ENVIRONMENTAL EFFECTS OF THERMAL POWER PLANT EMISSIONS - A CASE STUDY

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ENVIRONMENTAL EFFECTS OF THERMAL POWER PLANT EMISSIONS-A CASE STUDY

By

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Dedicated to My Parents,

M. Bachal and Khursheed,

For Their Invaluable Sacrifice,

Love, and Encouragement.

Abstract

During the last 20-25 years, Saudi Arabia has made remarkable progress in developing industrial infrastructure, with hundreds of billions of dollars invested in the energy sector. The power generation capacity during the last 20-25 years has increased by several folds in Saudi Arabia. However, like every other development, the power generation industry also has some environmental externalities and concerns. Some of these concerns are related to the emissions of primary pollutants and their human health, environmental and atmospheric effects. The emissions from thermal power plants include sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter (PM), organic compounds and toxic metals such as lead, arsenic and cadmium.

An attempt is made in this study to assess the environmental effects resulting from massive development in energy sector in Saudi Arabia. The emission inventory of thermal power plants was developed using AP-42 emission factors. Two dispersion models selected after detailed evaluation were: (a) HYsplit4, which is a long range transport model, and (b) ISCST3, which is a U. S. EPA approved model for short range modeling. The former model is used to assess regional effects of thermal power plant emissions in Saudi Arabia, and the later is used to assess the effects of a power plant, in local communities. The future expansion of a power plant's generation capacity and alternate energy sources are also studied using these models.

The estimated pollutant levels were compared with the Meteorological and Environmental Protection Agency (MEPA) National Ambient Air Quality Standards (NAAQS) for quantification of adverse effects. The HYsplit4 model was used to estimate total particulate deposition as well as SO_2 and NO_x ambient concentrations from power plants' emissions in the Arabian Peninsula including Saudi Arabia and the Gulf regions. The ISCST3 model was used to simulate the ambient concentrations of SO_2, NO_x, CO and PM within a 25 km radius for a power plant located in Eastern Saudi Arabia. Different simulation scenarios were also developed to study the effects of altered operational routine and fuel options on pollutant concentrations at desired or critical locations.

In order to reduce the pollution level with growing demands in the power sector, a fuel switching option i.e. a combination of crude oil and natural gas was also studied. It was found that the fuel switching option would be an economically viable option. However, a detailed investigation under site-specific meteo:ological conditions should be carried out with reliable data and fuel characteristics and plant specific information.

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List of Abbreviations

ADMS	Atmospheric Dispersion Modeling System
AES	Atmospheric Environment Service
AGL	Above Ground Level
AIRS	Aerometric Information Retrieval System
ANATEX	Across North America Tracer Experiment
ARL	Air Resources Laboratory
BL	Boundary Layer
CAA	Clean Air Act
CAPTEX	Cross-Appalachian Tracer Experiment
CFCs	Chlorofluorocarbons
DIFEUL	DIFfusion EULerienne (French abbreviation)
DIFPAR	DIFfusion of PARticles
DIFTRA	DIFfusion around TRAjectories)
DOE	Department of Energy
ECMWF	European Center for Medium Range Weather Forecast
EIA	Energy Information Administration
EIFG	Emission Inventory and Factor Group
EPA	Environmental Protection Agency
ETEX	European Tracer Experiment
EURAD	European Air quality Dispersion
FMS	Figure of Merit Space
GDAS	Global Data Assimilation System
GPP	Ghazlan Power Plant
GRAMP	Gulf Regional Air Monitoring Program
GUI	Graphic User Interface
HYsplit	Hybrid Single Particle Lagrangian Integrated Trajectory
ISC	Industrial Source Complex
ISCST	Industrial Source Complex Short Term
KSA	Kingdom of Saudi Arabia
LRTAP	Long-range Transport of Air Pollutants Program
MEPA	Meteorological and Environmental Protection Agency
MMT	Million Metric Tons
NAAQS	National Ambient Air Quality Standards
NAPAP	National Acid Precipitation Assessment Program
NCEP	National Centers for Environmental Prediction
NMHC	Non Methane Hydrocarbon
NOAA	National Oceanic and Atmospheric Administration
NRDC	National Resources Defense Council
OAQPS	Office of Air Quality Planning and Standards
OECD	Organization for Economic Cooperation and Development
PHS	Public Health Service
PM	Particulate Matter

RADM	Regional Acid Deposition Model
READY	Real time Environmental Applications and Display sYstem
RELAD	Regional Lagrangian Acidic Deposition
RELMAP	Regional Lagrangian Model for Air Pollution
SCECO	Saudi Consolidated Electric Company
STEM	Sulfur Transport and dEposition Model
TOC	Total Organic Carbon
UAE	United Arab Emirates
UTC	Universal Coordinated Time
VOCs	Volatile Organic Compounds
WMO	World Meteorological Organization

Chapter 1

Introduction

1.1. Background

The Presence of any visible or invisible particle or gas in the air apart from the normal composition of air is referred to as air pollution. Air pollution is proving to be an increasingly important problem these days. It is a major issue of concern for our health and the environment. Despite efforts by various regulatory agencies all over the world, in restricting industrial emissions, banning the use of certain chemicals, and making stricter air quality standards, our earth and atmosphere are still facing ever growing problems of global warming, adverse climatic changes, and environmental degradation.

