Implementation Plan

Mexico Emissions Inventory Methodology

Version 2.0

Prepared for:

Western Governors' Association and
Binational Advisory Committee
Denver, Colorado

March 1996

670-017-06-01
March 19, 1996

John T. Leary
Project Manager
Western Governors' Association
600 17th Street
Suite 1705, South Tower
Denver, CO 80202

Subject: Transmittal of the Mexico Emissions Inventory Methodology Implementation Plan, Version 2.0

Dear John:

Please find enclosed a copy of the revised Implementation Plan for the Mexico Emissions Inventory Methodology Project. Copies have been sent to the members of the Binational Advisory Committee, INE, and to Jim Yarbrough of EPA Region 6. Bill Jones requested that we add Mr. Yarbrough to the distribution list for this project.

This version reflects the comments we received last fall in Mexico City and your comments of last week. The funding scenarios have also been modified to reflect current and anticipated funding.

If there are any questions regarding this version of the Implementation Plan, please call me at 916/857-7467.

Sincerely,

Ronald J. Dickson
Senior Staff Engineer

c: Binational Advisory Committee
Dr. José Ortega, Corporación Radian
Jim Yarbrough, EPA Region VI

670-017-06-01

IMPLEMENTATION PLAN

FOR

MEXICO EMISSIONS INVENTORY METHODOLOGY

Version 2.0

Prepared for:

Western Governors' Association
Denver, Colorado

and

Binational Advisory Committee

Prepared by:

Radian Corporation
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March 19, 1996

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1.0 SUMMARY

Recently, there has been an increasingly larger degree of urbanization and industrial activity throughout Mexico, particularly in the Mexico/U.S. border region. Air quality has been impaired in several border regions, such as El Paso/Ciudad Juárez, Ambos Nogales, and Calexico/Mexicalli. In addition, there are significant air transboundary issues that must be better understood to address regional air pollution concerns pertaining to long range transport.

Air pollution results from a complex mix of literally thousands of sources ranging from industrial smoke stacks and motor vehicles, to the individual use of grooming products, household cleaners, and paints. Even plant and animal life can play an important role in the air pollution problem. The complex nature of air pollution requires the development of detailed plans on a regional level that provide a better understanding of the emission sources and methods for reducing the air quality impacts associated with air pollution. Mexico's National Institute of Ecology (INE) has expressed a desire to initiate the air quality planning process throughout the country of Mexico, including the border region. Consequently, both Mexico and the United States have a common need to develop inventories of emission sources and process operations to facilitate this planning activity.

Examples of air quality planning activities that require good emissions and process inventories include:

- Application of air quality models;
- Examination of source attribution for emissions control where deemed necessary;
- Characterization of process technologies and air pollution control methods used by industry;
- Development of emission projections to examine possible changes in future air quality;
- Analysis of emission trends; and
- Analysis of emissions transport from one region to another.

By conducting these types of activities, air quality planning in both Mexico and the United States will be enhanced. Development of a fundamentally sound inventory program (including emissions, process technologies, and air pollution control equipment) is a key first step towards achieving this goal.

Significant emissions inventory efforts and methodology development have already occurred in certain regions of Mexico, primarily Mexico City. Mexico's National Institute of Ecology desires to expand these efforts into other regions and to implement a national inventory program. As currently envisioned, emission estimates would be developed at the state and local level for point, area, and mobile sources and managed in a common database management system.

This document represents the final work product for Phase I of the Mexico Emissions Inventory Methodology Project. The purpose of the Implementation Plan is to prioritize activities that could be carried out in the Phase II portion of this effort to help Mexico establish a national inventory program. To assist in the allocation of potential resources, three funding scenarios have been developed to help establish priorities for the Phase II effort. Similarly, a detailed schedule has been developed illustrating the proposed sequencing of the recommended Phase II activities.

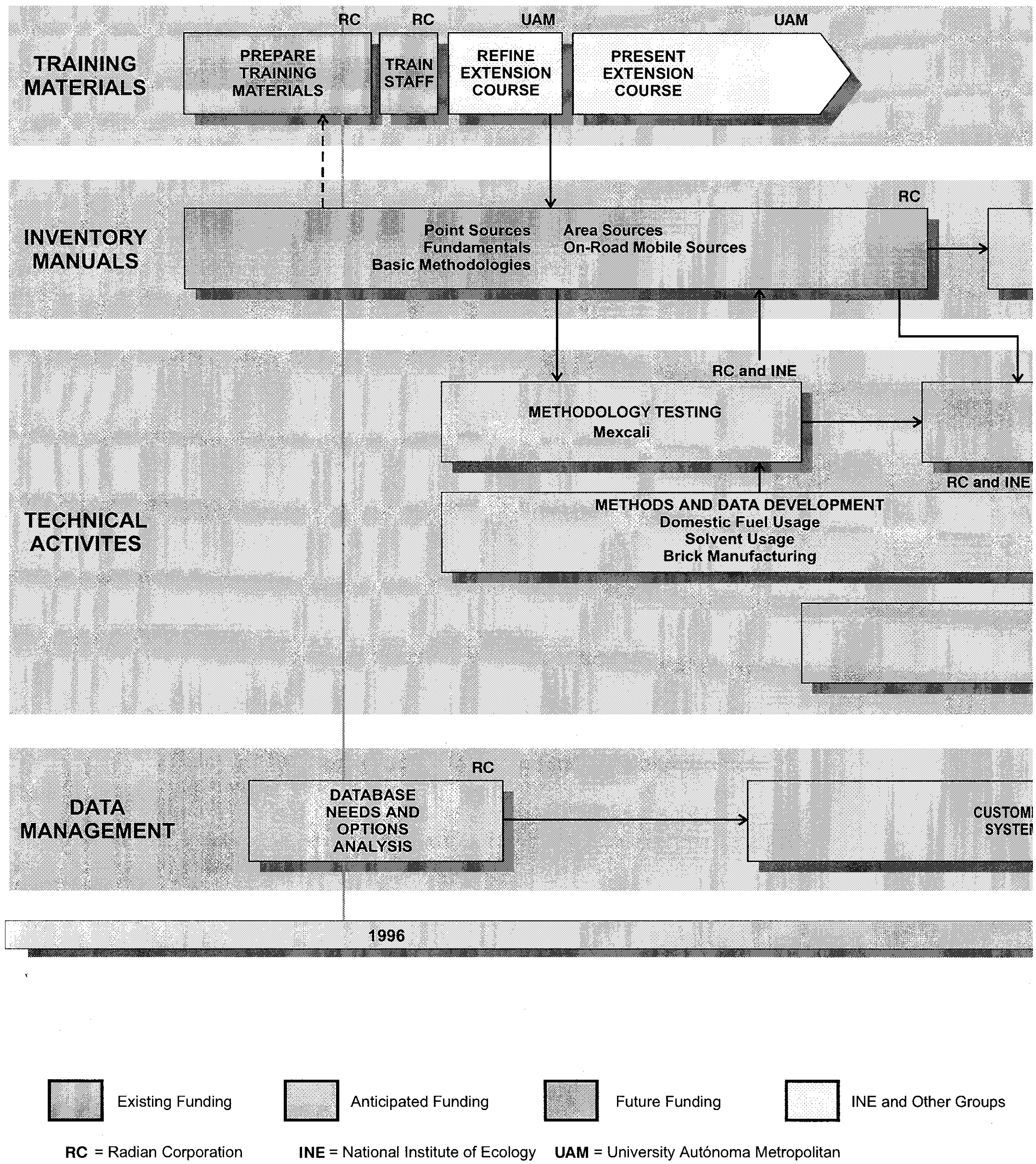
1.1 Phase II Activities

To establish the national program, the Phase II portion of this effort will consist of four elements:

- Development of inventory manuals;
- Development of training materials;
- Performance of various technical activities needed to develop certain information and data so that Mexico-specific emission estimates can be developed; and
- Development of a data management system.

A summary of the schedule for completing the Phase II activities is shown in Figure 1-1. Each of these four elements are summarized below.

Figure 1-1



RC
RC
UAM
UAM
TRAINING MATERIALS
PREPARE TRAINING MATERIALS
TRAIN STAFF
REFINE EXTENSION COURSE
PRESENT EXTENSION COURSE
RC
INVENTORY MANUALS
Point Sources
Fundamentals
Basic Methodologies
Area Sources
On-Road Mobile Sources
RC and INE
METHODOLOGY TESTING
Mexcali
RC and INE
TECHNICAL ACTIVITES
METHODS AND DATA DEVELOPMENT
Domestic Fuel Usage
Solvent Usage
Brick Manufacturing
RC
DATA MANAGEMENT
DATABASE NEEDS AND OPTIONS ANALYSIS
1996
Existing Funding
Anticipated Funding
Future Funding
INE and Other Groups
RC = Radian Corporation
INE = National Institute of Ecology
UAM = University Autónoma Metropolitan

Figure 1-1 (Continued)

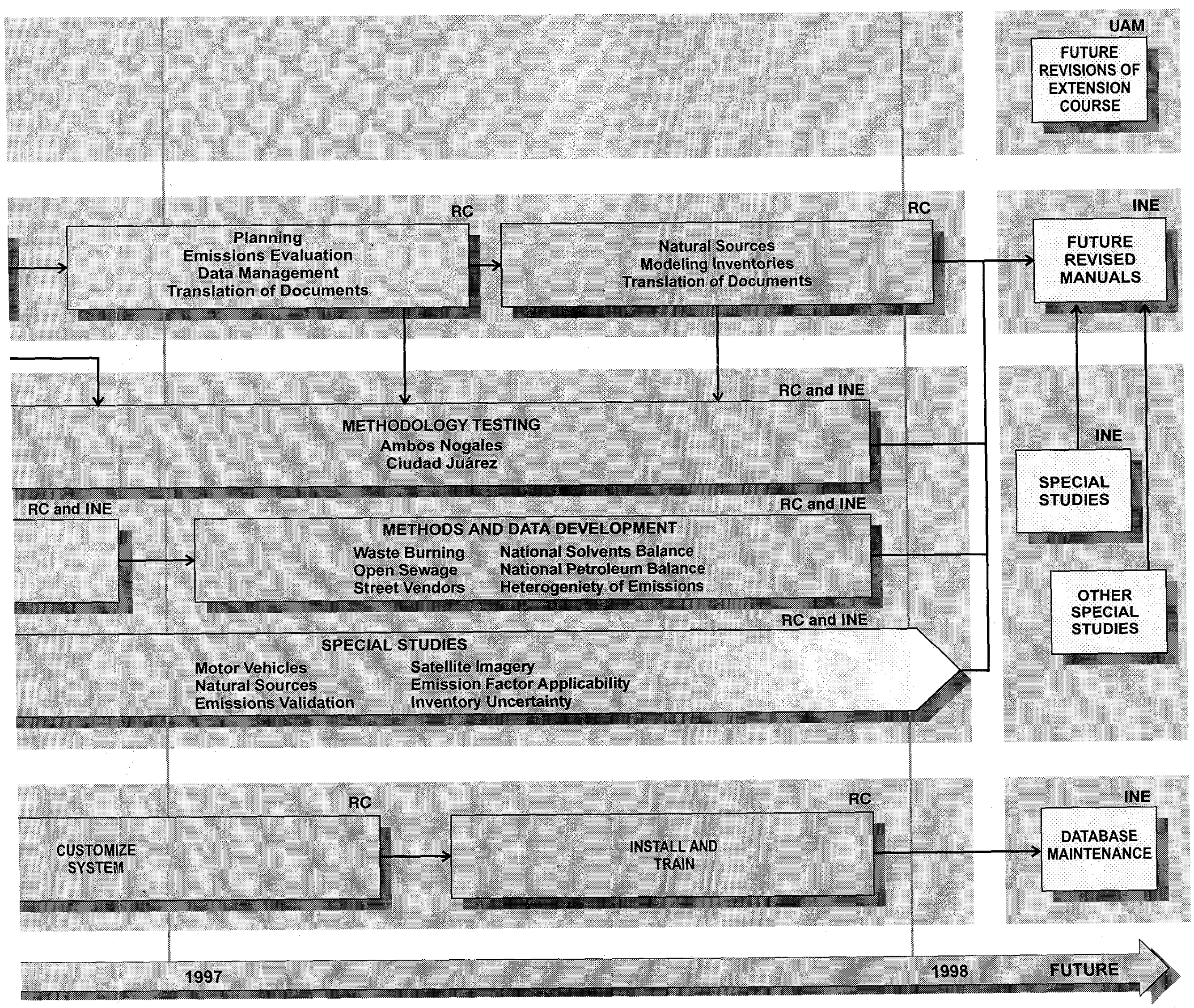


Figure 1-1.
Phase II Program

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er Groups

1.1.1 Inventory Manuals

INE staff have identified a specific need to develop a set of inventory manuals that can be used throughout the country to help coordinate the development of consistent emission estimates. In response to this need, conceptual plans for a set of manuals consisting of 11 volumes have been developed. These manuals will focus on the development of emission estimates, as well as program planning, database management, emissions validation, and other important topics. These manuals will assist the implementation of the inventory program and will provide a mechanism to maintain that program over time so that emissions and process technology inventories can be developed in periodic cycles and continually improved.

1.1.2 Training Materials

As currently envisioned, a college level extension course in emissions inventory development will be developed and given by staff at the University Autónoma Metropolitan - Azcotzalco (UAM). The course will be offered to state and local government staff to provide necessary training in emissions inventory development. Eventually, the class will be offered to industry and environmental consultants in Mexico to help promote the development of consistent and accurate emissions inventories. Developing this course will consist of three steps:

- Developing the course materials;
- Training UAM staff to teach the course; and
- Refining the course materials based on the review of knowledgeable inventory staff at INE and other organizations in Mexico.

1.1.3 Technical Activities

Several technical activities are envisioned for the Phase II effort so that specific data and information can be developed, allowing for the preparation of Mexico-specific emission estimates. Data are currently available to estimate emissions from most sources in Mexico, but the current emission factors and estimation methods do not always properly simulate conditions in Mexico. In addition, there are several emission sources unique to Mexico for which there is currently insufficient data and information to estimate emissions. To address these data and information limitations, various technical activities have been identified that fall into one of the following major areas:

- Special studies for area sources, including additional effort to develop the area source methodology (see previous report entitled *Methods Evaluation and Proposal for the Mexico Emissions Inventory Program*);
- Special studies for motor vehicles;
- Special studies for natural sources;
- Emission estimation methodology testing;
- Data and procedures for use in emissions validation;
- Emission factor applicability to Mexico; and
- Inventory uncertainty methodology and testing.

1.1.4 Data Management

For point sources, nearly all criteria-type emissions inventory data are collected by INE headquarters staff in Mexico City and by Regional Office personnel for designated cities in Mexico. These inventories are generated by INE staff on personal computers (PCs) using activity data (i.e., throughput, production, process rates, etc.) obtained from responses to annual questionnaires (encuestas) mailed to industrial facilities by INE. These responses are coupled with emission factors contained in the Sistema Nacional de Información de Fuentes Fíjas (SNIFF) or National System of Information on Stationary Sources. This is a Dbase III Plus format PC data handling system.

Data management at INE will be standardized on Oracle, Novell, and UNIX. They also plan on using Lotus Notes as a means to transfer and share large data sets or documents among multiple users. INE is currently in the process of developing a networked computer system at INE headquarters.

As part of this modernization effort, INE has requested technical support for the implementation of a more robust inventory data management system. The proposed approach to develop a new system for INE is described in Section 5.0. This effort will begin with a Database Needs Assessment and Options Analysis to select the approach best-suited to meet the requirements of the Mexico Emissions Inventory Program within schedule and budgetary constraints. During this analysis, the existing database system, SNIFF, will be evaluated, as well as other systems that have the potential to meet the data management requirements for this project. After the needs Assessment and Options Analysis is completed, decisions will be made to develop a new system or customize an existing system.

The newly developed or modified database design will be coded and tested. The finished product of this effort will consist of a completed and tested database system with supporting training and documentation.

1.2 Phase II Resource Estimates

Table 1-1 summarizes the resources required to fully implement the development of the manuals, training materials, and technical activities described in this document. At the start of this effort, it was recognized that Phase II resources would be insufficient to complete the $5M to $7M effort described here. Therefore, three different funding scenarios have been developed: (1) Existing Funding, (2) Anticipated Funding, and (3) Future Funding. These scenarios serve to identify priorities for carrying out the Phase II effort so that the most critical items can be addressed first, followed by other activities as funding becomes available. Tables 1-2 through 1-4 illustrate the activities that would be completed under each of these funding scenarios.

1.3 Phase II Schedule

Figure 1-1 illustrates the schedule for completing each of the recommended activities presented in this document. Full implementation of these activities will take several years. The schedule is quite aggressive, and completing all of these activities within the time frame shown is unlikely. Nonetheless, an aggressive schedule has been developed so that work can be initiated and completed as soon as possible.

Table 1-1

Summary of Phase II Implementation Costs

Program Element	Cost Estimate ($000)
Training Course	165
Inventory Manuals	350 - 480
Translation of Inventory Manuals	60
Area Source Methodology Development	300
Special Studies for Area Sources	550
Special Studies for Motor Vehicles	950 - 1,200
Special Studies for Natural Sources (Biogenics and Soil NO_x)	600
Methodology Testing (3 regions)	600
Emissions Validation Methodology	100
Data Management	160 - 1,100
Satellite Imagery Data	1,300
Emission Factor Applicability	250
Inventory Uncertainty Methodology and Testing	60
Total	5,400 - 6,800

Table 1-2

Technical Activities for Scenario #1 (Existing Funding)[a]

Primary Activity	Subactivities
Training for University	Develop Training Course Curriculum
	Train Staff
Manuals Development	Inventory Fundamentals Manual
	Basic Methodologies Manual
	Point Sources Manual
	Area Sources Manual
	On-Road Mobile Sources Manual

[a] Existing funds are approximately $345,000.

