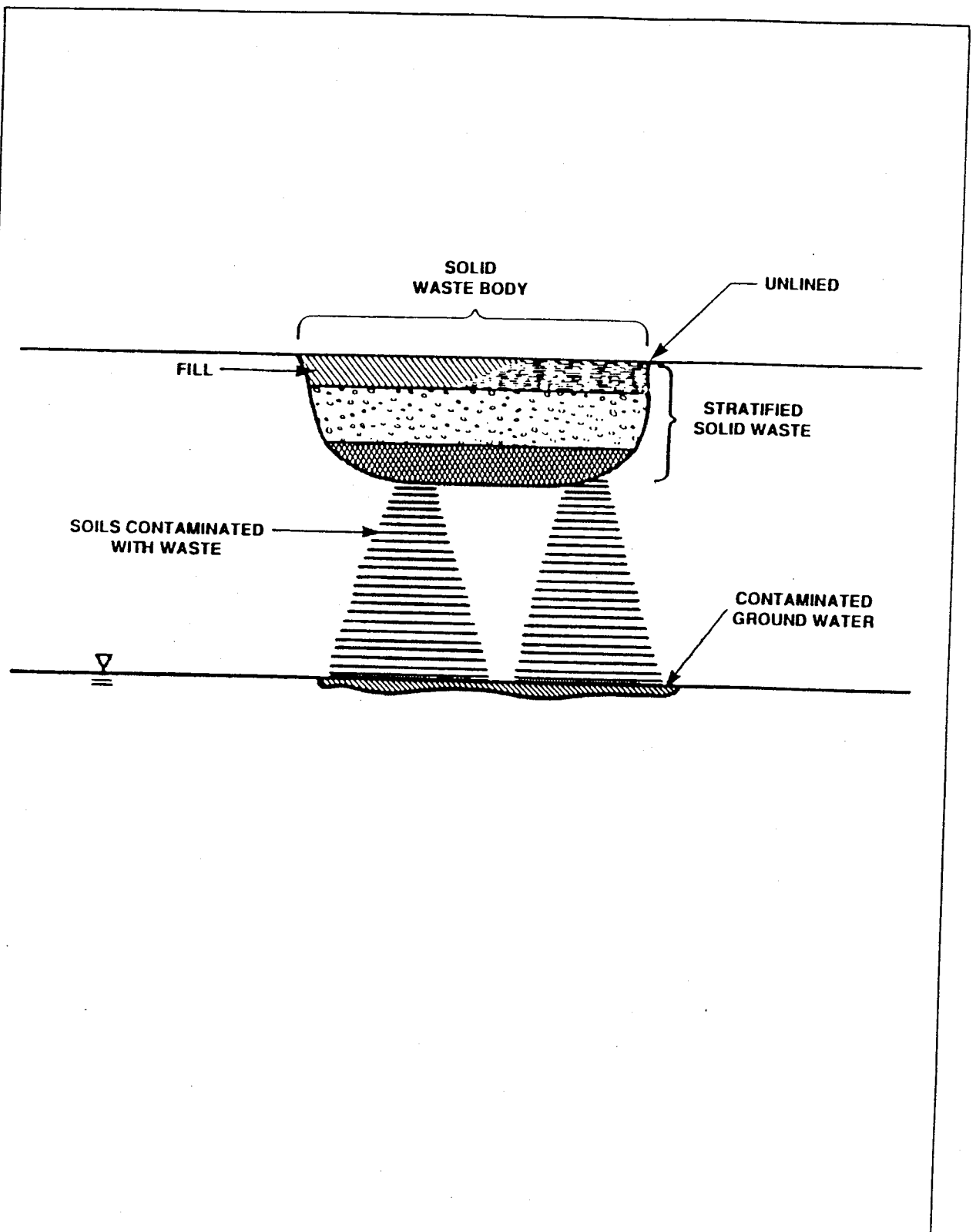


Figure 2. Conceptual schematic of a landfill.

