CASE STUDY #1: INVENTORY PREPARATION PLAN AND QUALITY ASSURANCE PLAN

Part 1: Goal

The objective of this case study is to learn the principles of emissions inventory planning. The specific goals to be achieved by this case study are:

- To develop an Inventory Preparation Plan/Quality Assurance Plan (IPP/QAP) for a regional emissions inventory (EI) project for an Indian city, which includes:
  - Identifying sources to be included in the EI;
  - Identifying pollutants to be included in the EI;
  - Identifying various data requirements and sources; and
  - Identifying available estimation methods and select the most appropriate estimation method.
- To develop appropriate QA/QC procedures to achieve the data quality objectives determined for the emissions inventory.

Part 2: Problem Description

Center City (a fictitious South African city) is an industrialized region located in Northern South Africa and is one of the many developing cities in the country. Due to industrial growth and subsequent urbanization, the inevitable pollution problems have started to become harsh reality. This situation is occurring not only in Center City, but also in the surrounding areas. Although the area is not yet exceeding any ambient air quality guidelines for criteria pollutants, there is a growing need to quantify the emissions generated within the area in anticipation of future air quality planning efforts to model ozone (O_3), PM_{10}, and $PM_{2.5}$ concentrations.

Most industrial point sources are located in the western part of the city. There are several sources for which an emissions inventory has never been developed, including two fertilizer manufacturing facilities (a urea plant and an ammonium phosphate plant). In addition, emissions previously have not been estimated for several small industries (i.e., nonpoint sources) including three brick making (i.e., small, open-furnace combustion processes using mainly wood waste for fuel) and eight dry cleaning businesses. Another nonpoint source category for which

emissions have never been estimated is domestic fuel combustion for cooking purposes (i.e., burning of primarily wood and coal fuels).

An emissions inventory for 2004 is needed for these sources. This inventory should include annual estimates (in Mg) as well as ozone season daily emissions (in kg/day) for each source. (The ozone season runs December through February.) Some basic characteristics for these sources are summarized below under "Activity Data Section."

Note to the student: All of the activity data and their references provided in this case study are fictitious and made up for the sole purpose of demonstrating the emissions inventory methodology. However, the emission factors and their references are based on the actual references as provided.

To ensure that this emissions inventory is developed correctly and that its data quality objectives are satisfied, an IPP/QAP must first be developed. The IPP/QAP will provide the air quality regulators in Center City with the background necessary to effectively manage the development of the emissions inventory.

In this case study, the student will outline and describe the content of each part of the IPP/QAP. It is not anticipated that the student will do a significant amount of writing, but rather provide sufficient detail within an outline format to enable an external reviewer to assess the important features of how the inventory will be conducted including:

- Source category descriptions and emissions characterization;
- Methodologies to be used to estimate emissions, including data inputs;
- Data quality objectives necessary for a modeling inventory; and
- Level of detail of results to be reported.

Activity Data Section:

Fertilizer Industry: Urea and Ammonium Phosphate Fertilizer Manufacturing

Operational schedule = 24 hr/day; 5 days/week; and 52 weeks/year.
Operating conditions (urea production) = 190 ºC; retention time = 20 minutes.
Amount of urea produced = 5 Mg/day (50% used in fertilizer production; 50% used in animal feed supplement).
Amount of ammonium phosphate produced = 8 Mg/day.
Ammonia phosphate granules produced = 4 millimeters (mm) in diameter.

The emission factors per Mg of urea produced are as follows:

Urea Manufacturing Operations	Uncontrolled PM emission factor (kg/Mg)[a]
Solution formation and concentration	0.0105
Fluidized bed prilling	3.1
Drum granulation	120
Rotary drum cooler	3.89
Bagging operations	0.095

Source: U.S. EPA, 1995 (AP-42, Table 8.2-1).
[a] PM_{10} Size fraction for Urea plants is 0.9600 and $PM_{2.5}$ Size fraction is 0.9500 (ARB, 1999).

The emission factors per Mg of ammonia phosphate produced are as follows:

Ammonia Phosphate Manufacturing Operations	Controlled PM emission factor (kg/Mg)[a]	Controlled SO_2 emission factor (kg/Mg)
Reactor/Ammoniator- granulation	0.76	NA
Dryer/cooler	0.75	NA
Product sizing and material transfer	0.03	NA
Total plant emissions	0.34	0.04

Source: U.S. EPA, 1995 (AP-42, Table 8.5.3-1).
NA = Not applicable.
[a] PM_{10} is 85% of total PM and $PM_{2.5}$ is 30% of total PM, U.S. EPA, 1995 (Table B.2.2, Appendix B, AP-42).
[b] Assume that total plant emissions include fugitive emissions throughout the facility, and do not include emissions from the reactor, dryer, or product sizing and material transfer operations.

Brick Manufacturing

There are three brick kilns in the inventory region that annually produce approximately 90,000 bricks each. The combustion material used for burns is mainly wood and

sawdust. A study conducted in the year 2002 determined that an average brick kiln in the inventory region produces about 6,600 bricks/burn. The brick makers work 10 hours/day, 7 days/week, 52 weeks/year.