Table 1-3

Technical Activities for Scenario #2 (Anticipated Funding)[a,b]

Primary Activity	Subactivities
Expanded University Training	Additional Time for Training
Manuals Development	Program Planning Manual
	Emissions Evaluation Manual
	Data Management Manual
	Translation of Manuals from English to Spanish Manual
Area Source Special Studies	Fugitive Emissions from Domestic LPG Usage
	Solvent Use Study
	Emissions from Brick Manufacturing
Database Management	Needs Assessment Report
	Options Analysis Report
Methodology Testing	Mexicali Region[c]

[a] These activities are incremental additions to the activities shown in Table 1-2.

[b] Anticipated funds are approximately $900,000.

[c] Region selected because of its diverse industrial sources in comparison to other regims along the border.

Table 1-4

Technical Activities for Scenario #3 (Future Funding)[a,b]

Primary Activity	Subactivities
Manuals	Modeling Inventory Development Manual
Area Source Methodology Development	Multivariate Emission Models
Special Studies for Area Sources	Waste Burning
	Open Sewage
	Street Vendors
	National Solvents Balance
	National Petroleum Balance
	Heterogeneity of Emissions in Mexico
	Nonroad Equipment
Special Studies for Motor Vehicles	Driving Cycle Development
	Vehicle Testing
	Emission Factor Model Improvements
	I/M Effectiveness Analysis
	Tampering and Misfueling Analysis
	Unregistered Vehicle Study
Special Studies for Natural Sources	Biogenic Hydrocarbons
	Soil NO_x
Methodology Testing	Ciudad Juárez Region
	Ambos Nogales Region
Emissions Validation	Range Checks
	Top-Down Inventory Techniques
Data Management	Customize/Develop Database Management System
	Installation and Training
Satellite Imagery Data	N/A
Emission Factor Applicability	N/A
Inventory Uncertainty	N/A

[a] These activities are incremental additions to the activities shown in Tables 1-2 and 1-3.

[b] Estimated resource requirements for this scenario are $5.4 to $6.8 million.

2.0 INTRODUCTION

Significant inventory development efforts have occurred in Mexico City and other metropolitan areas of Mexico. These efforts must be expanded to all regions of the country in a systematic manner to achieve INE's goal of a national inventory. Developing emission estimates to meet air quality planning needs requires continual development and refinement; "one time" inventory efforts are not conducive to the air quality planning process. For lasting benefit, therefore, an *inventory program* must be developed so that accurate emission estimates can be developed for all important geographic regions, refined over time, and effectively applied in the air quality planning and monitoring process. To develop an inventory program, technical capacity needs to be developed throughout Mexico to sustain the national inventory program that is desired. This document describes the elements of a complete inventory program and presents the recommended schedule and resources required to accomplish this important goal.

The implementation plan presented here concludes the Phase I planning effort for the development of Mexico's inventory program. The Phase I planning effort consisted of the following key tasks:

- Task 1 - Work Plan Development;
- Task 2 - Information Surveying;
- Task 3 - Critical Review of Emissions Data;
- Task 4 - Critical Review of Emissions Methodologies;
- Task 5 - Methodology Proposal;
- Task 6 - Implementation Plan for the Methodology; and
- Task 7 - Technology Transfer.

The knowledge gained during the performance of these tasks is reflected in this implementation plan. As described below, Phase II activities will consist of training and further development of the inventory methodology.

Developing the inventory program will require training of Mexico staff and the performance of key technical activities so that inventory tools and databases can be tailored to Mexico. Current plans call for the development of a set of inventory manuals that will cover each element of the inventory program. These manuals will be used by local, state, and federal staff, as well as industry and private consultants, to guide the development of consistent emission estimates.

Work is also underway to develop a college level course in emissions inventory development. This course will be taught by the Environmental Engineering Department of the University Autónoma Metropolitan - Azcotzalco. Both the development of the manuals and the inventory course are described in Section 3.0 of this document.

Several technical activities have also been identified to better develop emission estimates that are specific to Mexico. These technical activities are described in Section 4.0. Data management issues are discussed in Section 5.0. Sections 6.0 and 7.0 describe the resource requirements and schedule, respectively, for carrying out the recommendations contained in this implementation plan.

Table 2-3

Mobile Source Categorization Used for Methods Evaluation

Category	Priority[a]	Pollutant	Comments
On-Road Motor Vehicles	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Category includes light-duty gas vehicles, light-duty diesel vehicles, light-duty gas trucks, light-duty diesel trucks, heavy-duty gas vehicles, heavy-duty diesel vehicles, and motorcycles.
Aircraft	2	CO, NO_x, SO_x, VOC, and PM	Category includes commercial, military, and private aircraft.
Railroads	2	CO, NO_x, SO_x, VOC, and PM	Category consists of diesel locomotives used only in switching and line haul application. Electric locomotives use electricity generated at stationary power plants (point sources), so these are not included as a nonroad source.
Commercial Marine Vessels	2	CO, NO_x, SO_x, VOC, and PM	Commercial marine vessels include fishing vessels, harbor vessels, cruise ships, ferries, commercial ships, etc.
Agricultural Equipment	2	CO, NO_x, SO_x, VOC, and PM	Agricultural equipment category includes tractors, combines, sprayers, harvesters, agricultural hydropower equipment, etc.
Construction Equipment	2	CO, NO_x, SO_x, VOC, and PM	Category consists of pavers, rollers, excavators, cement mixers, cranes, off-highway trucks, bulldozers, backhoes, etc.
Industrial Equipment	2	CO, NO_x, SO_x, VOC, and PM	Industrial equipment category consists of aerial lifts, forklifts, sweepers, abrasive blasters, industrial scrubbers/blowers/vacuums, airport service equipment, etc.
Light Commercial Equipment	2	CO, NO_x, SO_x, VOC, and PM	Category includes generators, pumps, compressors, welders, etc.
Lawn & Garden Equipment	3	CO, NO_x, SO_x, VOC, and PM	Category consists of lawnmowers, tillers, chainsaws, chippers, etc.
Recreational Equipment	3	CO, NO_x, SO_x, VOC, and PM	Recreational equipment category includes all-terrain vehicles, off-road motorcycles, golf carts, etc.

Table 2-4

Natural Source Categorization Used for Methods Evaluation

Major Category	Priority[a]	Pollutant	Comments
Biogenic VOC	1	VOC	Category includes isoprene, terpene, and other VOC emissions from natural, agricultural, and urban vegetative biomass.
Soil NO_x	2	NO_x	Microbial nitrification and denitrification cycles in soil under certain conditions can result in significant releases of NO_x. NO is the principle nitrogen species emitted by soils (overall under certain conditions NO_2 comprises less than 10% of soil NO_x emissions).
Soil NH_3	2	NH_3	Through the natural ammonification cycle, soil surfaces can emit significant amounts of NH_3.
Windblown Dust	1	PM	Wind erosion of crustal material can be a significant source of particulate matter. Although emissions originate primarily from disturbed lands (e.g., agricultural areas), emissions can also occur from undisturbed lands.
Lightning	3	NO_x	Several studies have shown lightning to be a source of NO_x. On a regional basis, emissions are typically low compared to anthropogenic emissions.
Geogenic	3	SO_x, VOC, and PM	There are a number of geogenic sources that can be important sources of air emissions under certain conditions. Examples include volcanoes and natural oil and gas seeps that can emit sulfur, particulate matter and VOCs.

[a] A priority has been assigned to communicate the current, perceived importance of each source type. The priorities assigned to each source type will be refined over time as feedback is obtained from INE and more Mexico-specific information is gathered.

3.0 TECHNOLOGY TRANSFER

The concept of technology transfer is a key element of this overall effort. The Phase II technology transfer activities will focus on the preparation of inventory manuals and the development of a college level course pertaining to emissions inventory activities. The proposed approach for these two activities is summarized below.

3.1 Development of Inventary Manuals

The Mexico Emissions Inventory Program Manuals will be developed as one of the major work elements in Phase II of the Mexico Emissions Inventory Project. The purpose of the manuals is to serve as a tool to support the development and implementation of an emissions

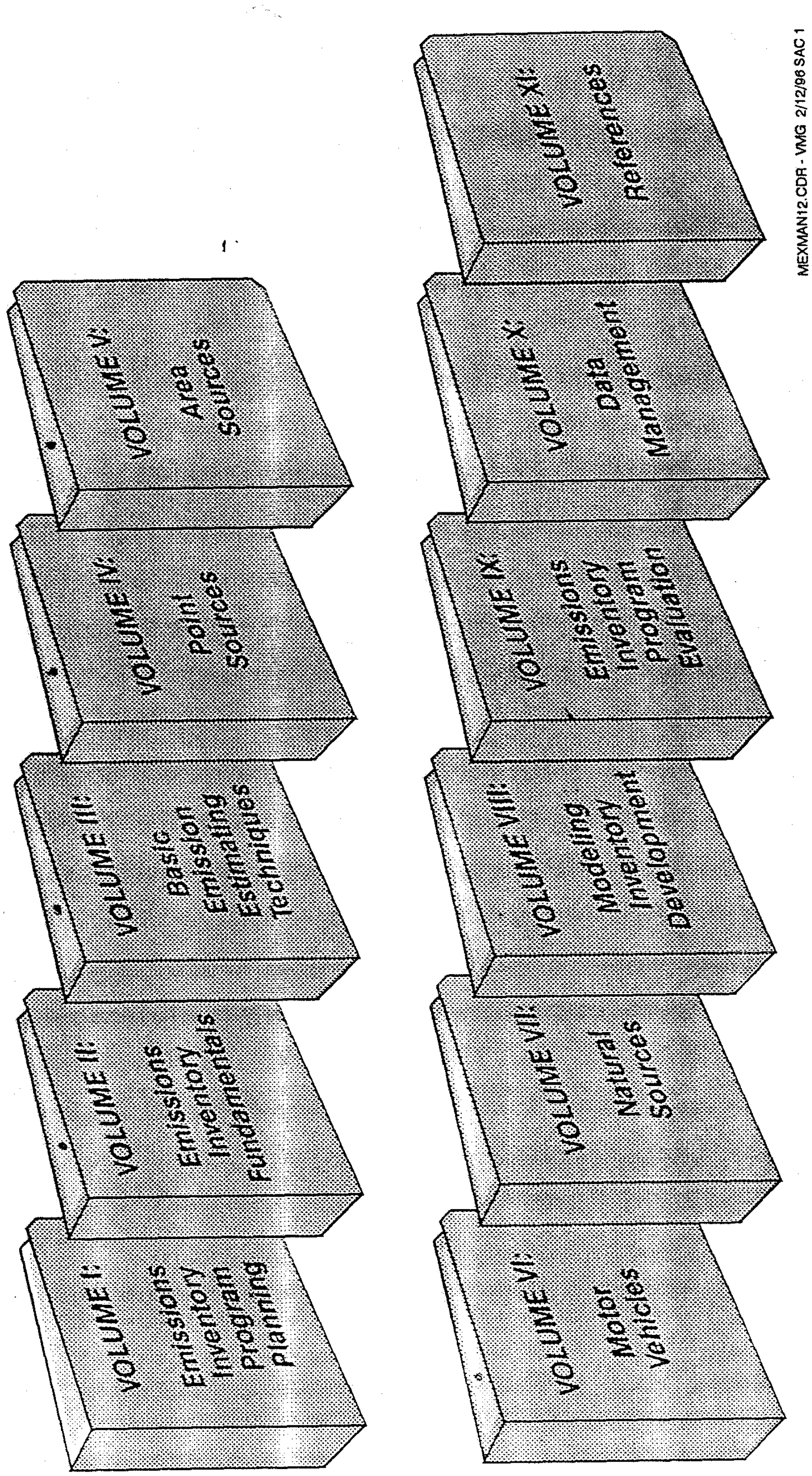


Figure 3-1 Mexico Emissions Inventory Program Manuals

inventory program in Mexico. Figure 3-1 shows the recommended series of manuals that should be developed to support a complete inventory program.

Currently, there is no consistent set of manuals that can be used directly to meet INE's needs. However, there are several existing reference documents and other materials that can be used to minimize required resources. In addition, the development of the manuals should closely follow the ongoing development of materials in the U.S. under the Emissions Inventory Improvement Program (EIIP). Radian staff are currently participating in the EIIP and will use these existing materials to the greatest extent possible.

Our conceptual approach for developing the Mexico Emissions Inventory Program Manuals consists of the following steps:

- First, a draft outline will be developed to present initial recommendations on the contents of each manual (see Appendix A).

- Second, a prioritization list will be made to determine the order in which the various manuals should be developed. Although it is likely that the development of multiple volumes will occur in parallel, the prioritization list is intended to help in the allocation of project resources and development of the manuals schedule. The prioritization is shown in Section 6.0.

- Next, work will begin on the high-priority manual(s). Based on the initial outlines, draft sections will be developed.

- To ensure that the manuals will serve as useful tools to INE, draft sections for at least the key documents will be prepared and submitted for review and comment. In this way, mid-course corrections can be made prior to completing and submitting the draft manual(s) for final review and comment.

- Last, the draft manuals will be finalized (in English) and translated into Spanish.

The first step, the development of a draft outline for the Mexico Emissions Inventory Program Manuals, has been completed and is presented in Appendix A as part of our implementation plan for technology transfer. The main purpose of each manual or volume is summarized below. A preface will be developed for each manual that describes the need for consistent and thorough inventory development throughout Mexico. The preface will also summarize the contents of each manual, providing the user with a quick reference guide to find the desired information.

Volume I—Emissions Inventory Program Planning. This manual will address the important planning issues that must be considered in an air emissions inventory program. Program planning will be discussed not as an "up-front" activity, but rather as an ongoing process to ensure the long-term growth and success of an emissions inventory program.

Volume II—Emissions Inventory Fundamentals. This manual will present the basic fundamentals of emissions inventory development. The objective is to discuss inventory elements that apply to multiple source types (e.g., point and area) in this one manual, so as to avoid the need for repetition in multiple volumes.

Volume III—Emissions Inventory Development: Basic Methodologies. This manual will present the basic methodologies used to develop emission estimates. Starting with information previously presented in the Methodology Proposal, this manual will provide additional detailed discussion of each methodology, including examples and sample calculations. Inventory tools associated with each methodology will be identified and included in Volume XI (References).

Volume IV—Emissions Inventory Development: Point Sources. This manual will provide guidance for developing the point source emissions inventory. A table will be developed to cross-reference each industry/device type combination (e.g., petroleum refining/combustion devices) with one or more of the basic methodologies presented in Volume III.

Volume V—Emissions Inventory Development: Area Sources (Includes Non-Road Mobile). This manual will provide guidance for developing the area source emissions inventory. After the presentation of general area source information, a table will be provided to cross-reference each area source category (e.g., asphalt application) with one or more of the basic methodologies presented in Volume III. Then, source category-specific information will be discussed for each source category defined in the table.

Volume VI—Emissions Inventory Development: On-Road Mobile Sources. This manual will explain the necessary steps for development of an emissions inventory for on-road mobile sources. Motor vehicles are a significant emissions source within the overall emissions inventory. Because motor vehicles are inherently different from point and area sources, the available estimation methods and required data are also different. To estimate emissions from these complex sources, models are the preferred estimation tool. Many of these models utilize extensive test data inputs applicable to a given country or region. This manual will focus primarily on the data development phase of estimating motor vehicle emissions.

Volume VII—Emissions Inventory Development: Natural Sources. This manual will provide guidance for developing the natural source emissions inventory (i.e., biogenic VOC and soil NO_x). In addition, this manual will include the theoretical aspects of emission calculations and discussion of specific models.

Volume VIII—Modeling Inventory Development. This manual will provide guidance for developing inventory data for use in air quality models and will address issues such as temporal allocation, spatial allocation, speciation, and projection of emission estimates.

Volume IX—Emissions Inventory Program Evaluation. This manual will consist of three parts: quality assurance/quality control (QA/QC), uncertainty analysis, and emissions verification. The QA/QC portion will define the overall QA/QC program and be written to complement source specific QA/QC procedures written into other manuals. The uncertainty analysis will include not only methods of assessing uncertainty in emission estimates, but also for assessing uncertainty in modeling values such as speciation profiles and emission projection factors. The emissions verification section will describe various analyses that can be done to examine the accuracy of the emission estimates. Examples include receptor modeling and trajectory analysis combined with specific data analysis techniques.

Volume X—Data Management. This manual will address the important needs associated with the data management element of a comprehensive emission inventory program. System and user's information will be provided in other documents. Volume X will describe the basic philosophy for collecting data and managing it in consistent manner for each region in Mexico. Responsibilities, schedules, and other relevant information will be presented.

Volume XI—References. This will be a compendium of tools that can be used in emission inventory program development. Inventory tools referenced in the other manuals will be included.

Development of Inventory Training Course Materials

This section describes the process for transferring the technical insights gained from the emission inventory development and implementation procedures to the academic and regulatory communities in Mexico. A Preliminary Draft Training Plan was submitted to the Binational Advisory Committee (BAC) and INE on 29 August 1995 (see Appendix B for the current plan). The Training Plan will be refined and expanded as the course content develops. A summary of the three major elements contained in the Draft Training Plan is presented below.

University Level Curriculum

The inventory training effort will be focused on the development of a university level extension course. The first step in the development of this curriculum includes developing a course syllabus, reading list, and workbook, on the emissions inventory (EI) process. Eventually the emission inventory course may be offered through university extension programs along the U.S. - Mexico border region. At some time in the future, the course may also be incorporated into environmental engineering curriculum at the University Autónoma Metropolitan - Azcapotzalco (UAM-AZC).