Studies show evidence of a direct association between the levels of air pollutants and adverse effects on human health. Air pollution related human health effects vary from mild irritation to very severe asthmatic sickness and sometimes chronic carcinogenic effects. Children, elderly people and people with respiratory problems such as asthma and bronchitis, and people involved in vigorous outdoor activities are more susceptible to the adverse affects of the air pollution. Thousands of people in North America die prematurely each year because of the effects of air pollution. The air pollutants of great concern for human health are: fine particulate and acidic aerosols, ground level ozone, SO_2, NO_x and other pollutants which are inhaled deep into the lungs. Table 1-1 presents the summary of some of the major air pollutants, their sources and effects.

Other than health issues, acidification of water bodies, global warming and adverse climatic changes resulting in melting of ice caps, more severe and frequent storms, photochemical smog, stratospheric ozone depletion, and toxic pollutants are also of major concern. These global issues are also related to the physical and chemical alteration of the earth's atmosphere by the introduction of different species of air pollutants.

The processes, activities or agencies emitting pollutants into the atmosphere are termed as sources (of air pollution), such as various human activities, industrial processes, fuel combustion, vehicular exhaust etc, whereas, any process which contributes to the removal of pollutants from the atmosphere is termed as a sink. The major sink processes for air pollutants are chemical reactions, and wet and dry deposition processes. The sources of air pollution range from daily household activities to large industrial processes. Ever increasing use of vehicles, greater energy consumption and more vigorous economic

Table 1-1, Summary of Criteria Air Pollutants (EPA, 1992).

Pollutant	Description	Sources	Effects
Ozone	Colorless gas and a major constituent of photochemical smog. Stratospheric ozone layer (at an altitude of about 12-48 km from earth's surface) protects earth from harmful radiation from sun.	Ground level ozone is produced when oxygen reacts with VOCs and the oxides of nitrogen in the presence of sunlight. Thus, the sources contributing to the formation of ozone include emissions from vehicles, factories, landfills, industrial solvents, gas stations, farm equipment etc.	Irritation of respiratory tract, impairment of lung functions, throat irritation, chest pain, cough and lung inflammation. Reduced agricultural yield. Injury to forests and other vegetation. Most injurious pollutant to the plant life.
Sulfur dioxide	Colorless gas, with no smell at low concentration, but pungent odor at higher concentration.	Fuel combustion sources, domestic furnaces and boilers, petroleum refineries, smelter plants, paper mills, and chemical plants.	Precursor to acid rain and sulfate deposits and smog. Affects respiratory tract and causes lung damage. It aggravates existing lung diseases, and constricts breathing passages in asthmatic people.
Nitrogen dioxide	Light brown gas at lower concentration. A major component of unpleasant looking brown urban haze at high levels.	Fuel combustion in utilities and industrial boilers and transportation sources.	Precursor to formation of smog and acid rain. At sufficiently high concentrations harmful to animals and vegetation.
Particulate Matter	Solid matter of aerosols, ash and fine particles	Industrial processes, smelters, automobiles, combustion sources, wood-smoke, dust, seas-prays, construction, agricultural ground breaking.	Increased respiratory diseases and lung damage. Effects visibility and contributes to smog formation.

Table 1-1, Summary of Criteria Air Pollutants (EPA, 1992) (continued).

Carbon monoxide	Odorless and colorless gas.	Incomplete combustion of fuels, vehicular exhaust and industrial processes.	Reduces oxygen carrying capacity of blood. Affects cardiovascular and nervous systems. Causes dizziness, headache and fatigue at higher concentrations.
Greenhouse gases	Gases that build up in the atmosphere and induce greenhouse effect. These gases include carbon dioxide, methane and nitrous oxide.	Carbon dioxide is produced from incomplete combustion of fuels. Methane is produced from landfills, cud chewing livestock, coal mines and rice paddies. Nitrous oxide results from industrial processes.	Global climate change, increased temperature of earth, increased severity and frequency of storms and other weather extremes such as melting of polar ice cap and sea level rise.
Lead	Toxic metal; main source in urban areas as a result of use of leaded gasoline.	Vehicular emissions, coal combustion, smelters, battery plants, and garbage incineration.	Elevated lead level can adversely affect mental development, kidney function and blood chemistry.
Stratospheric ozone depleters	Chemicals such as CFCs, halons, carbon tetrachloride, methyl chlorofom, rise to the upper atmosphere and destroy protective ozone layer.	Industrial and household refrigeration, cooling and cleaning processes, air conditioning, fire extinguishers and plastic foam products.	Increased exposure to UV radiation. Increase in skin cancer, cataracts, suppression of the human immune response system.
Toxic air pollutants	Pollutants such arsenic, asbestos and benzene.	Chemical plants, industrial processes, vehicular exhaust, fuels and building material.	Known or suspected to cause cancer, respiratory effects, birth defects, reproductive and other serious health effects.