The emission factors per burn for brick manufacturing are as follows:

Pollutant	Emission Factor (kg/burn)
NO_x	4.75
CO	279.9
PM[a]	44.9
VOC	61.8

Source: El Paso Electric Company "Source Test Report for Testing on Brick Kiln" June 2002.
[a] Assume that PM = PM_{10} = $PM_{2.5}$ based on conversations with El Paso Electric representatives in charge of testing and emission factor development.

Dry Cleaning Facilities

Operational schedule = 8 hrs/day; 6 days/week; and 52 weeks/year
Weight of clothes cleaned = 200 kg/week/facility

Solvent data obtained from National Dry Cleaners Association (NDCA), 2002:

- Quantity of non-chlorinated dry cleaning solvent used in Center City = 105,990 liters/year;
- Specific gravity of dry cleaning solvent = 0.78 at 60 °F; and
- VOC content in dry cleaning solvent = 450 g of VOC/liter of solvent.

Employees in dry cleaning facilities in Center City are as follows:

Facility	Employees
Dry cleaner #1	8
Dry cleaner #2	14
Dry cleaner #3	22
Dry cleaner #4	16
Dry cleaner #5	20
Dry cleaner #6	10
Dry cleaner #7	9
Dry cleaner #8	29

Source: State Bureau of Economic Statistics, 2003, Center City.

Domestic Fuel Combustion (Cooking)

The uncontrolled emission factors to be used for wood and coal fuels are as follows:

Pollutant	Wood Fuel Emission Factor (kg/Mg)
PM-10[a]	17.3
CO	126.3
SO_x	0.2
NO_x	1.3
CO_2	1700
N_2O	0.15
Total VOC	114.5
POM	0.008
Aldehydes	1.2

[a]Contains filterable and condensable PM; PM emissions are considered to be 100% PM-10.
[b]Factors obtained from AP-42, Chapter 1, Section 9, Table 1.9-1.

Pollutant	Coal Fuel Emission Factor (kg/Mg)
Filterable PM[a]	7.5
Filterable PM-10	3.1
SO_x[b,c]	15.5S
NO_x[d]	4.6
CO[e]	137.5

[a]PM emission factors are for a hand-fed combustion unit, factors taken from AP-42, Chapter 1, Section 1, Table 1.1-4.
[b]SO_x, NO_x, and CO emission factors are for a hand-fed combustion unit, factors taken from AP-42, Chapter 1, Table 1.1-3.
[c]Expressed as SO_2, including SO_2, SO_3, and gaseous sulfates. Factors in parentheses should be used to estimate gaseous SO_x emissions for subbituminous coal. In all cases, S is weight % sulfur content of coal as fired. Emission factor would be calculated by multiplying the weight percent sulfur in the coal by the numerical value preceding S. For example, if fuel is 1.2% sulfur, then S = 1.2. On average for bituminous coal, 95% of fuel sulfur is emitted as SO_2, and only about 0.7% of fuel sulfur is emitted as SO_3 and gaseous sulfate. An equally small percent of fuel sulfur is emitted as particulate sulfate (References 22-23). Small quantities of sulfur are also retained in bottom ash. With subbituminous coal, about 10% more fuel sulfur is retained in the bottom ash and particulate because of the more alkaline nature of the coal ash. Conversion to gaseous sulfate appears about the same as for bituminous coal.
[d]Expressed as NO_2. Generally, 95 volume % or more of NO_x present in combustion exhaust will be in the form of NO, the rest NO_2. To express factors as NO, multiply factors by 0.66. All factors represent emissions at baseline operation (i. e., 60 to 110% load and no NO_x control measures).
[e]Nominal values achievable under normal operating conditions. Values of 1 to 2 orders of magnitude higher can occur when combustion is not complete. Emission factors for CO_2 emissions from coal combustion should be calculated using kg CO_2/Mg coal = 36.3C, where C is the weight % carbon content of coal.

Domestic wood use in Center City for cooking in 2004 has been determined through a limited home survey conducted by the National Energy Board. Based on the results of the survey, the total amount of wood consumed by homes for cooking in 2004 was 8,245 Mg. Coal use for 2004 was determined from data collected from the two major coal suppliers in the city. Statistics were

collected on the total amount of coal supplied to private residences in 2004. Of this total amount, 15% on average (based on literature reported value) was assumed to have been used for cooking purposes.

Part 3: Planning

An IPP/QAP should be prepared according to an outline containing the following elements:

- Inventory area status (i.e., attainment or nonattainment with ambient guidelines);
- Inventory scope (i.e., geographic area and population, pollutants of concern, base year, temporal resolution);
- Data quality objectives;
- Background and purpose of the inventory;
- Inventory resources;
- Emissions estimation methodologies;
- QA/QC Procedures
  - Internal QA/QC procedures; and
  - External QA/QC procedures (to be conducted in Step 6 by exchanging solutions with another group, and completing the QA/QC Checklist).