Prerequisites. Since the course is envisioned as a university extension course, most students will have had exposure to air pollution fundamentals in previous environmental engineering courses and practical work experience. Students should have reading skills in English equivalent to at least one year of university level English since most of the existing reference documents and computer models are in English.

Materials. Much of the technical material covered in the course will be drawn from Volumes II - VI, as described in Section 3.1. The manuals will contain example calculations which may be compiled into a workbook, along with other pertinent materials. The preparation of the Training Plan and the manuals began in parallel, but course development activities will soon outpace the much larger effort to develop the manuals. Thus, the emissions inventory course will include topics and example calculations for which the corresponding manual has not yet been developed. In these and other cases, the relevant course materials will be drawn from other sources.

Syllabus. The proposed EI course is designed for a 4-day university extension course meeting 8 hours per day. The contents of the proposed course are contained in Appendix B.

Reference List. A recommended list of references will be compiled. The list will include documents, research papers, conference proceedings, and background textbooks that students should consult throughout the course but especially for the execution of their assigned projects.

Materials. The following materials will be needed to complete this course:

- A 3-ring binder workbook of sample calculations and their solutions intended for the professor's use in assigning homework problems and developing test questions;
- Twenty-two sets of handouts and overhead presentation graphics (1 for each class meeting);
- Two copies of the written materials to be identified in the reading list; and
- All recommended computer models and their associated user guides. Note that UAM will need to furnish computer hardware that students can access to run their assigned software package or else suitable equipment may need to be purchased.

Except for the workbook, all of these materials should be assembled in one location at UAM to facilitate student access.

Couser for Trainer

Before the emissions inventory course can be given, training materials for future instructors must be developed. As the second element of the training effort, this material will be given to select professors who can then teach the full emissions inventory course to the professional air quality community. Initial students from the professional air quality community will be drawn from organizations such as INE, Mexico City metropolitan air pollution agency (Departamento de Distrito Federal - DDF), and Procuraduría Federal de Protección al Ambiente (PROFEPA).

The syllabus for the condensed course would cover the material presented in Appendix B. However, the emphasis may shift to more sophisticated topics such as emissions inventory program verification, given the audience's familiarity with basic air pollution and some emissions inventory concepts. This group of students may be asked to solve some or all of the workbook problems to assess the clarity of both the problems and the solutions.

Course Evaluation

The third element of the Training Plan is an ongoing evaluation strategy by which the effectiveness of the condensed course, the initial offering for air quality professionals, and the ultimate extension course can be assessed. This mechanism will allow appropriate adjustments in course content, presentation, and emphasis, as needed.

Radian is developing a training plan in close cooperation with Professor Alfonso Espitia, Director, UAM Environmental Engineering Program. Radian staff will lead the effort to develop a training plan and will be in frequent communication with Professor Espitia, including meeting with UAM staff and discussing preliminary work products before they are submitted to the Western Governor's Association (WGA), INE, and the BAC.

Several opportunities to evaluate and improve the course are envisioned including:

- Ongoing communication with Professor Espitia and the BAC team will focus the developing course to meet various technology transfer objectives.
- Radian and UAM will receive written evaluations (in lieu of examinations) from air quality professionals who take the initial condensed course. Their

answers to workbook problems will be used to refine the types of problems later posed to university students.

- Radian will devise a written course evaluation questionnaire that can be given to all students for ongoing feedback.

4.0 TECHINICAL ACTIVITIES

This section of the Implementation Plan presents recommended technical activities that should be considered for inclusion in the Phase II activities. Many of these technical activities are recommended so that emission estimates specific to Mexico can be developed.

4.1 Special Stidies and Further Development of Inventory Methodologies

This section addresses the need for further development of inventory methodologies that were presented in the Methodology Evaluation and Proposal Report. In particular, this section focuses on the development of the "multivariate model" methodology. This section also discusses the role of special technical studies in Mexico's emissions inventory program and provides a list of specific recommended studies.

Special studies are important to the Mexico emissions inventory program because they extend inventory coverage to include those source categories that have been previously uninventoried. In some instances, emissions for a particular source category have not been previously estimated because basic information needed for the emissions estimation has been unavailable. Also, some source categories have previously been thought to be insignificant or nonexistent in traditional inventories. Consequently, emissions estimation methodologies for these uninventoried categories do not exist for use in those areas where they actually are significant sources of emissions. Methods need to be developed for these unique source categories so that they can be included in the inventory process.

The following subsections present special technical studies and research that are needed for development and improvement of Mexico's emissions inventory program. The special technical studies have been divided into point, area, on-road mobile, and biogenic sources with an additional subsection describing necessary research for development of multivariate models. Each special study has also been assigned a priority ranking with a "1" indicating highest priority and a "3" indicating lowest priority. These priority rankings should be considered if there are limited resources for emissions inventory development. It should be noted that these special studies are only intended to aid in the development of emissions estimates for source categories that are unique to Mexico and known to have been previously uninventoried. These studies are not designed to identify new sources. Also, in most cases, these studies are not designed to verify existing emission estimates. Finally, these special studies are intended to support emissions estimation in all regions, as opposed to region-specific studies needed to develop geographic-specific data for source categories that are traditionally included in emissions inventories (e.g. fugitive dust or wildfires).

4.1.1 Point Soerce Special Studies

There is limited need for special technical studies in the development of emissions estimates for point sources. As indicated in the Methods Evaluation and Proposal Report, the estimation of emissions from point sources relies extensively on source sampling, emission factors, and surveys. Special studies would not significantly improve upon the source sampling methodology. The emission factor methodology would also be largely unaffected; however some care must be exercised concerning the applicability of non-Mexico emission factors to Mexico specific emission sources. This issue is discussed more fully in Section 4.3. Finally, there is one area of needed improvement related to the survey methodology. An improved point source questionnaire should be developed to improve the quality of data collected during surveying efforts of point sources.

Multivariate Model Development

Although the Methods Evaluation and Proposal recommends the use of source sampling, emission factors, and surveys for most point sources, a multivariate model is recommended for fugitive emissions from petroleum refineries and chemical manufacturing facilities. Furthermore, multivariate models are widely recommended for area sources in the Methods Evaluation and Proposal, particularly for the long-term. Before these individual multivariate models are implemented, however, significant research and development will need to be conducted.

Multivariate models are based on the concept that emission estimates can be expressed in terms of a set of variables that characterize a system. Further detailed discussion of multivariate models can be found in the Methods Evaluation and Proposal. It is quite likely that the set of applicable variables and its respective emissions estimation algorithm varies among source categories. As a result, several multivariate models will need to be developed in order to estimate emissions for all recommended source categories.

There will be some significant development costs associated with multivariate models. For example, a multivariate model has been recommended for fugitive emissions from petroleum refineries and chemical manufacturing facilities. At the current time, the development of this multivariate model has been assigned a priority ranking of "3." Development costs for this multivariate model have been estimated to be $10,000-20,000. It is likely that development costs for area source multivariate models will be higher than for this example. One possible reason for this is that model variables associated with fugitive emissions from petroleum refineries are probably closely related to actual refinery operations. These variables would be more easily quantified than area source multivariate model variables which might be more distantly related to the actual emission processes.

4.1.3 Area Source Special Stidies

Examination of the near-term recommended methods presented in the Methods Evaluation and Proposal Report for area sources reveals that there are several area source categories that have previously been uninventoried. These categories are the focus of special studies presented in this subsection. These special studies, along with their priority ranking and a brief description, are presented in Table 4-1.

Table 4-1

Special Studies for Area Sources

Subject of Special Study	Priority	Purpose and Scope of Special Study
Fugitive Emissions from Domestic Liquified Petroleum Gas (LPG) Usage	1	Determine areas of propane fuel use and quantities of use. Develop emissions estimating techniques, including source sampling if required.
Emissions from Residential Biomass or Waste-Derived Fuels	1	Determine areas of biomass/waste-derived fuel use, fuel composition, and quantities of use. Develop emissions estimating techniques using surveys and source sampling as required.
Emissions from Waste Burning (Refuse Burning/Open Burning Dumps)	1	Characterize extent of open burning dumps, quantity of refuse burned, refuse composition, and typical burning practices. Develop emissions estimating techniques which would likely include surveys and/or source sampling.
Emissions from Open Sewage	1	Characterize extent of open sewage and typical chemical composition of sewage. Develop emission estimating techniques, including source sampling if required.
Emissions from Brick Manufacturing	1	Determine areas with small-scale brick kilns, quantity of fuel used, and fuel composition. Develop emissions estimating techniques using surveys and/or source sampling.
Emissions from Street Vendors	2	Characterize extent of street vendors, quantity of fuel used, and fuel composition. Develop emissions estimating techniques using surveys and/or source sampling.
Solvent Usage	2	Conduct a stratified survey to develop solvent usage data by industrial/commercial sector. Develop emissions estimating techniques for solvent area source categories.
National Solvents Balance	2	Perform a national solvents balance based on information from appropriate manufacturers' association data, import/export records, and other data sources. Use results to develop or verify emissions estimates for solvent area source categories.
National Petroleum Balance	2	Perform a national level petroleum balance based on information from PEMEX and other data sources. Test and confirm the reasonableness of petroleum balance. Data used to supplement area source categories that consume petroleum-based fuels.
Heterogeneity of Emissions in Mexico	2	Identify region-specific factors that affect emission estimates. Assess qualitatively (and possibly quantitatively) what effects these factors have on various source categories. Develop procedures for adjusting emissions based on geographic differences.
Nonroad Equipment	3	Confirm that Mexico has a smaller engine population than the U.S. Conduct survey to quantify actual engine populations.

On-Road Mobile Source Special Studies

Due to fundamental differences in emissions from Mexico on-road mobile sources and U.S. on-road mobile sources, a substantial number of special studies are needed to accurately estimate emissions from this source category. Several of these studies focus on the development of basic data that are a central part of a Mexico-specific emission factor model. The remainder of the studies determine appropriate adjustment factors to account for differences between the emission factor model and various non-ideal conditions. All of these special studies are presented in Table 4-2.

Table 4-2

Special Studies for Mobile Sources

Subject of Special Study	Priority	Purpose and Scope of Special Study
Emission Factor Model	1	Develop an emission factor model from vehicle test data. Modify emission factor model by any applicable results from other special studies.
Driving Cycles	1	Quantify typical Mexico driving patterns. Use driving pattern data to derive an appropriate driving cycle to be used in vehicle testing.
Vehicle Registrations	1	Survey vehicle registration data at the local level. Confirm the accuracy of existing vehicle registration distributions.
Vehicle Testing	1	Measure emissions from a representative vehicle mix. Use emissions data to populate an emission factor model.
Emission Control Technology	2	Conduct a survey to confirm the extent of emission control technology in various types of vehicles. Use results to help develop mobile source emissions estimates.
Inspection and Maintenance (I/M) Programs	2	Conduct survey to determine the actual effectiveness of established I/M programs. Compare results to theoretical effectiveness of I/M programs. Information used to adjust emission factor model and emissions estimates.
Tampering and Misfueling	2	Conduct survey to establish the level of tampering and misfueling among those vehicles that have emission control technology. Data used to adjust emission factor model and emissions estimates.
Unregistered Vehicles	2	Conduct survey to quantify the number of unregistered vehicles present in the Mexico vehicle fleet. Data used to modify existing vehicle registration distribution data.

Natural Sources Special Studies

Algorithms and models are available for application in Mexico that could be used to develop emission estimates for natural source such as biogenic hydrocarbons and soil NO_x. Mexico-specific data to use in existing models, however, are limited and the data that are available may not reflect Mexico conditions. Special studies are needed to develop fundamental data for the natural source categories.

There are two special technical studies that are needed to estimate emissions from biogenic sources. The first study would develop land use/land cover (LULC) data for Mexico. The second study would develop biomass data for Mexico plant species and relevant emission factors. Further discussion concerning these data is presented below.

Estimating emissions for the natural source categories will rely extensively on land use/land cover data (LULC). For example, land use describes the type of vegetation that may be present (e.g., natural versus urban) and also the type of vegetation present (e.g., row crop versus orchard). Development of natural source emission estimates for Mexico would be greatly enhanced through the application of satellite imagery data to develop LULC data. These data could be used directly to develop biogenic hydrocarbon, soil NO_x, and windblown dust emissions.

Further field research is also warranted so that a more refined biogenic emission estimate can be developed for Mexico. The applicability of the current biogenic emission models may have limited applicability in many regions of Mexico. The work performed to develop the biogenic hydrocarbon inventory for the Grand Canyon Visibility Transport Commission found that biogenic emission estimates for the southwestern U.S. appear to be overestimated. It is possible that the scrubland LULC category for the southern U.S. and northern Mexico should incorporate a lower biomass than is currently used in the biogenic emissions calculations. No other biomass data are available for this region.

In summary, a large effort will be required to develop the necessary data for natural source emission estimates. Satellite imagery would greatly enhance the process, but additional fundamental research will be required to develop other model parameters. This includes soil parameters for soil NO_x estimates and biomass data to support the modeling of biogenic hydrocarbons.

Methodology Testing

In an earlier stage of this effort, a conceptual approach for developing emission estimates on a national level for Mexico was presented. After the method is further developed, testing of the method is desired before it is implemented on a national level. This section outlines our recommended approach for testing the methodology.

The methodology can be thought of in three parts:

- Use of questionnaires to collect point source emissions data, including process information, activity rates, and any available source test results;
- Use of census based emission factors and multivariate models for area sources; and
- Emission models for on-road motor vehicles.

Testing the methodology will require implementing all three methods in one or more region of Mexico. This effort can be divided logically into three parts: region selection and work plan development, emissions estimation, and emissions validation.

4.2.1 Region Selection and Work Plan Development

Most of the detailed emissions inventory work conducted in Mexico has been centered in Mexico City. To provide a more strenuous test, the testing effort should be focused on other regions that have not received as much attention. At the same time, however, there are several advantages of selecting regions that have on-going environmental analyses that would complement the testing effort and provide a synergistic effect. The testing effort should also be conducted by both Mexico and U.S. staff so that this effort can be used as a training exercise. Using these three criteria, several border regions appear to be logical choices: Mexicali, Ambos Nogales, and Ciudad Juárez. As part of the work plan development effort, this recommendation will be refined and specific regions will be selected and agreed upon followed by detailed planning. Additional thoughts on using these three cities as a test regions are presented below.

Mexicali is the leading candidate for emissions testing because of the diverse nature sources in this region. The region consists of a large urban environment, a large motor vehicle population, and the most diverse industrial base of the three regions selected. Therefore, Mexicali would provide the most streneous test.

Work will soon begin in Ambos Nogales to develop a PM_{10} and air toxics inventory. This inventory effort will be performed under an accelerated schedule to provide initial emission estimates. By choosing Ambos Nogales as a test site, the more rigorous methodology could be compared to the initial estimates to evaluate the incremental improvement of more robust estimating methods. In addition, a geographic information system (GIS) database has been developed that would facilitate the emission estimation process for area sources in this region.

Our interest in Ciudad Juárez stems primarily from the motor vehicle data that have been developed in that region. This includes not only the motor vehicle activity data that have been compiled, but also the emissions test data that are being collected. Point and area source emission estimates would also be developed.

Emissions Estimation

In this phase of the testing, needed data would be collected and used to develop emission estimates. For training purposes, this effort should be carried out by Mexico staff to supplement the classroom training that will be available from UAM. To the extent possible, the resulting emission estimates should be managed in the selected data management system to facilitate both reporting and data analysis functions.

Emissions Validation

Once the emission estimates have been completed, several "validation" analyses should be conducted. Section 4.3 discusses the different types of validation activities that could be implemented. At this time, range checks, development of alternative emission estimates, comparison of emission estimates with measured ambient concentrations, and the use of receptor models are recommended. These analyses will be designed to evaluate the completeness and precision of the emission estimates.

Validation of Emission Estimates

Developing accurate emission estimates is an important aspect of the air quality planning process. Historically, assessing the accuracy of an emissions inventory has been a very difficult process. A good point source inventory may contain over a thousand emitting devices, while a complete area source inventory can easily contain over 150 discrete source categories. When combined, these emissions constitute an emissions database with thousands of data points. This volume of data makes it very difficult to "validate" an emissions inventory.

For an air quality model, predictions are compared to observations to assess the performance of the model. Similar opportunities are difficult to find for the emissions inventory process and are often expensive to implement. Nonetheless, there are four methods that can be used in the emissions validation process:

- Quality assurance/quality control procedures that involve range checks to identify outliers;
- Development of alternative emission estimates for cross comparison;
- Comparison of emission estimates with measured ambient concentrations using data analysis techniques; and
- Analysis of emission estimates using air quality models such as receptor models and three dimensional grid models.

Of these potential approaches, range checks and calculation of alternative emission estimates should be adopted as routine procedures in Mexico's inventory development process. These techniques will be described in the inventory manuals (see Section 3.1) and presented such that they should be used routinely in the inventory development process.

Data analysis techniques involving comparisons with ambient measurement data and model predictions should be performed as special studies. These are expensive techniques that can not be performed on a routine basis. Nonetheless, when properly performed, they provide valuable insight into the uncertainty associated with an emissions inventory. Each of the validation methods is discussed briefly below.

4.3.1 Validation Through Range Checking

An emissions database consists of thousands of data points. Range checks can be applied to verify the accuracy for many of the data elements, such as stack parameters, missing pollutants, activity rates, source classification, etc. A few examples follow.

- Stack height, velocity/flow rate, and diameter should all be compared against typical values to identify outliers. For example, stack heights over 100 meters should be flagged and examined closely to validate their accuracy. Previous experience has also found many instances where the stack gas velocity, when computed from the stack diameter and flow rate, is greater than the speed of sound.

- Combustion devices should have emissions of combustion pollutants, such as NO_x and CO. Emitting devices burning certain fuels should also have SO_2 emissions. Surface coating and solvent usage sources should have VOC emission estimates; any combustion pollutants associated with VOC sources should be flagged and validated.