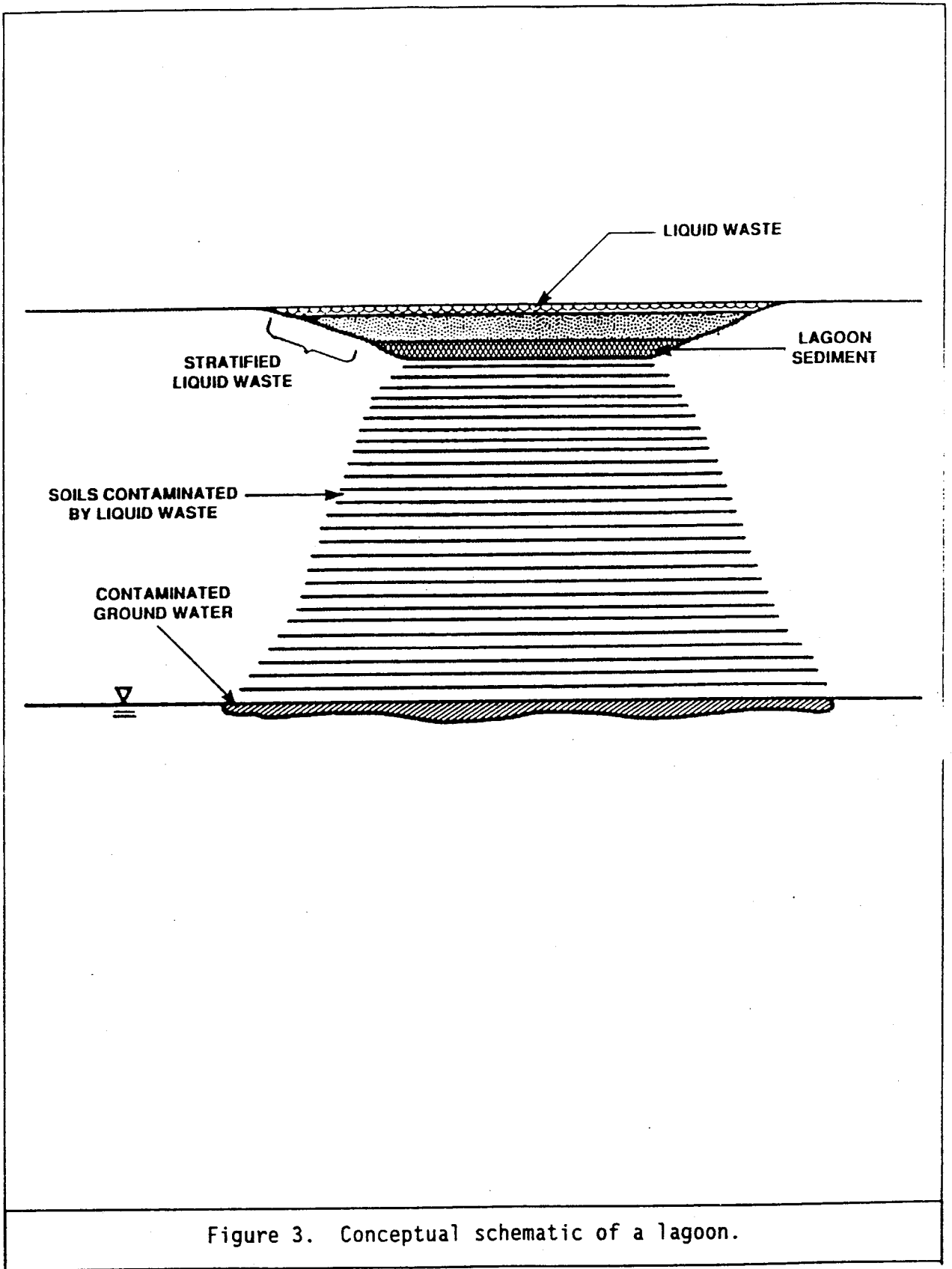


Figure 3. Conceptual schematic of a lagoon.

2.1 GENERAL DESCRIPTION

2.1.1 Landfills

Landfills are facilities into which wastes are placed for permanent disposal, and often are simply excavated pits. Landfills may vary in size from a few tenths of an acre to several hundred acres, and other landfill characteristics can also vary greatly from one site to the next. Most variations are attributable to the types of stored wastes, the operating practices and the age of the facility, and hence, its design.

Commercial landfills can be categorized by design criteria such as liners and gas-venting systems. Older landfills are usually unlined. Newer landfill designs may specify liner systems to retard transport of leachate and wastes into soils and ground water. Some landfills have built-in gas venting systems to prevent build up of landfill gases.

Landfills can be further differentiated by the types of waste they store. Commercial landfills are commonly classified as municipal or hazardous, depending on the types of waste accepted. Municipal landfills accept solid, semi-solid, and liquid nonhazardous wastes, including garbage, glass, plastics, paper, plant matter, ashes, some industrial wastes, and demolition and construction wastes.

Hazardous waste landfills accept hazardous sludge, liquids, semi-solids, residues, concentrates, or leachate or ash originating from a waste. Much of the hazardous waste originates from manufacturing, petrochemical, and chemical industries. Federal, state, and local regulations establishing minimum design standards and restricting types of acceptable landfill wastes have evolved over the last 25 years. In the past, mixtures of liquid and solid waste were common practice. Today, landfills can no longer accept liquid wastes or solids that contain free liquids unless they've been treated with fixatives and stabilizers to eliminate the free liquids prior to disposal.