- Emission factors can be back calculated from an emitting devices activity rate and emissions and then compared to the standard emission factor. This type of check helps to identify devices that have been misclassified (i.e., they have been assigned incorrect Source Classification Codes).

- Typical ranges for the most important area source categories can be developed and applied to help identify suspicious area source emission estimates that require further checking and verification.

Many emissions inventory programs in the United States use range checking as a means of controlling the quality of data contained in their emissions database. The types of range checks currently used vary from simple to complex.

In summary, range checking should be incorporated into the Mexico Emissions Inventory Program. Section 6.0 presents cost estimates for developing this capability in Mexico.

Development of Alternative Emission Estimates

Developing alternative emission estimates is another method for assessing the validity of an emissions inventory. The methodology evaluation and proposal prepared under Tasks 4 and 5 described the possibility of developing alternative emission estimates using greenhouse gas (GHG) inventory techniques as a means of verifying emission estimates developed at the state and local level. The GHG approach uses general indicators of activity to estimate emissions for large geographic regions. In inventory terminology, this is referred to as a top-down approach. Conversely, detailed emission estimates developed from surveys and local statistical data are referred to as bottom-up estimates. Using top-down estimates to verify bottom-up calculations has been used in the U.S. to help identify inventory problems. At the same time, it may also create some new problems. Specifically, two different emission estimates are generated, and it may not be clear which estimate is the most accurate.

In spite of the problems that can arise with multiple emission estimates, INE staff should develop top-down emission estimates as a means of verifying the bottom-up calculations performed at the state and local level. The techniques used to develop GHG inventories appears to be an efficient mechanism for developing top-down estimates. Section 6.0 presents a cost estimate for developing this capability in Mexico.

4.3.3 Comparison of Emission Estimates with Ambient Measurements

As a check of the overall inventory, emission estimates can be compared to ambient measurements. In the past, simple comparisons of VOC to NO_x ratios were computed from the emission estimates and compared to the same ratio for the measurement data. More recently, this type of analysis has been expanded to include a comparison of speciated hydrocarbon emissions with ambient measurements of individual species. This type of analysis was performed for the Lake Michigan Ozone Study and in the South Coast Air Basin by the California Air Resources Board (Fujita et al., 1992). From the South Coast study, the researchers examined the possible underestimation bias in the motor vehicle emissions modeling process.

This type of analysis is not recommended for routine use as part of the emissions inventory development process. As special air quality planning studies are conducted in various regions of Mexico, however, this type of analysis should be included in the overall effort. The manuals will include reference materials that can be reviewed by INE and other staff to better determine how this type of analysis can be incorporated into a regional air quality study.

4.3.4 Evaluation of Emission Estimates Using Air Quality Models

This is a relatively new concept that is being used more frequently in the U.S. Application of air quality models in an emissions validation frame work helps to identify potential bias in the inventory. To our knowledge, two different modeling approaches have been used as emissions verification tools: receptor models and three dimensional grid models.

Evaluation of Emission Estimates Using Receptor Models. This technique has been used in several air quality studies in the U.S. Results of a receptor model show the contribution of major sources to either the particulate or VOC measured at an ambient monitor. This distribution can be compared to the distribution of estimated emissions in the inventory for the same source categories. Discrepancies in the source apportionment between the receptor model and the emissions model are investigated to identify potential problems with the emissions inventory. Two examples are summarized below.

In the Southeast Michigan Ozone Study, the University of Chicago at Illinois used VOC receptor modeling to evaluate the emission estimates from several major sources types: motor vehicles, gasoline distribution and handling sources, petroleum refining, graphic arts, surface coating, and coke ovens. Results of this analysis indicated that emissions from motor vehicles, gasoline vapor sources, architectural coatings, and coke ovens were reasonable. In contrast, the receptor model predicted more petroleum refinery and graphic arts emissions than were contained in the emissions inventory (Scheff et al., 1995).

The Desert Research Institute applied PM_{10} receptor modeling in the Phoenix metropolitan area to examine the sources of PM_{10} in that region. The emissions inventory indicated that large amounts of PM_{10} were being emitted from several sources, including entrained road dust. Results of the receptor modeling, however, indicated that the fugitive emission estimates were probably overstated, thus suggesting that refinement in the emission estimating technique is warranted (Watson, 1994).

Evaluation of Emission Estimates Using Three Dimensional Grid Models. Three dimensional grid models are also being used more frequently to help evaluate the uncertainty in the emissions inventory process (see e.g., Chang et al., 1993 and Mulholland and Seinfeld, 1995). Two recent examples include the Mexico City Air Quality Research Initiative

(MARI) and the Arizona Hazardous Air Pollution Research Program. In the MARI study, staff of Los Alamos National Laboratory and the Mexican Petroleum Institute concluded that VOC inventory for Mexico City is low by nearly a factor of four (LANL and IMP, 1994). This conclusion was reached through data analysis techniques, including trajectory analysis, as part of the model performance evaluation.

In the Arizona HAPs Research Program, Radian and other consultants are comparing modeling results with ambient measurements to evaluate the uncertainty in the emission estimates. Based on this results, specific areas of the inventory have been targeted for refinement.

Analysis of Existing Emission Factor Applicability to Mexico

A major concern with the existing emission estimates prepared for Mexico is that they rely extensively on inventory technology from the United States, including emission factors as well as general methodologies for calculating emission estimates. The extent to which U.S. emission factors adequately represent Mexican sources must be investigated. This evaluation should be performed through an analysis of Mexico source test data. These data will be used to:

- Confirm that Mexico's emission sources are comparable to those used to develop United States emission factors, and that AP-42 emission factors are valid for use in compiling Mexico's emission inventory; or

- Document that Mexican emission sources are significantly different for specific sources or source-types and that the source test-derived emission factors must be used in compiling the emission inventory.

This section presents an overview of emission factor application, a general discussion of how emission factors are derived from source measurements, and proposed methods for evaluating the applicability of current emission factors to Mexican sources. The evaluation should be performed in two steps:

1. Source identification and data collection.

2. Statistical comparison with existing emission factors.

Emission Factors and Their Appropriate Use

Depending on the source type and available information, emission estimates are determined using three approaches:

- Direct source measurement;
- Mass balance calculations; and/or
- Engineering calculations.

An emission factor is the average quantity of a pollutant released to the atmosphere during a known activity (e.g., road paving) or during the production of a known amount of material (e.g., tons of steel). It is usually expressed in units of weight of pollutant per unit of activity or quantity of production (e.g., kilograms of nitrogen oxide per kilogram of municipal waste burned, or kilograms of sulfur dioxide per kilogram of coal burned). Emission factors also may be based on continuous or batch (or cyclical) production schedules.

Examples of the assumptions which must be made during the plant-specific estimation process include:

- Process configuration (few facilities are identical);
- Process conditions (temperatures, hold times, use of proprietary catalysts, amount of water used);
- Quality and quantity of feedstock and/or chemicals used; and
- Age of plant and level of maintenance.

Many other parameters that vary somewhat from plant to plant may also need to be considered, even within the same industrial category. Of course, the type of control device and its efficiency of operation at a specific facility must also be taken into account.

The above discussion serves to illustrate the difficulties associated with developing emission factors. There is a general concern that sources in Mexico may be sufficiently different than sources in the U.S. where most of the currently available emission factors were developed. The following discussion describes the recommended process for determining if U.S. emission factors are representative of Mexico sources.

Source Identification and Data Collection

To adapt the U.S. EPA's AP-42 approach to Mexico, the emitting devices defined in AP-42 must be compared with industry operations in Mexico. Key source types must then be selected for the analysis. Resource and time constraints will prevent a comparison of the hundreds of emission factors that have been developed in the U.S. After identifying the sources to include in the analysis, properly documented source testing data should be collected from Mexico. The source testing data may be used to:

- Confirm or reject AP-42 emission factors; or
- Derive emission factors for new categories or for existing AP-42 categories whose data are incompatible with Mexico results.

Once source groups or process type categories have been defined, available source test data must be collected. Since all aspects of testing are important, each source test should be reviewed to determine that referenced protocols were followed. A quality assurance/quality control (QA/QC) program should be established to ensure that the quality of the data can be defined and that the results are defensible.

Complete records of facility production or activity must be collected and provided to the data analysis team. Since the emission factors are the ratio of emission-to-activity rate, the accuracy of the emission factor is equally dependent on the accuracy of both numbers. The testing should be conducted when the plant is operated in a conventional manner at or near capacity.

In addition, if the results are to be compared to U.S. emission factors, the unit of activity that is used and the control equipment that is installed should be consistent with that used in the development of the AP-42 emission factor.

4.4.3 Statistical Comparison Study Desing and Overview

Once valid source tests have been collected, a statistical comparison will be conducted. The objective of the study is to determine whether source sample-derived emission factors are statistically comparable to those presented for the same source types in AP-42. A detailed work plan should be prepared prior to initiating the analysis so that the statistical procedures can be identified and agreed upon. The remainder of this section discusses the statistical issues that must be addressed in the work plan.

The following three general categories of statistical applications can be used to provide a meaningful and valid comparison study:

- Descriptive statistics;
- Statistical significance testing for emission factor comparison; and
- Assessment of variability within and between sources.

Choosing a statistical comparison test will depend on the information available to characterize the emission factor distributions for each pollutant and source type. Several different tests may be used to accommodate varying levels of completeness in the emission factor datasets. Emission factor comparability for each source type can be determined using tolerance intervals, confidence intervals, t-tests, or Wilcoxon Rank-sum tests. The tolerance interval is recommended for most source types because the AP-42 data have limited information that would allow use of the other standard comparison tests. If adequate data are available, confidence intervals, t-tests, or the Wilcoxon Rank-sum non-parametric test should be performed. Each of these procedures will establish whether the source sample-derived emission factors are statistically comparable to the AP-42 emission factors, although the power of the tests and risk of false negative or false positive results may vary depending on the emission factor datasets.

The selection of statistical comparison tests should be based on the following criteria:

- The availability of a standard deviation or variance estimate for the emission factor. The AP-42 emission factors have a rating criterion to indicate the level of confidence in the factor, but do not have a standard deviation, which limits use of the t-test or calculation of confidence intervals.

- The number of measurements used to obtain the average emission factor. If an emission factor is based on a single or a few measurements, there may be less confidence in the representativeness or greater variability associated with that factor.

- The underlying distribution of source-specific emission factors. If the distribution is highly skewed or non-normal, the non-parametric comparison may be a more appropriate test.

The variability within and between sources or processes can be characterized from the source sample and activity data to provide a measure of the precision and accuracy that can be expected in the source-specific emission factors. These types of assessments will promote a better understanding of the precision of the average emission factors and emission inventory.

Expected relationships can be investigated by producing bivariate plots of source sample and activity data for each source type, and performing linear regression analyses to assess the goodness of fit. The scatter of data points is also of interest because it illustrates how closely the data follow the expected linear trend and provides a graphical representation of the variability from all aspects of the measurement procedures and process operations. If the data points show a highly skewed distribution (having most points occurring in the highest or lowest part of the range), several factors could be influencing the results and the average emission factor may not be representative of the source type.

Uncertainty Analysis

This section discusses the complex technical issues associated with estimating emissions uncertainty and outlines a process for addressing uncertainty in the Mexico inventory. To estimate uncertainty in the Mexico inventory, a needs analysis should be completed to better determine the degree of uncertainty analysis required by INE, the appropriate statistical approach must be selected, and finally, the uncertainty in the emissions inventory estimated for a specific geographic region to test the selected approach. As a first step, a work plan should be prepared that expands on the information presented in this section. The approach for assessing uncertainty will be refined and expanded as the corresponding manual addressing uncertainty analysis is also prepared.

To aid in the understanding of this material, a brief discussion of the statistical concepts of bias and variability (i.e., imprecision) are first presented. This material is followed by the proposed approach for establishing an uncertainty estimation process in Mexico.

Background

An appreciation for the various expressions of uncertainty is an important prerequisite to identifying the best approach. The term "uncertainty" comprises two types of error in estimation: bias and variability. These terms are defined below, followed by a historical perspective of uncertainty analysis.

Bias. This term defines the extent to which an estimate is persistently inaccurate. In emissions inventory data, bias results from a systematic error in which some aspect of the emissions process is misrepresented or not taken into account. For example, the tendency of older generation motor vehicle emission factor models to underestimate VOC emissions due to evaporative and running losses resulted in biased (low) estimates of VOC emissions from on-road motor vehicles.

Bias is typically represented in either of two ways:

- The *absolute bias* is the difference between the estimate and the true value. However, the true value is rarely known.
- The *relative bias* is the absolute bias expressed in percentage terms. For emissions inventory work, the relative bias is generally preferred over the absolute bias.

As part of the emissions development process, the goal is to reduce all known sources of bias, both across sources and within sources. If a bias is known to exist, then effort should be initiated to quantify and remove the bias. However, this may be difficult to accomplish because of a lack of resources, data, or other factors.

Variability. This term refers to the imprecision of an estimate. It is the difference due to random error or fluctuations between a measurement and its true value. In emissions inventory data, variability may result from temporal or spatial fluctuations in the parameters (activity data) used to estimate emission factors (i.e., hourly variation in the fuel sulfur content, heating value, and load for an industrial boiler). The imprecision may also result from sampling error due to the inability to obtain a comprehensive set of measurements for all sources or source conditions (i.e., one cannot perform source sampling on a given boiler under all conditions under which it may operate nor can one test all identical boilers).

Methodologies to Estimate Emissions Uncertainty. Most emission estimates are produced using a model that assumes emissions are the product of a series of independent parameters (i.e., emission factor times activity data times control factor times temporal adjustment, etc) of the form

$$ER_t = p_1 \times p_2 \times \ldots \times p_n$$

where

ER_t	=	Emission rate for time t
p_i	=	Parameter used to estimate emissions
n	=	Number of parameters

In this context, a model is a simplified representation of the processes leading to the emissions. Model uncertainty stems from the inability of one to simulate the emission process completely with the resultant use of surrogate variables, exclusion of variables from the computation process, and over-simplification of emission process in the model.

This same general equation applies from the simple case of an emission factor (e.g., grams per kilogram combusted) times an activity datum (e.g., number of kilograms combusted per day) to the complex case where a model such as the BEIS model is used to estimate biogenic emissions or the MOBILE5 model is used to estimate on-road motor vehicle emission factors.

There are a number of real world problems and complexities associated with estimating emissions uncertainty when the above equation is used to develop the emission inventory. These problems include the inherent (and generally erroneous) assumption of independence of the individual parameters (i.e., no temporal or spatial correlation in emissions), the complications inherent in obtaining temporal, spatial, and speciated estimates of emissions from average values of emissions (e.g., obtaining gridded, speciated, hourly emission estimates from annual county-wide emission estimates), the limited amount of data that may be available for validation of estimates, and the difficulty posed by temporal and spatial data dependencies in validating those estimates even when data are available. The net result of ignoring these difficulties in an analysis of emissions uncertainty is that the uncertainty is underestimated.

Because of the complications associated with development of estimates of emission uncertainties, a number of methods have been applied to estimation of uncertainty. Table 4-3 presents a brief overview of six general methodologies that have or are currently being used to estimate emissions uncertainty. The methods range from the highly subjective expert estimation in Delphi-type techniques to the highly complex and computationally intensive direct simulation and inverse air quality modeling approaches.

Table 4-3

Overview of Common Methodology Used to Estimate Emissions Uncertainty

Methodology	Reference	Discussion
Data Quality Ratings	USEPA, 1985 Beck et al., 1994	Subjective rankings are assigned to each emission factor or parameter. In the DARS method, numerical values are then attributed to each ranking through objective methods.
Expert Estimation	Linstene and Turaff, 1975 SCAQMD, 1982 Horie, 1988 Horie and Shorpe, 1989	Emission distribution parameters (i.e., mean, standard deviation, and distribution type) are estimated by experts. Simple analytical and graphical techniques can then be used to estimate confidence limits from the assumed distributional data. In the Delphi method, expert judgment is used to estimate uncertainty directly.
Propagation of Errors	Mangat et al., 1984 Benkovitz, 1985 Benkovitz and Oden, 1989 Balentine et al., 1994 T.J. McCann & Associates, 1994	Emission parameter means and standard deviations are estimated using expert judgment, measurements, or other methods. Standard statistical techniques of error prorogation typically based upon Taylor's series expansions are then used to estimate the composite uncertainty.
Direct Simulation (e.g., Monte Carlo)	Freeman et al., 1986 Oden and Benkovitz, 1990 T.J. McCann & Associates, 1994	Monte Carlo, resampling, and other numerical methods are used to estimate directly the central value and confidence intervals of individual emission estimates. In the Monte Carlo method, expert judgment is used to estimate the values of the distribution parameters prior to performance of the Monte Carlo simulation. Other methods require no such assumptions.
Receptor Modeling (Source Apportionment)	Watson et al., 1984 Lowenthal et al., 1992 Chow et al., 1992 Sheff et al., 1992	Receptor modeling is an independent means to estimate the relative contribution of specific source types to observed air quality measurements. The method works best for non-reactive pollutants for which unique emission composition "fingerprints" exist for all significant source categories. The method provides a measure of the relative contribution of each source type but not absolute emission estimates.
Direct or Indirect Measurement (Validation)	Pierson et al., 1990 Fujita et al., 1992 Mitchell et al., 1995 Claiborn et al., 1995	Direct or indirect field measurement of emissions are used to compute uncertainty directly. These methods also provide data for validating emission estimates and models.
Inverse Air Quality Modeling	Chang et al., 1993 Mulholland and Seinfeld, 1995	Air quality simulation models are used in an inverse sense to estimate the emissions that would be required to produce the observed concentrations fields.

Subjective ranking methods such as that used for AP-42 emission factors (U.S. EPA, 1985) rely on a ranking of from A (best) to E (worst) for each emission factor. No numerical uncertainty values are associated with each rating. Newer methods such as the Data Attribute Rating System (DARS) (Beck et al., 1994) assign a numerical value to the quality of the various components of the emissions inventory and allow numerical manipulation of the uncertainty estimates of the system.

The expert estimation and propagation of errors methods rely on the assumption of independence between all the input emission parameters. They also assume the emission parameters obey a normal or lognormal distribution and require estimates of the parameters (means and standard deviations) required to define the distributions.These two methods tend to be relatively simple to implement but the assumption of independence is rarely achieved or verified. Direct simulation methods, using error minimization, Monte Carlo, and resampling approaches, are not limited by assumptions of independence but may require estimates of distribution type. These methods are very powerful, but they require sophistication in statistics and emissions analysis to implement properly.

Field measurement studies directly (or indirectly) estimate emissions and emissions uncertainty and provide data for use in validation of emission estimates. However, field data are valid only for those sources and conditions for which measurement were made. The inverse modeling procedures are very powerful procedures that yield direct estimates of uncertainty. However, they require considerable sophistication in advanced air quality modeling in addition to statistics and emissions analysis. They are also quite expensive and are subject to the inherent limitation that air quality simulation models are imperfect representations of the real world.

4.5.2 Needs Analysis for Mexico

To determine the degree and type of uncertainty analyses that will be appropriate for Mexico, a needs analysis should be conducted. This analysis would be part of the work plan development and should include definition of the type of uncertainty analysis required, geographic extent of the analysis, and the emission sources on which to focus. Source categories should be rank ordered to identify those categories that dominate the emissions inventory, and the uncertainty analysis should focus on those sources. Although it will often be of interest to refine average emission estimates in order to achieve finer temporal and spatial resolutions of the estimates, the cost of achieving a higher level of confidence should be evaluated. For example, a single municipality-wide emission estimate for VOC from surface coating may be spatially allocated to a uniform grid based upon population, and then temporally allocated to a set of hourly seasonal and day-of-week estimates. These kinds of adjustments introduce additional variability into the estimate but quantifying and eliminating this variability may not be warranted if VOC from surface coating is less than 1% of the inventory.

A qualitative approach to assessing the need for rigorous uncertainty analysis is recommended, based on such factors as:

- The appropriateness of emission estimation techniques and inventory methods;

- The level of quality assurance and verification used to develop the emission estimates; and

- The level of rigor used to develop the activity data for the emission estimates (i.e., were detailed surveys used or were emission estimates extrapolated from other geographic regions?)

Evaluation of Uncertainty Estimation Methods

The second step will be to select the appropriate methodology to use for estimating uncertainty in the emissions estimates. The specific method selected will depend on the results of the needs analysis. There are a number of general methodologies available for evaluation of uncertainty (imprecision and bias) in emission estimates (see Table 4-3). For this effort, developing a new method is not recommended, but rather applying and possibly refining an existing method.

There is a generally a tradeoff in the selection of the uncertainty estimation methodology. The simpler methods involving error propagation are easy to implement, require few resources, and are relatively inexpensive to use. However, they require the assumption of independence which is generally not met and which generally results in underestimating the amount of uncertainty in the emission estimates. The more sophisticated methodologies generally do not require the assumption of independence but tend to be computationally intensive and require considerable sophistication in their implementation and can be expensive. In addition, the data required to completely implement these methods generally do not exist and must be approximated, adding additional uncertainty to the analysis.

A major factor in the selection of the appropriate methodology is therefore the resources available for performance of the analysis. If data providing detailed information on the emissions and emission parameters are available due to field measurements or intensive inventory development programs, the sophisticated, computationally intensive methodologies can probably be used effectively. However, if there is very little, or no, data for the emission sources of concern, the more simplistic methodologies are likely more appropriate because the level of detail in the methodology should approximate the level of detail in the available data. For our work in Mexico, data availability will limited. Therefore, a less sophisticated methodology will likely be more appropriate for the analysis but a specific approach has not been selected. The actual selection of the appropriate methodology will be made during preparation of the workplan.

The workplan will review the available methodology in detail and develop a recommended methodology for estimation of emissions uncertainty. The use of a Monte Carlo approach to simulate directly uncertainty estimates for the Mexico inventory should be examined carefully. Three primary difficulties are invisioned that must be addressed in the selection of this emissions uncertainty methodology. Table 4-4 presents these three areas and our current thinking on the appropriate methodology for overcoming the difficulty. The information presented in this table is tentative and will be finalized as part of the workplan, along with the specific methodology to be used.

Table 4-4

Areas of Difficulty in Estimating Emissions Uncertainty for Mexico and Our Tentative Approach to Overcome the Difficulty

Area of Difficulty	Proposed Methodology	Discussion
Definition of the distribution type for each emission parameter	Define the distribution of each emission parameter as normal, lognormal, or weibull.	Because of the lack of data on emissions in Mexico, the use of the most sophisticated uncertainty analysis methods that do not require the definition of underlying distributions is probably unwarranted at this time. Consequently, informed judgments must be made regarding as the distributional nature of each required emission parameter.
Estimation of values defining the distribution for each emission parameter	Use expert judgment and published literature to estimate the mean and standard deviation for each emission parameter.	Without site-specific data available to define the distributional variables for individual parameters, the analysis is are limited to the use of expert judgment and literature values to estimate these key variables.
Lack of independence of the emission parameters	Define the dependent relationships between the various parameters and develop analytic functions that can be implemented as part of the Monte Carlo analysis.	The approach should analyze each of the emission parameters (e.g., population, employment, fuel use, etc) and develop an analytic formula to define the dependent relationship between these and all other factors used to estimate emissions for each source. These analytic relations will then be incorporated into the Monte Carlo analysis setup.

Development of Numerical Uncertainty Estimates

The third step of this process will involve testing the selected approach in a designated geographic area. This region could be one of the three test regions discussed in Section 4.2 or it could be another geographic region for which INE has special needs to assess uncertainty. Whatever region is selected, INE staff should participate in the effort so a training benefit is also realized.

5.0 DATA MANAGEMENT

Inventory data can be managed almost entirely by computer. During the inventory planning stages, an agency should anticipate the volume and types of data-handling needed in the inventory effort and should weigh the relative advantages of manual versus computerized systems. If an agency must deal with large amounts of data, maximizing the use of computerized inventory data-handling systems will allow the agency to spend more time gathering, analyzing, and validating the inventory data, as opposed to manipulating the data.

The computerized data-handling approach is superior for large areas with diverse sources. Computerized data handling becomes significantly more cost-effective as the database, the variety of tabular summaries, or the number of iterative tasks increase. In these cases, the computerized inventory requires less overall time involvement and has the added advantage of forcing organization, consistency, and accuracy.

Some activities that can be performed efficiently and rapidly by computer include:

- Printing mailing lists and labels for distribution of questionnaires and other correspondence;
- Maintaining status reports and logs;
- Calculating and summarizing emissions;
- Performing error checks and other audit functions;
- Storing source, emissions, and other data;
- Sorting and selectively accessing data; and
- Generating output reports.

The selection of a data management system will depend on several factors, such as:

- Type of computer system;
- Size of the inventory database;
- Complexity of the emissions calculations;
- Number of calculations to be made;
- Variety of tabular summarizes to be generated;
- Availability and expertise of clerical and data-handling personnel; and
- Time constraints.

Current Database System

For point sources, nearly all criteria-type emissions inventory data are collected by INE headquarters staff in Mexico City and by Regional Office personnel for designated cities in Mexico. These inventories are generated by INE staff on personal computers (PCs) using activity data (i.e., throughput, production, process rates, etc.) obtained from responses to annual questionnaires (encuestas) mailed to industrial facilities by INE. These responses are coupled with emission factors contained in the Sistema Nacional de Información de Fuentes Fijas (SNIFF) or National System of Information on Stationary Sources. This is a Dbase III Plus format PC data handling system.

SNIFF is comprised of 25 programs and 23 relational databases that are menu-driven to be more user-friendly. SNIFF consists of two main parts. The first, the National Census of Stationary Sources, contains general information about Mexican industrial facilities (e.g., name, address, license numbers, etc.). The second part, the National Inventory of Emissions, contains general source information and data on process type, raw materials, products, emissions, and control devices. Almost all emission factors in SNIFF were obtained from the U.S. EPA FIRE emission factor database. Data quality control consists of manual review of questionnaires and rudimentary data checks built into the SNIFF system.

INE staff have recognized the need for a more advanced and comprehensive data management system. Data management at INE will be standardized on Oracle, Novell, and UNIX. They also plan on using Lotus Notes as a means to transfer and share large data sets or documents among multiple users. INE is currently in the process of developing a networked computer system at INE headquarters.

INE staff have also been involved in preliminary efforts to evaluate software options. Over the past few years, Mexico has been working with the German and Japanese environmental protection agencies to develop a more adequate emissions inventory data management system. Prototype systems were documented and evaluated by Mexico. INE also considered using the German Information Management System as proposed by a German consulting firm, TUV Reinland. In addition, INE, in conjunction with Environment Canada, has evaluated the Regional Air Pollution Inventory Development System (RAPIDS) software.

Staff of INE have requested technical support for the implementation of a more robust data management system than is currently in place. The Phase II portion of the Mexico Emissions Inventory Program project will contribute to INE's ongoing software evaluation

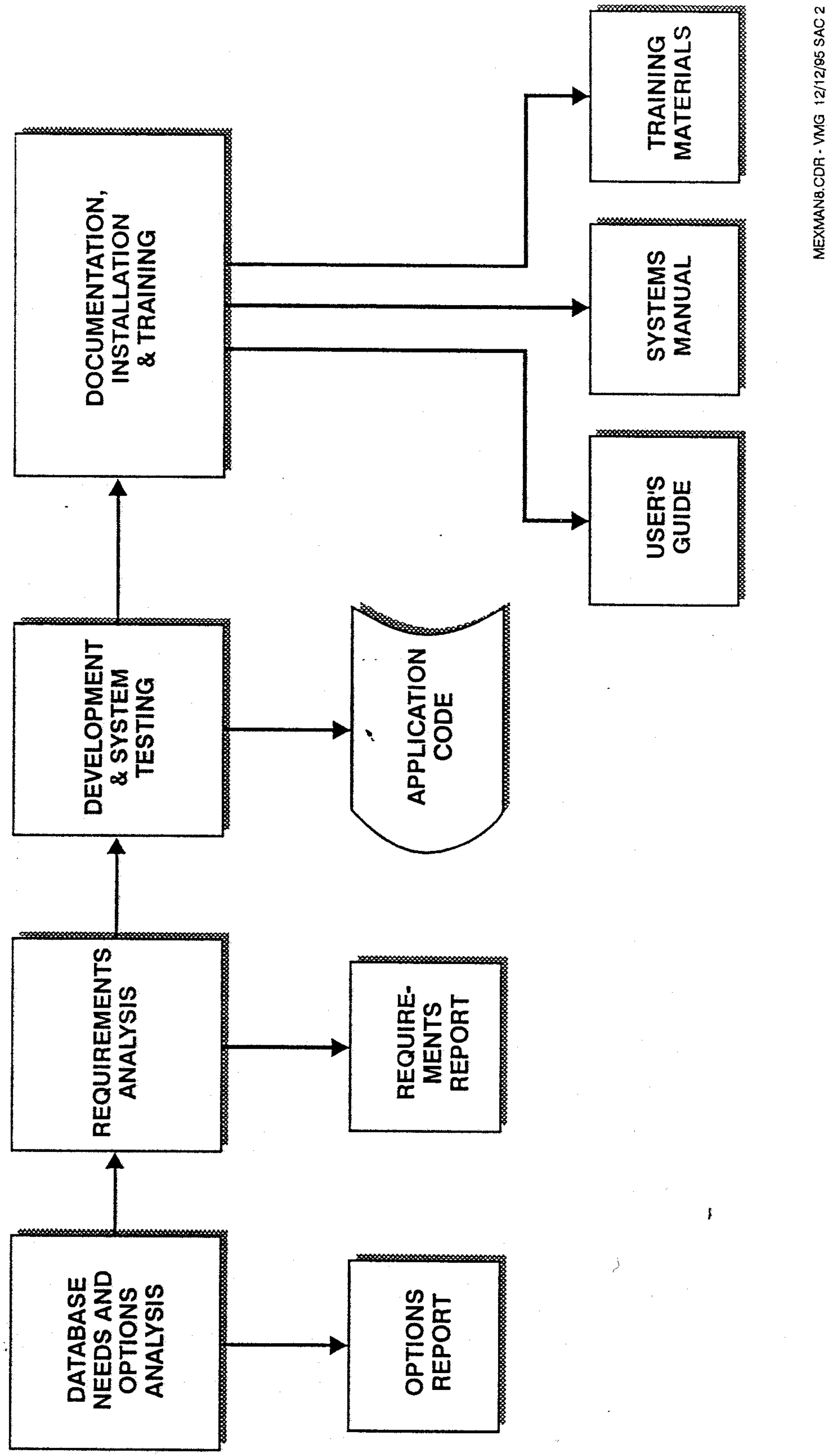


Figure 5-1. Data Management Development Process

efforts. The proposed approach to the development of a more advanced data management system for INE is illustrated in Figure 5-1 and further described by the following recommended technical activities.

Database Needs and Options Analysis

The development of relational databases for INE will begin with a Database Needs and Options Analysis to select the approach best-suited to meet the requirements of the Mexico Emissions Inventory Program within the schedule and budgetary constraints. The first step in this analysis will be to perform a needs analysis. The purpose of the needs analysis will be to determine the requirements of the system. For example, should the system contain both air toxics and criteria pollutant emissions? Should the system have a multimedia focus? How will data in the system be shared with other interested groups, such as the United States?

Following the needs assessment, various options will be evaluated. To begin, the existing database system, SNIFF, will be evaluated. Other systems will also be evaluated that have the potential to meet the data management requirements for this project. A Database Options Analysis Report will be prepared containing a recommendation on the most appropriate database for this project. Multiple database options will be considered that would allow INE to develop a new system, to use or modify a public-domain system, or to use a proprietary system. Example database options include:

- Develop new relational database system (using FoxPro, SAS®, Oracle, etc.);
- Regional Air Pollution Inventory Development System (RAPIDS);
- STEPS system commercially available from Pacific Environmental Systems;
- Aerometric Information Retrieval System (AIRS);
- California Emissions Inventory Development and Reporting System (CEIDARS) from the California Air Resources Board (CARB);
- Paradox system developed for the Arizona Department of Environmental Quality (AZDEQ); and

- GloTech/GloED used for managing global-scale emissions data.

This list will be expanded as necessary prior to the initiation of the database options analysis.

Database System Development

After the Options Analysis is completed, it is likely that either system development or customization of an existing system will be required. Therefore, the detailed requirements for the selected database system must be defined, including the queries, displays, and reports. These specifications should be presented in a written Requirements Analysis. The Requirements Analysis is necessary for the software programmers to code and test a new system or to customize an existing system.

The newly developed or modified database design must then be coded and tested, based on the Requirements Analysis. The finished product of this task will consist of a completed and tested database system.

Following the Options Analysis, decisions will be needed to determine who carries out the remaining tasks. For example, should the Options Analysis select RAPIDS as the database system, it is possible that INE may elect to work with Environment Canada on the Requirements Analysis and subsequent coding and testing.

System Installation and Training

Finally, written documentation for the database system must be provided in the form of a Systems Manual and User's Guide. The database system must be installed at INE and training classes conducted. Regardless of the system developed and/or selected, provisions should be made for ongoing technical support for approximately two years to ensure that INE fully implements the new system.

6.0 PROPOSED RESOURCE ALLOCATION

Developing costs and setting priorities for the activities needed to develop Mexico's national inventory program is subjective. The material in this section reflects our best professional judgement on resource needs and allocation of those resources. Consequently, the values presented in this section should be viewed from a planning standpoint rather than as exact values. Another level of cost estimation should be performed once the Phase II resources have been established. With this objective in mind, priorities have been assigned to each activity discussed in this report according to three different funding scenarios:

- Scenario 1 - approximately $400,000 is available in Phase II to establish the national inventory program;
- Scenario 2 - approximately $1M can be obtained; and
- Scenario 3 - the approximately $5M to $7M listed in Table 6-1 can be obtained to develop the program.

Table 6-1 presents detailed cost estimates for each of the program elements discussed in this plan. Where appropriate, cost ranges are presented. Total costs for the initiation of a complete inventory program in Mexico are estimated between $5.5M and $6.8M. Each line item listed in Table 6-1 is assigned to one of the three funding scenarios based on our perception of priorities. Scenarios 1 and 2 are presented at the end of this section.

Current funding available through the Western Governors' Association for the development of the inventory program is $345,000. This represents scenario #1. Anticipated funding is approximately $1M, and is shown as Scenario #2.

Table 6-1

Recommended Activities and Estimated Costs

Program Element	Activity	Funding Scenario[a]	Cost Estimate ($000)	Discussion
Training Course	Training Course Curriculum and Materials	1	100	This cost estimate assumes that some of the manuals can be used as text material in the course.
	University Autónoma Metropolitan - Azcaptzalco	1	15	UAM sponsorship for some of UAM's efforts in the development of the course materials.
	Train UAM Staff	1	50	Development of materials to train UAM staff.
	Translation of Materials	N / A	0	No funds have been budgeted for translating any of the training materials.
Inventory Manuals	Emissions Inventory Program Planning	1	15 - 20	This manual will address the important planning issues that must be considered in an air emissions inventory program. Program planning will be discussed not as an "up-front" activity, but rather as an ongoing process to ensure the long-term growth and success of an emissions inventory program.
	Emissions Inventory Fundamentals	1	12 - 18	This manual will present the basic fundamentals of emissions inventory development. The objective is to discuss inventory elements that apply to multiple source types (e.g., point and area) in this one manual, so as to avoid the need for repetition in multiple volumes.
	Basic Methodologies	1	20 - 28	This manual will present the basic methodologies used to develop emission estimates. Starting with information previously presented in the Methodology Proposal, this manual will provide additional detailed discussion of each methodology, including examples and sample calculations. Inventory tools associated with each methodology will be identified and included in Volume XI (References).
Inventory Manuals (Cont.)	Point Sources	1	50 - 75	This manual will provide guidance for developing the point source emissions inventory. A table will be developed to cross-reference each

Table 6-1

(Continued)

Program Element	Activity	Funding Scenario[a]	Cost Estimate ($000)	Discussion
				industry / device type combination (e.g., petroleum refining / combustion devices) with one or more of the basic methodologies presented in Volume III.
	Area Sources	1	75 - 100	This manual will provide guidance for developing the area source emissions inventory. After the presentation of general area source information, a table will be provided to cross-reference each area source category (e.g., asphalt application) with one or more of the basic methodologies presented in Volume III. Then, source category-specific information will be discussed for each source category defined in the table.
	On-Road Mobile Sources	1	60 - 80	This manual will explain the necessary steps for development of an emissions inventory for on-road mobile sources. Motor vehicles are a significant emissions source within the overall emissions inventory. Because motor vehicles are inherently different from point and area sources, the available estimation methods and required data are also different. To estimate emissions from these complex sources, models are the preferred estimation tool. Many of these models utilize extensive test data inputs applicable to a given country or region. This manual will focus primarily on the data development phase of estimating motor vehicle emissions.
Inventory Manuals (Cont.)	Natural Sources	3	30 - 40	This manual will provide guidance for developing the natural source emissions inventory (i.e., biogenic VOC and soil NO_x). In addition, this manual will include the theoretical aspects of emission calculations and discussion of specific models.

Table 6-1

(Continued)

Program Element	Activity	Funding Scenario[a]	Cost Estimate ($000)	Discussion
	Modeling Inventory Development	3	10 - 25	This manual will provide guidance for developing inventory data for use in air quality models and will address issues such as temporal allocation, spatial allocation, speciation, and projection of emission estimates.
	Evaluation	2	50 - 60	This manual will consist of three parts: quality assurance/quality control (QA/QC), uncertainty analysis, and emissions verification. The QA/QC portion will define the overall QA/QC program and be written to complement source specific QA/QC procedures written into other manuals. The uncertainty analysis will include not only methods of assessing uncertainty in emission estimates, but also for assessing uncertainty in modeling values such as speciation profiles and emission projection factors. The emissions verification section will describe various analyses that can be done to examine the accuracy of the emission estimates. Examples include receptor modeling and trajectory analysis combined with specific data analysis techniques.
	Data Management	2	30 - 40	This manual will address the important needs associated with the data management element of a comprehensive emission inventory program.
	Translation	NA	60	All manuals will be completed in English and then translated into Spanish.
Area Source Methodology Development	Develop Multivariate Emission Models	3	300	Cost estimate covers only the high priority area sources for which multivariate modeling approach has been recommended. Including all area source categories would increase this amount to approximately $700,000.
Special Studies	Fugitive Emissions from Domestic	2	50	Determine areas of propane fuel use and quantities

Table 6-1

(Continued)

Program Element	Activity	Funding Scenario[a]	Cost Estimate ($000)	Discussion
for Area Sources	Fuel Usage			of use. Develop emissions estimating techniques, including source sampling if required.
	Emissions from Waste Burning	3	75	Characterize extent of open burning dumps, quantity of refuse burned, refuse composition, and typical burning practices. Develop emissions estimating techniques which would likely include surveys and/or source sampling.
	Emissions from Open Sewage	3	25	Characterize extent of open sewage and typical chemical composition of sewage. Develop emission estimating techniques, including source sampling if required.
	Emissions from Brick Manufacturing	2	35	Determine areas with small-scale brick kilns, quantity of fuel used, and fuel composition. Develop emissions estimating techniques using surveys and/or source sampling.
	Emissions from Street Vendors	3	25	Characterize extent of street vendors, quantity of fuel used, and fuel composition. Develop emissions estimating techniques using surveys and/or source sampling.
	Solvent Usage	2	150	Conduct a stratified survey to develop solvent usage data by industrial/commercial sector. Develop emissions estimating techniques for solvent area source categories.
Special Studies for Area Sources (Cont.)	National Solvents Balance	3	30	Perform a national solvents balance based on information from appropriate manufacturers' association data, import/export records, and other data sources. Use results to develop or verify emissions estimates for solvent area source categories.
	National Petroleum Balance	3	25	Perform a national level petroleum balance based on information from PEMEX and other data sources. Test and confirm the reasonableness of

Table 6-1

(Continued)

Program Element	Activity	Funding Scenario[a]	Cost Estimate ($000)	Discussion
				petroleum balance. Data used to supplement area source categories that consume petroleum-based fuels.
	Heterogeniety of Emissions in Mexico	3	30	Identify region-specific factors that affect emission estimates. Assess qualitatively (and possibly quantitatively) what effects these factors have on various source categories. Develop procedures for adjusting emissions based on geographic differences.
	Nonroad Equipment	3	150	Confirm that Mexico has a smaller engine population than the U.S. Conduct survey to quantify actual engine populations.
Special Studies for Motor Vehicles	Driving Cycle Development	3	250 - 500	Quantify typical Mexico driving patterns. Use driving pattern data to derive an appropriate driving cycle to be used in vehicle testing.
	Vehicle Testing	3	300 to 500	Measure emissions from a representative vehicle mix in cities south of Mexico - U.S. border. Use emissions data to populate an emission factor model.
	Emission Factor Model	3	150	Refine emission factor model from vehicle test data. Modify emission factor model by any applicable results from other special studies.
Special Studies for Motor Vehicles (Cont.)	I/M Effectiveness Analysis	3	125	Conduct survey to determine the actual effectiveness of established I/M programs. Compare results to theoretical effectiveness of I/M programs. Information used to adjust emission factor model and emissions estimates.
	Tampering and Misfueling Analysis	3	75	Conduct survey to establish the level of tampering and misfueling among those vehicles that have emission control technology. Data used to adjust emission factor model and emissions estimates.

Table 6-1

(Continued)

Program Element	Activity	Funding Scenario[a]	Cost Estimate ($000)	Discussion
	Unregistered Vehicle Study	3	50	Conduct survey to quantify the number of unregistered vehicles present in the Mexico vehicle fleet. Data used to modify existing vehicle registration distribution data.
Special Studies for Natural Sources	Biogenic Hydrocarbons	3	350	Develop Mexico-specific biomass and emission factors for key plant species.
	Soil NO_x	3	200	Develop soil NO_x fluxes for Mexico specific conditions.
Methodology Testing	Develop Emissions Inventory for Ambos Nogales	3	150	Inventory effort will build upon planned efforts by Arizona Department of Environmental Quality for this region.
	Develop Emissions Inventory for Cd. Juárez	3	200	Inventory effort will build upon ongoing efforts by the Texas Natural Resources Conservation Commission to develop a motor vehicle emissions inventory. Point and area sources would also be included.
	Develop Emissions Inventory for Mexicali	2	250	This effort is expected to require more resources because little inventory work has been performed in this region.

Table 6-1

(Continued)

Emissions Validation	Develop Range Checks for Mexico Sources	3	50	Range checks would be used to validate emissions databases developed in the inventory program.
	Develop National Top-Down Inventory Techniques	3	50	Top down emission calculations would be performed by INE Headquarters staff as a means to evaluate emission estimates developed at the local and state levels.
Data Management	Conduct a Database Needs and Options Analysis	1	30	This task would identify and evaluate database management options. A recommended approach will be presented.
	Customize Database System for INE's use.	3	100 to 1,000	The range of costs for this task is large due to the wide range of available options. For $100,000, a simple customization of an existing system for INE use could be performed. The cost to develop a new system could approach $1M.
	Install and Train INE staff on Selected System	3	30 to 60	Includes development/refinement of system and users manuals.
Satellite Imagery Data	Gather and produce LULC data from satellite images.	3	1,300	Land use/land cover data needed for biogenic emission estimates and to facilitate the multivariate emissions modeling approach for area sources.
Emission Factor Applicability	Examine key Mexico sources and Evaluate Applicability of Existing Emission Factors	3	250	Key source types would be identified and ranked. Emission factors for key sources would be examined for applicability in Mexico.
Inventory Uncertainty	Develop and Apply Emission Uncertainty Methodology	3	60	A small effort would used to refine existing approaches with most of the resources applied to estimate uncertainty in emission estimates for one selected geographic region.

[a] Four different funding scenarios have been established: $500,000, $1M, $2M, and $5M - $7M. This table represents scenario #4.

N/A = Not applicable.

As a final point, developing the cost ranges presented in Table 6-1 required several key assumptions.

- Several of the costs associated with the technical activities are complimentary to the development of the manuals. For example, if the Evaluation Manual is not developed, then costs for the uncertainty method development will have to be increased.
- Costs for inflation have not been taken into account. Inflationary costs are assumed to be less than the imprecision of the cost estimates.
- Translation of materials from English to Spanish will only be performed for the manuals. No other translation costs have been included.
- For nearly all of the technical activities, such as the special studies for area sources, Mexican personnel are assumed to participate in the effort to provide in-kind support and to use the effort as a training exercise.

SCENARIO #1

Existing Funding ~ $345,000

Program Element	Cost ($000)
Training for University	120
Manuals Development	
Fundamentals	14
Basic Methodologies	26
Point Sources	50
Area Sources	75
On-Road Mobile Sources	60
Total	345

SCENARIO #2

Anticipated Funding ~ $1M

Program Element	Cost ($000)
Training for University	165
Manuals Development	
Program Planning	15
Fundamentals	14
Basic Methodologies	26
Point Sources	50
Area Sources	75
On-Road Mobile Sources	60
Emissions Evaluation	33
Data Management	30
Translation	60
Manuals Subtotal	355
Database Needs and Options Analysis	30
Area Source Special Studies	
Fugitive Emissions from Domestic Fuel Usage	50
Solvent Usage Study	150
Emissions from Brick Manufacturing	35
Area Source Subtotal	235
On-Road Motor Vehicle Special Studies	
Driving Cycle Study	0
Vehicle Testing	0
Methodology Testing	
Mexicali	250
Total	1,000

SCHEDULE

This section illustrates the anticipated sequencing and duration of each of the Phase II activities discussed in this report. Each activity is shown in the following scheduling chart.

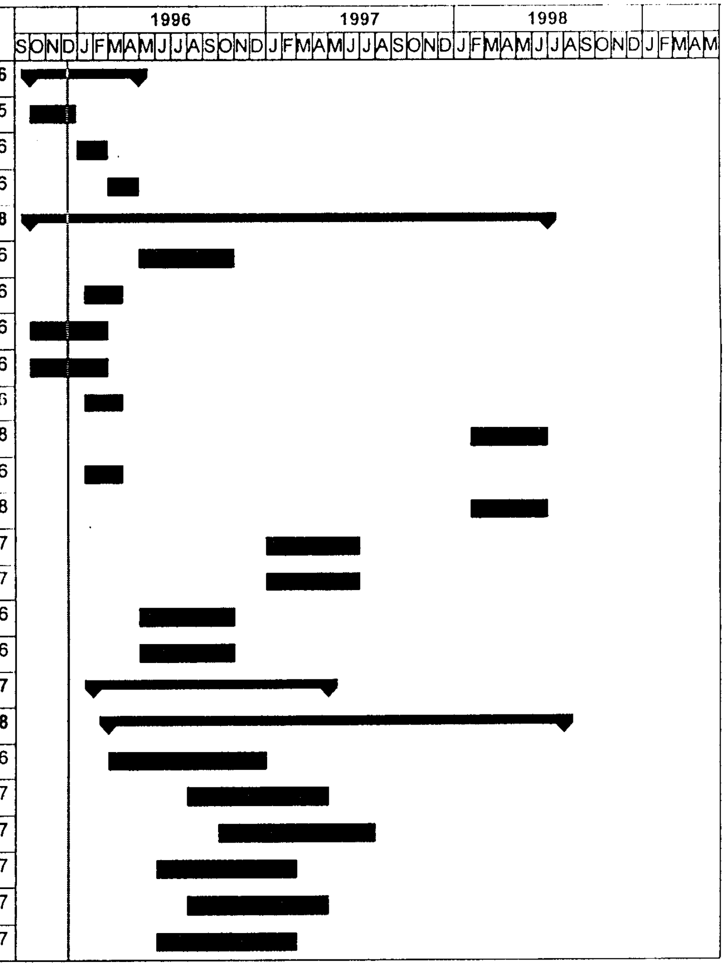
Completing all of these efforts will require several years. The current schedule illustrates that work on the Phase II activities will begin in October 1995 and conclude in December 1998. Although this represents slightly more than three full years to implement the activities discussed in this report, this is viewed as a very aggressive schedule. Completing all of these activities according to their individual durations is unlikely. Nonetheless, an aggressive schedule was developed so that work can be initiated and completed as soon as possible.

Higher priority items, such as those shown in Scenario 1 of Section 6.0, should be completed by mid 1996. Medium priority activities described in Scenario 2 would be completed by approximately the end of 1997. Several lower priority items would be completed by the end of 1998.

The most difficult scheduling issue appears to be the coordination of the development of the inventory manuals while additional methodology development and special studies proposed for area and mobile sources are taking place. Rather than delaying these manuals until these technical activities are completed, draft manuals should be developed, which would then be revised after the technical studies were completed.

Phase II Activities under the Mexico Emissions Inventory Methodology Project

ID	Task Name	Days	Start	Finish
1	**TRAINING COURSE**	**153d**	**10/2/95**	**4/30/96**
2	Training Materials	66d	10/2/95	12/29/95
3	Train UAM Staff	44d	1/1/96	2/29/96
4	Prototype	43d	3/1/96	4/30/96
5	**INVENTORY MANUALS**	**718d**	**10/2/95**	**6/30/98**
6	Emissions Inventory Program Planning	132d	5/1/96	10/31/96
7	Emissions Inventory Fundamentals	55d	1/15/96	3/29/96
8	Basic Methodologies	110d	10/2/95	2/29/96
9	Point Sources	110d	10/2/95	2/29/96
10	Initial Area Sources	55d	1/15/96	3/29/96
11	Revised Area Sources	107d	2/2/98	6/30/98
12	Initial On-Road Mobile Sources	55d	1/15/96	3/29/96
13	Revised On-Road Mobile Sources	107d	2/2/98	6/30/98
14	Natural Sources	129d	1/1/97	6/30/97
15	Modeling Inventory Development	129d	1/1/97	6/30/97
16	Evaluation	132d	5/1/96	10/31/96
17	Data Management	132d	5/1/96	10/31/96
18	**AREA SOURCE METHODOLOGY DEVELOPMENT**	**325d**	**2/1/96**	**4/30/97**
20	**SPECIAL STUDIES FOR AREA SOURCES**	**631d**	**3/1/96**	**7/31/98**
21	Fugitives Emissions from Domestic Fuel Usage	218d	3/1/96	12/31/96
22	Emissions from Waste Burning	195d	8/1/96	4/30/97
23	Emissions from Open Sewage	217d	10/1/96	7/30/97
24	Emissions from Brick Manufacturing	195d	6/3/96	2/28/97
25	Emissions from Street Vendors	195d	8/1/96	4/30/97
26	Solvent Usage	195d	6/3/96	2/28/97



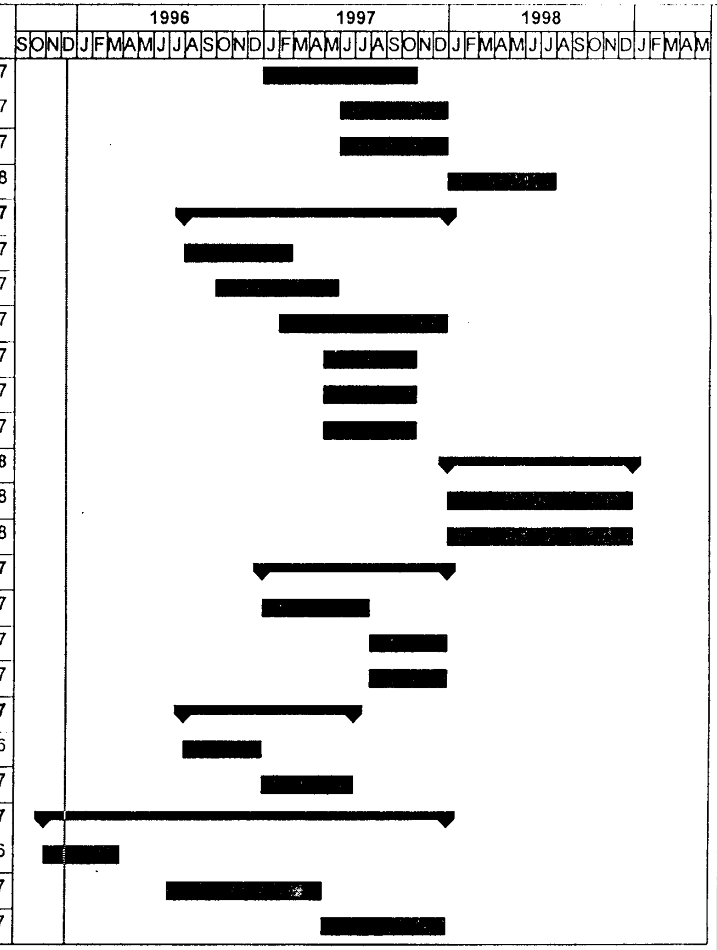
PROJECT SCHEDULE

Date Produced: 12/12/95

Task Summary — Task

Phase II Activities under the Mexico Emissions Inventory Methodology Project

ID	Task Name	Days	Start	Finish
27	National Solvents Balance	218d	1/1/97	10/31/97
28	National Petroleum Balance	153d	6/2/97	12/31/97
29	Heterogeneity of Emissions in Mexico	153d	6/2/97	12/31/97
30	Nonroad Equipment	152d	1/1/98	7/31/98
31	**SPECIAL STUDIES FOR MOTOR VEHICLES**	**370d**	**8/1/96**	**12/31/97**
32	Driving Cycle Development	152d	8/1/96	2/28/97
33	Vehicle Testing	174d	10/1/96	5/30/97
34	Emission Factor Model	238d	2/3/97	12/31/97
35	I/M Effectiveness Analysis	132d	5/1/97	10/31/97
36	Tampering & Misfueling Analysis	132d	5/1/97	10/31/97
37	Unregistered Vehicle Study	132d	5/1/97	10/31/97
38	**SPECIAL STUDIES FOR NATURAL SOURCES**	**261d**	**1/1/98**	**12/31/98**
39	Biogenic Hydrocarbons	261d	1/1/98	12/31/98
40	Soil NOx	261d	1/1/98	12/31/98
41	**METHODOLOGY TESTING**	**261d**	**1/1/97**	**12/31/97**
42	Ambos Nogals	152d	1/1/97	7/31/97
43	Cd. Juarez	109d	8/1/97	12/31/97
44	Mexicali	109d	8/1/97	12/31/97
45	**EMISSIONS VALIDATION**	**238d**	**8/1/96**	**6/30/97**
46	Develop Ronge Checks	109d	8/1/96	12/31/96
47	Develop National Top-Down Inventory Method	129d	1/1/97	6/30/97
48	**DATA MANAGEMENT**	**567d**	**11/1/95**	**12/31/97**
49	Conduct Database Options Analysis	109d	11/1/95	3/29/96
50	Customize System	218d	7/1/96	4/30/97
51	Install & Train	175d	5/1/97	12/31/97



PROJECT SCHEDULE

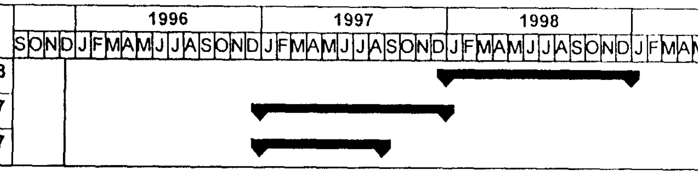
Date Produced: 12/12/95

Task Summary

Task

Phase II Activities under the Mexico Emissions Inventory Methodology Project

ID	Task Name	Days	Start	Finish
52	SATELLITE IMAGERY DATA	261d	1/1/98	12/31/98
54	EMISSION FACTOR APPLICABILITY	261d	1/1/97	12/31/97
56	INVENTORY UNCERTAINTY	173d	1/1/97	8/29/97



PROJECT SCHEDULE

Date Produced: 12/12/95

Task Summary

Task

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APPENDIX A
DRAFT OUTLINE FOR THE
MEXICO EMISSIONS INVENTORY PROGRAM MANUALS

This is a draft outline for the Mexico Emissions Inventory Program Manuals to be developed as one of the major work elements of Phase II of the Mexico Emissions Inventory Project. Each Roman numeral (i.e., I, II, III, etc.) in this outline represents a separate manual or volume. The major items or subjects proposed for each manual are presented below.

I. EMISSIONS INVENTORY PROGRAM PLANNING

PURPOSE: This manual will address the important planning issues that must be considered in an air emissions inventory program. Program planning will be discussed not as an "up-front" activity, but rather as an ongoing process to ensure the long-term growth and success of an emissions inventory program.

- Broad Purpose of the Emissions Inventory Program;
- Emissions Inventory End Uses (use of the data);
- Regulatory Requirements for Data Collection (including limits of regulatory authority);
- Coordination of Local/State/Federal Levels;
- Emissions Inventory Staff Requirements;
- Data Management Requirements (data handling and reporting);
- Emissions Inventory Software/Hardware Requirements; and
- Identification and Evaluation of Needs for Special Studies (e.g., emission factor applicability in Mexico, development of Mexico-specific emission factors, etc).

II. EMISSIONS INVENTORY FUNDAMENTALS

PURPOSE: This manual will present the basic fundamentals of emissions inventory development. The objective is to discuss inventory elements that apply to multiple source types (e.g., point and area) in this one manual, so as to avoid the need for repetition in multiple volumes.

- Introduction (how to use emissions inventory development manuals);
- Applicable Regulations (i.e., how emission regulations are applied in emission inventories through rule effectiveness and rule penetration);

- Rule Effectiveness (i.e., the adjustment of emissions to account for incomplete compliance with emission reduction regulations);

- Rule Penetration (i.e., the adjustment of emissions to account for emission sources exempt from requirements of emission reduction regulations);

- Identification of All Pollutants to be Included in the Emissions Inventory and their definitions (e.g., Volatile Organic Compounds [VOC], Reactive Organic Gases [ROG], oxides of nitrogen [NO_x] etc.);

- Point/Area Source Delineation; and

- Point/Area Source Reconciliation (i.e., to prevent double-counting of emissions in both the point and area source inventories).

III. EMISSIONS INVENTORY DEVELOPMENT: BASIC METHODOLOGIES

PURPOSE: This manual will present the basic methodologies used to develop emission estimates. Starting with information previously presented in the Methodology Evaluation and Proposal Report, this manual will provide additional detailed discussion of each methodology, including examples and sample calculations. Inventory tools associated with each methodology will be identified and included in Volume XI (References).

- Source Sampling;

- Emissions Models;

- Surveying;

- Emission Factors and Census-based or other Activity Data;

- Material Balance; and

- Extrapolation.

IV. EMISSIONS INVENTORY DEVELOPMENT: POINT SOURCES

PURPOSE: This manual will provide guidance for developing the point source emissions inventory. A table will be developed to cross-reference each industry/device type combination (e.g., petroleum refining/combustion devices) with one or more of the basic methodologies presented in Volume III.

- Cross-Reference Table of Industry/Device Type to Methodology (see Table A-1 for industry/device type listing);
- Stack Parameters (i.e., identify and provide guidance for collecting parameters);
- Control Devices (i.e., identify and provide guidance for collecting control information);
- Design and Process Considerations Influencing Emissions;
- Geographic Differences and Variability in Mexico;
- Quality Assurance/Quality Control (QA/QC);
- Typically Overlooked Processes and Ambiguities;
- Data Tables or References (emission factors, activity data, etc.);
- Data Collection Forms (questionnaires) and Instructions; and
- Notes or Special Considerations.

V. EMISSIONS INVENTORY DEVELOPMENT: AREA SOURCES (Includes Non-Road Mobile)

PURPOSE: This manual will provide guidance for developing the area source emissions inventory. After the presentation of general area source information, a table will be provided to cross-reference each area source category (e.g., asphalt application) with one or more of the basic methodologies presented in Volume III. Then, source category-specific information will be discussed for each source category defined in the table.

1. General Information

    - Definition of Area Sources and Source Categorization;
    - Typically Overlooked Processes and Ambiguities;

- Geographic Differences and Variability in Mexico;
- Quality Assurance/Quality Control (QA/QC); and
- Control Factors (i.e., based on emission reduction regulations).

2. Cross-Reference Table of Area Source Category to Methodology (See Table A-2 for Area Source Category listing)

3. Source Category-Specific Information (the following information will be provided for each source category in the cross-reference table)

   - Source Category Description;
   - Source Category Coding (i.e., numerical codes);
   - Data Tables or References (emission factors, activity data, etc.);
   - Data Collection Forms (Questionnaires) and Instructions; and
   - Notes or Special Considerations.

VI. EMISSIONS INVENTORY DEVELOPMENT: ON-ROAD MOBILE SOURCES

PURPOSE: This manual will explain the necessary steps for development of an emissions inventory for on-road mobile sources. Motor vehicles are a significant emissions source within the overall emissions inventory. Because motor vehicles are inherently different from point and area sources, the available estimation methods and required data are also different. In order to estimate emissions from these complex sources, models are the preferred estimation tool. Many of these models utilize extensive test data inputs applicable to a given country or region. This manual will focus primarily on the data development phase of estimating motor vehicle emissions.

- **Available Estimation Methods—**Travel-based estimation techniques, fuel consumption-based estimation techniques, and fuel balances;
- **Primary Data and Information—**Vehicle kilometers traveled (VKT), vehicle registration distribution, fuel consumption, fuel composition (% sulfur, % lead, etc.), emission control technology information, average vehicle speeds, and ambient temperature data;
- **Secondary Data and Information—**Inspection and maintenance (I/M) program

information, tampering and misfueling data, number of U.S. vehicles present in fleet (mainly applicable in the border areas), number of unregistered vehicles present in fleet, mileage accumulation rates;

- **Tertiary Data and Information—**Roadside surveys and driving pattern studies;

- **Source Category Information—**Description of vehicle categorization, numerical coding guidelines, and emission control technology equivalence matrix (equates Mexican vehicles to other vehicles with similar characteristics in order to utilize existing test data);

- **Emission Factor Data Sources—**U.S. EPA MOBILE-based emission factor model (for VOC, CO, and NO_x), U.S. EPA PART5-based emission factor model (for particulate matter), fuel balances (for SO_x);

- **Mexico-U.S. Differences—**Engine types (gasoline or diesel), vehicle types (light duty automobile, light duty truck, heavy duty truck, bus, etc.), control technology, and driving patterns;

- **Geographic Differences in Mexico—**Engine types, vehicle types, control technology, fuel specifications, driving speeds, driving patterns, I/M programs, temperature, altitude, etc; and

- **Quality Assurance/Quality Control (QA/QC)—**Comparison of mobile source emissions as a percentage of total inventory, comparison of gasoline mobile source emissions to diesel mobile source emissions, calculation of emissions per VKT or emissions per capita, and comparison of these estimates to similar regions.

VII. EMISSIONS INVENTORY DEVELOPMENT: NATURAL SOURCES

PURPOSE: This manual will provide guidance for developing the natural source emissions inventory (i.e., biogenic VOC and soil NO_x). In addition, this manual will include the theoretical aspects of emission calculations and discussion of specific models.

- Source Category Description (e.g., biogenic VOC and soil NO_x);

- Emission Mechanisms and Theoretical Aspects Influencing Emissions;

- Basic Emission Algorithms;

- Biomass Determination (biogenic VOC only);

- Land Use/Land Cover Data Development;

- Temporal and Meteorological Adjustments; and

- Emission Calculation Approaches.

VIII. MODELING INVENTORY DEVELOPMENT

PURPOSE: This manual will provide guidance for developing a modeling inventory and will address issues such as temporal allocation, spatial allocation, speciation, and projections.

- Definition of modeling inventory terms and purpose of data;

- Seasonal Adjustment (e.g., ozone-season day);

- Temporal Allocation (i.e., disaggregation of annual emission estimates to smaller time intervals, typically to produce hourly emission estimates for use in grid-based air quality models);

- Spatial Allocation (i.e., disaggregation of national or state emission totals to smaller spatial regions such as counties or municipalities, or even grid cells);

- Speciation (e.g., chemical speciation of VOC, PM, NO_x, and SO_x); and

- Projections (based on growth and control factors for future years from both an economic and a regulatory standpoint).

IX. EMISSIONS INVENTORY PROGRAM EVALUATION

PURPOSE: This manual will consist of three parts: quality assurance/quality control (QA/QC), uncertainty analysis, and emissions verification. The QA/QC portion will define the overall QA/QC program and be written to complement source specific QA/QC procedures written into other manuals. The uncertainty analysis will include not only methods of assessing uncertainty in emission estimates, but also for assessing uncertainty in modeling values such as speciation profiles and emission projection factors. The emissions verification section will describe various analyses that can be done to examine the accuracy of the emission estimates. Examples include receptor modeling and trajectory analysis combined with specific data analysis techniques.

1. Quality Assurance/Quality Control

   - Description of Inventory QA/QC Concepts and Definition of Terms;

   - Inventory Review Protocol (i.e., description of process that will be used to guide QA/QC program);

   - Completeness Review Procedures;

   - Accuracy/Reasonableness Review Procedures (e.g., data quality objectives); and

   - Consistency Review Procedures.

2. Uncertainty Analysis

   - Description of Uncertainty Analysis Concepts and Definition of Terms; and

   - Recommended Methodologies for Uncertainty Analysis.

3. Emissions Verification

   - Description of Emissions Verification Concepts and Definition of Terms (e.g., range checks, top-down versus bottom-up emission calculations, comparison with ambient monitoring data, use of air quality models, etc.); and

   - Applicable Methodologies for Emissions Verification.

X. DATA MANAGEMENT

PURPOSE: This manual will address the important needs associated with the data management element of a comprehensive emission inventory program.

- Introduction;

- General-Purpose Data Management Systems and Tools;

- Specific-Purpose Software Systems and Tools;

- Specific Data Items (e.g., coding system and confidentiality);

- Electronic Transmittal;
- Frequency of Updates;
- Recordkeeping (electronic and paper archives);
- Mexico-Specific Databases (e.g., industrial codes, emission factors, speciation profiles); and
- Reports (standard and user-defined).

XI. REFERENCES

PURPOSE: This will be a compendium of tools that can be used in emission inventory program development. Inventory tools referenced in the other Manuals will be included.

- Hardcopy documents;
- Electronic documents and databases (placed on a bulletin board); and
- Electronic models (TANKS, MOBILE5a, PART5 etc.).

Table A-1

Point Source Types to be Referenced in Manuals

Major Category	Subcategories	Priority[a]	Pollutant	Comments
Electric Utility	Combustion by Fuel Type	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Category consists of internal and external combustion devices used to produce electricity.
Chemical Manufacturing	Process Emissions	1	VOC and NH_3	Typically VOCs generated during the manufacture of organic chemicals.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuels burned to supply energy to the chemical manufacturing process.
	Fugitives From Equipment Leaks	1	VOC	Subcategory includes VOC emissions from such devices as pipeline valves and flanges, and compressor seals.
	Storage Tanks	1	VOC	Floating and fixed roof storage tanks release VOC emissions from tank breathing and the filling of the tank.
	Miscellaneous Solvent Usage	3	VOC	Organic solvents are used for equipment maintenance and can be an important source of VOC emissions.
Petroleum Refining	Process Emissions	1	VOC	Example process emissions include fluid catalytic cracking units and vacuum distillate column condensers.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuels burned to supply energy to the refining process.
	Fugitives From Equipment Leaks	1	VOC	Subcategory includes VOC emissions from such devices as pipeline valves and flanges, and compressor seals.
	Storage Tanks	1	VOC	Floating and fixed roof storage tanks release VOC emissions from tank breathing and the filling of the tank.
	Miscellaneous Solvent Usage	3	VOC	Organic solvents are for used equipment maintenance and can be an important source of VOC emissions.

Table A-1

(Continued)

Primary Metal Production	Process Emissions	1	SO_x and PM	Subcategory includes numerous operations that occur during the smelting and refining of metals such as copper, lead, iron/steel, zinc, etc. Process emissions primarily consist of crushing and grinding of raw materials followed by pyrometallurgical and casting operations to produce metal ingots.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuel burned to supply energy to the smelting and refining processes.
	Fugitive Emissions	2	PM	Subcategory includes TSP emissions from such devices as storage piles and entrained dust from unpaved roads.
Secondary Metal Production	Process Emissions	2	VOC and PM	Emissions from finishing process that produce VOCs and TSP.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuel burned to supply energy to secondary metal finishing processes.
Cement Production	Process Emissions	1	PM	Emission sources include material handling and crushing and grinding of both raw and finished materials.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuel burned to supply energy to the kiln.
	Fugitive Emissions	2	PM	Fugitive sources include piles and entrained dust from equipment operation on unpaved surfaces.
Miscellaneous Mineral Products (e.g. lime and aggregate kilns)	Process Emissions	1	PM	Emission sources include material handling and crushing and grinding of both raw and finished materials.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuel burned to supply energy to the kiln.
	Fugitive Emissions	2	PM	Fugitive sources include piles and entrained dust from equipment operation on unpaved surfaces.

Table A-1

(Continued)

Automotive Industry	Process Emissions	1	VOC	Emission sources include surface coating and other processes that emit VOCs.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuel burned to supply energy for production of automobiles and associated parts.
	Fugitive Emissions	2	VOC	A variety of solvents are used in addition to the coating material. These solvents are used for such activities as wipe cleaning and thinning of coating materials.
Wood Pulping Operations	Process Emissions	1	SO_x, VOC, and PM	Manufacture of pulp involves numerous process operations such as digesters, evaporators, and oxidation towers that produce VOC, TSP, and sulfur compounds.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Large quantities of fuel are consumed in the pulping process to provide heat to process operations and to recover chemicals used in the pulping process. In addition to liquid and gaseous fuels, large quantities of wood may also be burned.
Oil and Gas Production	Process Emissions	1	VOC	This subcategory applies mostly to the processing of natural gas. Example processes include gas sweetening and stripping operations.
	Fugitive Emissions	1	VOC	Subcategory includes VOC emissions from such devices as well heads and sumps/pits. It also includes pipeline valves and flanges and compressor seals.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Liquid and gaseous fuels are burned to supply energy to the oil and gas process.
	Storage Tanks	1	VOC	Typically fixed roof storage tanks are used to store crude oil in the field. Releases of VOC emissions from the tank are a result of tank breathing and filling.

Table A-1

(Continued)

Printing and Publishing	Process Emissions	1	VOC	Operations used in the printing industry (letter press, flexographic, lithographic, and gravure) produce VOC emissions.
	Fugitive Emissions	2	VOC	In addition to the printing operations, miscellaneous solvents are also used in the printing industry for thinning of inks and cleaning of equipment.
Surface Coating	Process Emissions	1	VOC	Application of coating materials results in significant VOC emissions.
	Degreasing Emissions	1	VOC	Degreasers are frequently used at facilities involved in coating operations. Solvent evaporation from the degreaser results in VOC emissions.
	Fugitive Emissions	1	VOC	A variety of solvents are used in addition to the coating material. These solvents are used for such activities as wipe cleaning and thinning of coating materials.
Bulk Fuel Terminals	Loading Operations	1	VOC	Loading and unloading of fuels into marine vessels, rail cars, and trucks results in VOC emissions. Also includes VOC emissions generated by spills.
	Storage Tanks	1	VOC	Floating and fixed roof storage tanks used at bulk terminals release VOC emissions from tank breathing and the filling of the tank.
Mining and Quarrying	Process Emissions	1	PM	There are many different mining operations that emit TSP, such as drilling/blasting, loading, and hauling.
	Fugitive Emissions	2	PM	Fugitive sources include piles and entrained dust from equipment operation on unpaved surfaces.
Wood Products Manufacture	Process Emissions	2	VOC and PM	The manufacture of finished lumber and plywood, etc. involves several processes such as pressure treating, drying, and sawing. VOCs generated in finishing process.
	Combustion Emissions	2	CO, NO_x, SO_x, VOC, PM, and NH_3	Various fuels, including wood, are used to provide the energy needed during the manufacturing process.

Table A-1

(Continued)

Sugar Production	Process Emissions	2	PM	Processing of sugar results in some TSP emissions.
	Combustion Emissions	2	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuel burned to supply energy for sugar processing.
	Fugitive Emissions	2	PM	Possible fugitive VOC and TSP emissions from degreasing, maintenance or cleaning activities.
Tanning and Leather Finishing	Process Emissions	2	VOC	Substantial VOC emissions result from the tanning and finishing processes.
	Combustion Emissions	2	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuel burned to supply energy for tanning and finishing processes.
	Fugitive Emissions	2	VOC	Possible fugitive VOC emissions from processing activities.
Glass Production	Process Emissions	2	VOC and PM	Some TSP emission from the various glass manufacturing processes.
	Combustion Emissions	2	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuel burned to supply energy for glass manufacturing processes.
	Fugitive Emissions	2	VOC and PM	Possible fugitive VOC and TSP emissions from manufacturing processes.
Rubber and Plastic Parts	Process Emissions	2	VOC	Category includes such devices as tire manufacturing, fabricated plastic products, fiberglass resin products, and plastic foam products. These manufacturing operations use a variety of processes that mostly emit VOC.
	Combustion Emissions	2	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuel burned to supply energy to rubber and plastic fabrication processes.

Table A-1

(Continued)

Fabricated Metal Products	Process Emissions	2	PM	Manufacture of fabricated metal products use process operations such as electroplating, conversion coating, abrasive blasting, and metal deposition. VOCs generated in the finishing process.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Various fuels are burned in process heaters.
Textile Products	Process Emissions	2	VOC	Various chemicals/solvents are used in the production of textiles that may result in VOC emissions.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuel burned to supply energy to textile manufacturing process.
Solid Waste Disposal	Landfill Gas Emissions	3	VOC	Solvents placed in landfills and biological decomposition of materials in landfills results in VOC emissions.
	Municipal Waste Combustors	1	CO, NO_x, SO_x, VOC, and PM	Combustion of municipal waste in incinerators at waste management facilities releases combustion pollutants and air toxics.
	Open Burning Dump	2	CO, NO_x, SO_x, VOC, and PM	Combustion pollutants are emitted during this process.
Miscellaneous Industrial Activities/Processe s	Process Emissions	2	CO, NO_x, SO_x, VOC, and PM	There will be a number of industrial activities that don't fit into a traditional source category, such as semiconductor manufacturing. These facilities have process emissions that should be included in a point source inventory.
	Combustion Emissions	2	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuels maybe burned to support process operations. Fuels are also used frequently for space heating.
	Fugitive Emissions	2	VOC	Many miscellaneous facilities use solvents for such things as degreasing and wipe cleaning.

Table A-1

(Continued)

Government Facilities	Combustion Emissions	2	CO, NO_x, SO_x, VOC, PM, and NH_3	Research and development, military, and other institutional facilities often burn fuels for space heating, or to a lesser extent, for process operations.
	Fugitive Emissions	2	VOC	Many facilities use solvents for such activities as degreasing and wipe cleaning. This can be a large source of VOC emissions.
Food and Agriculture	Process Emissions	3	VOC and PM	Category includes numerous food and agriculture related processes that generate primarily TSP and VOC. Examples include: alfalfa dehydration, coffee roasting, grain elevators, beer production, vegetable oil processing, etc.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuels burned to supply energy to processing of agricultural products.
Asphalt Plants	Process Emissions	3	PM	Emission sources in this category include such groups as screens, bins, and mixers; heaters; and dryers.
	Combustion Emissions	1	CO, NO_x, SO_x, VOC, PM, and NH_3	Fuel burned to supply energy to the asphalt plant.

[a] A priority has been assigned to communicate the current, perceived importance of each source type. The priorities assigned to each source type will be refined over time as feedback is obtained from INE and more Mexico-specific information is gathered.

Table A-2

Stationary Area Source Types to be Referenced in Manuals

Major Category	Subcategory	Priority[a]	Pollutant	Comments
Stationary Source Fuel Combustion - Industrial and Commercial	By fuel type	1	CO, NO_x, SO_x, VOC, and PM	Subcategories include fuels such as coal, combustoleo, natural gas, and waste-derived fuels. This will be an important category initially, until many of the smaller sources are incorporated into the point source inventory.
Stationary Source Fuel Combustion - Residential Commercial Fuels	Commercial fuels by fuel type	1	CO, NO_x, SO_x, VOC, and PM	Subcategories include fuels such as coal, combustoleo, natural gas, etc.
Stationary Source Fuel Combustion - Residential Biomass or Waste-Derived Fuels	Biomass or waste-derived fuels by fuel type	1	CO, NO_x, SO_x, VOC, and PM	Subcategories include fuels such as wood, waste oil, tires, etc.
Paved Road Dust	N/A	1	PM	An important source of particulate matter.
Unpaved Road Dust	N/A	1	PM	An important source of particulate matter.
Surface Coatings and Clean-up Solvents - Industrial	By industrial sector	1	VOC	Subcategories include textile products, machinery & equipment, etc. This will be an important category initially until many of the smaller sources are incorporated into the point source inventory.
Industrial Surface Cleaning (Degreasing)	By industrial sector	1	VOC	Subcategories include fabricated metal products, industrial machinery & equipment, auto repair services, etc. This will be an important category initially until many of the smaller sources are incorporated into the point source

Table A-2

(Continued)

Major Category	Subcategory	Priority[a]	Pollutant	Comments
				inventory.
Dry Cleaning	By solvent type	1	VOC	Subcategories include perchloroethylene, special naphthas, and other solvents.
Consumer Solvents	By product type	1	VOC	Subcategories include personal care products, household products, pesticides, etc.
Storage and Transport (Storage Tanks, Loading/Unloading Operations, and Fugitive Component Leaks from Pipelines, Bulk Terminals, Service Stations, and Transport Vessels/Trucks)	By product type	1	VOC	Subcategories include petroleum products (crude oil, gasoline, diesel, etc.) and may also include organic, inorganic, and bulk materials.
Agriculture Production	Livestock	1	PM and NH_3	Feedlots are a major source of NH_3 and a source of particulate matter.
Waste Management - On-Site Incineration	N/A	1	CO, NO_x, SO_x, VOC, and PM	Includes incineration of all industrial waste types.
Waste Disposal - Refuse Burning	N/A	1	CO, NO_x, SO_x, VOC, and PM	Includes agricultural and other types of open burning.
Fires	Wildfires	1	CO, NO_x, SO_x, VOC, and PM	May be a significant source of particulate matter.
	Prescribed burning	1	CO, NO_x, SO_x, VOC, and PM	May be a significant source of particulate matter.
	Structures	2	CO, NO_x, SO_x, VOC, and PM	Minor source of particulate matter.
Industrial Processes	By industrial sector	2	CO, NO_x, SO_x, VOC, and PM	Subcategories include chemical manufacturing, rubber/plastics, food and kindred products (tortilla factories), brick manufacturing, etc. This could be an important category initially, until many of the smaller

Table A-2

(Continued)

Major Category	Subcategory	Priority[a]	Pollutant	Comments
				sources are incorporated into the point source inventory.
Surface Coatings and Clean-up Solvents - Architectural Coatings	N/A	2	VOC	Architectural coatings are thought to be a significant source of VOC emissions in urban areas of Mexico.
Surface Coatings and Clean-up Solvents - Auto Refinishing	N/A	2	VOC	Auto refinishing is thought to be a significant source of VOC emissions in urban areas of Mexico.
Graphic Arts	N/A	2	VOC	Minor VOC source.
Asphalt Application	N/A	2	VOC	Includes application of various types of asphalt materials.
Agriculture Production	Pesticide Application	2	VOC	May be an important VOC source.
	Crops	2	PM and NH_3	Agricultural tilling can be an important particulate matter source. Fertilizer application can be a significant NH_3 source.
Waste Management - Wastewater Treatment	N/A	2	VOC and NH_3	Minor source of VOC, but possibly a significant source of NH_3.
Open Sewage	N/A	2	VOC and NH_3	Most likely a minor source of VOC. Possibly a significant source of NH_3.
Street Vending/Cooking	N/A	2	CO, NO_x, SO_x, VOC, and PM	Magnitude of emissions is uncertain.
Domestic Ammonia Emissions	N/A	2	NH_3	Includes domesticated dogs and cats, human respiration, human perspiration, household ammonia use, cigarette smoke, and untreated human waste.
Building Construction	N/A	3	PM	Building construction and demolition produce fugitive TSP emissions through processes such as site preparation and mechanical/explosive dismemberment.

Table A-2

(Continued)

Major Category	Subcategory	Priority[a]	Pollutant	Comments
Surface Coatings and Clean-up Solvents - Traffic Markings	N / A	3	VOC	Traffic markings are thought to be a minor source of VOC emissions in Mexico.
Rubber and Plastics Fabrication	N / A	3	VOC	Minor VOC source.
Waste Management - Landfills	N / A	3	VOC	Minor source of VOC.

[a] A priority has been assigned to communicate the current, perceived importance of each source type. The priorities assigned to each source type will be refined over time as feedback is obtained from INE and more Mexico-specific information is gathered.

Table A-2

(Continued)

Recreational Boats	3	CO, NO_x, SO_x, VOC, and PM	Category includes inboard motors and outboard motors on recreational motorboats. This category also includes auxiliary motors on sailboats.

APPENDIX B

TRAINING PLAN

This Training Plan describes the process for transferring technical insights gained from the emissions inventory development and implementation procedures gained in the U.S. to the academic and regulatory communities in Mexico. The primary means of technology transfer will be through an emissions inventory course and its supporting materials. As currently conceived, the emissions inventory course will be offered through the extension program, Comisión de Apoyo y Desarrollo Académico (CADA), at the University Autónoma Metropolitan - Azcapotzalco Campus (UAM-AZC).

Radian is developing this Training Plan in close cooperation with Professor Alfonso Espitia, Director, UAM-AZC Environmental Engineering Program. Radian staff will lead the effort to develop the emissions inventory course but will be in frequent communication with Professor Espitia, including meeting with UAM-AZC staff and discussing preliminary work products before they are submitted to the Western Governor's Association (WGA), Instituto Nacional de Ecología (INE), and Binational Advisory Committee (BAC). Where appropriate, the Training Plan will note where resources of other organizations will be needed to accomplish the stated objectives.

Eventually the emission inventory course may be offered through university extension programs along the U.S.-Mexico border region. At some time in the future, the course may also be incorporated into the Environmental Engineering curriculum at UAM-AZC. However, current resources only extend to the initial offering through CADA.

The Training Plan consists of the following three major elements, and will be refined and expanded as the course content develops:

(1) Development of course materials;

(2) Presentation of a condensed course to train future instructors; and

(3) Critique session to further evaluate the course content and delivery.

These components are described in further detail in the following sections.

EMISSIONS INVENTORY COURSE CURRICULUM

The first element is the development of a course curriculum, including a course syllabus, reading list, examinations and workbook, on the emissions inventory process. Students will also be assigned homework problems and preliminary and final examinations will be given.

The emissions inventory course should attract students from various disciplines, such as industrial engineering and mechanical engineering. It is recommended that students have reading skills in English equivalent to at least one year of university level English since most of the existing reference documents and computer models are in English.

Materiales

Much of the technical material covered in the course will be drawn from Radian's Tier 1, Volumes II - VI inventory manuals, as described in Appendix A. The manuals will contain example calculations which may be compiled into a workbook, along with other relevant materials. The preparation of the Training Plan and the manuals began in parallel, but course development activities will soon outpace the much larger effort to develop the manuals. Thus, the emissions inventory course will include topics and example calculations for which the corresponding manual has not yet been developed. In these and other cases, the relevant course materials will be compiled from other sources, such as those listed below:

General Inventory Guidance

- *Procedures For Emission Inventory Preparation, Volume I: Emission Inventory Fundamentals,* EPA-450/4-81-026a, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1981.

- *Procedures For Emission Inventory Preparation, Volume II: Point Sources*, EPA-450/4-81-026b, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1981.

- *Procedures For Emission Inventory Preparation, Volume III: Area Sources*, EPA-450/4-81-026c, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1981.

- *Procedures For Emission Inventory Preparation, Volume IV: Mobile Sources*, EPA-450/4-81-026d, U. S. Environmental Protection Agency, Research Triangle Park, NC, 1992.

<u>The AP-42 Series</u>

- *Compilation Of Air Pollutant Emission Factors, Volume I: Stationary Point And Area Sources*, Fifth Edition, AP-42, U. S. Environmental Protection Agency, Research Triangle Park, NC, January 1995.

- *Compilation Of Air Pollutant Emission Factors, Volume II: Mobile Sources*, Fourth Edition, AP-42, U. S. Environmental Protection Agency, Ann Arbor, MI, September 1985.

- *Supplement A To Compilation Of Air Pollutant Emission Factors, Volume II*, Fourth Edition, AP-42, U. S. Environmental Protection Agency, Ann Arbor, MI, January 1991.

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The emissions inventory course is designed for a 4-day university extension course meeting 8 hours per day. A syllabus is presented in Table B-1.

Table B-1

Emission Inventory Course Syllabus

Day/Hours	Topic
1. / 0.5	Preliminary Exam
1 / 0.5	Course Overview
1 / 1	Principles of Air Pollution
1 / 1	Types of Air Pollutants
1 / 2	Emission Inventory Fundamentals
1 / 2	Point Sources
2 / 2	Point Source (continued)
2 / 6	Area Sources
3 / 6	Mobile Sources
3 / 2	Natural Emission Sources
4 / 2	Emission Factor Development
4 / 2	QA / QC
4 / 2	Uncertainty Analysis
4 / 1.5	Course Summary
4 / 0.5	Final Exam

Reference List

A recommended list of references will be compiled. The list will include documents, research papers, conference proceedings, and background textbooks that students should consult throughout the course. The list will include references in Spanish and in English.

Materials to be Prepared

The following materials will be prepared by Radian to support the emissions inventory course:

- Computer disks containing the Microsoft Power Point files of the course slides (approximately 300 slides will prepared in both English and Spanish for a total of 600 slides);

- A workbook of sample calculations and their solutions intended for the professor's use in assigning homework problems and developing test questions;

- Eight sets of handouts and overhead presentation graphics (one for each prospective instructor);

- Two sets of the written materials identified in the reading list (some references may be provided on CD-ROM);

- All recommended computer models and their associated user guides. Currently, three models have been identified, MOBILE5, TANKS2, and BEISII, to illustrate emission inventory concepts for motor vehicles, storage of organic liquids, and biogenic sources, respectively. Suitable computer hardware to run the models will be furnished by UAM-AZC;

- A preliminary and final examination to test the student's initial understanding and final comprehension of course materials.

Except for the workbook, all of these materials will be assembled in one location at UAM-AZC to facilitate student access.

Before the emissions inventory course is presented through CADA, a condensed course, the second element of the Training Plan, was devised to serve as a course prototype in order to familiarize future instructors with course materials. On January 9 - 11, 1996, this Train-the-Trainers course was given to 4 professors from UAM-AZC and to 4 senior air quality professionals from INE to serve as a course prototype for the future instructors who will be presenting the critique session and ultimately the university extension course. Recipients of the Train-the-Trainers course took an examination both before and after the course to evaluate the efficiency of the course delivery.

CRITIQUE SESSION

The third element of the Training Plan is a Critique Session, tentatively scheduled for late April, 1996, in which UAM-AZC professors will present the 4-day course to approximately 20 air quality professionals from INE. Radian personnel will provide technical and other support, as needed, and will revise course materials according to Critique Session participants. This mechanism will allow appropriate adjustments in course content, presentation, and emphasis, as needed.

IMPLEMENTATION SCHEDULE

Table B-2 summarizes the training schedule and milestones.

Table B-2

Schedule of Activities for the Development of a University Level for the Emissions Inventory Course

Program Element	Responsibility	Completion Date
Training Plan and Outline of Related Materials	Radian	28 August 1995
Comments on Training Plan and Outline	UAM/WGA/INE/BAC	18 September 1995
Prototype of Training Materials	Radian	4th Quarter 1995
Comments on Prototype	UAM/WGA/INE/BAC	1st Quarter 1996
Draft Training Materials	Radian	1st Quarter 1996
Train-the-Trainers Session	Radian/UAM/INE	January 9 - 11, 1996
Critique Session	UAM/Radian/INE	Late April, 1996
Final Revision of Course Material	Radian/UAM	June, 1996