activities, all play vital roles in contributing to air pollution. Of all the sources of air pollution, both stationary and mobile combustion sources such as power plants and transportation are the biggest sources of air pollution these days. The combustion of fossil fuels in power plants produces tons of ashes and soot with several primary pollutants such as oxides of sulfur and nitrogen, carbon monoxide, organic compounds, various trace elements, carbon dioxide and methane and other greenhouse gases.

The mechanism by which pollutants are carried away from their source to receptors is called pollutant transport. Wind is the pollutant transport agent, which carries the pollutants hundreds and thousands of miles away from the source. These pollutants go through various physical and chemical processes, collectively termed diffusion, before finally being deposited. Meteorological and topographical conditions greatly influence the transportation, dispersion and deposition of air pollutants. The factors that greatly affect the dispersion and deposition of air pollutants are wind speed and direction, turbulence, temperature, topography, atmospheric moisture content and stability, and other meteorological parameters.

Air pollution transport can be categorized as follows (Zannetti, 1990):

- Near field transport: Where building aerodynamics causes downwash effects of the plume.
- Short range transport: Within 10 km from the source, and in this region, the primary pollutants are known to have maximum ground level impact.

- Intermediate transport: Between 10 km and 100 km from the source, where the chemical reactions play an important role in the transformation of the pollutants.
- Long range transport: At distances of more than 100 km from the source, where large scale meteorological effects and deposition and transformation rates play a significant role.

Only until recently, most of the investigation has been carried out to assess the short range effects and problems of air pollution. More complex problems like acidic deposition, visibility degradation and global warming have highlighted the importance of long range transport processes.

The increased level of air pollution is causing significant changes in our atmosphere affecting all forms of life and their environments. These environmental effects as a result of air pollution have made it imperative for the regulatory agencies to enforce strict regulations, and efficient control technologies. In order to assess the deteriorating air quality and/or the effects of an existing or proposed facility/project, monitoring and modeling are the two basic techniques used by regulatory and control agencies. The cost of monitoring is very high, therefore modeling is considered as the most viable and economical tool and widely used for such purposes.

Air pollution models are mathematical constructs, which with given information, simulate the current physical and chemical processes, and predict the future concentrations of pollutants in the atmosphere. These models have been serving the regulatory agencies and research groups for decades, in devising improved regulations and efficient control technologies to reduce the further deterioration of the atmosphere.

1.2. The Study Objectives

As mentioned earlier, power plants are the major sources of air pollution, according to the Aerometric Information Retrieval System (AIRS) 1997 sectoral emission data, power generation industry is the highest producer of SO_2 and NO_x in the United States. A review of the world electric power development shows that the Kingdom of Saudi Arabia (KSA) has made significant progress in the energy sector in last 20 years. During this period, the power generation capacity of Saudi Arabia has increased at an annual rate of 16%. and according to 1997 statistics (Electrical Affair Agency, KSA, 1997) the total generation capacity was over 19,000 MW, or 17 times what it was in 1975. In addition, the power consumption has increased at an annual rate of 5% per subscriber. These figures clearly demonstrate the immense pace at which power generation is growing in Saudi Arabia, and it is expected to reach 65,000 MW by the year 2020 (EIA, 1999). To meet this growing power demand, the Saudi Arabian Government is initiating various developmental schemes, such as a $117 billion-25-Year Electrification Plan, a possible merger of the Kingdom's four electricity companies into one entity, and restructuring of the power tariff to make investment in the sector commercially attractive to local and foreign investors.

Since, there is a great deal of expansion taking place in the energy sector in Saudi Arabia, this research will attempt to assess the environmental effects of such development by estimation of short-term as well as the long-term impact of emissions. Appropriate modeling techniques will be used to estimate emissions from these thermal power plants, and to study the dispersion characteristics of these emissions using short range and long range models. The results of this study will help in evaluating emissions and finding economically viable solutions to reduce ground level pollutant concentrations. This study will also help in future siting of power plants to meet regulatory requirements.

1.3. Layout of the Thesis

There are six chapters covering formulation and analysis of the work. Chapter 1 briefly presents an overview of air pollution problems and the objectives of the study. Chapter 2 compiles an extensive survey of the available literature related to air pollution modeling and thermal power plant emissions. A brief history of air pollution and human health effects and an overview of air quality modeling techniques and available models are also presented in this chapter. Fossil fuel electric generation is described in terms of types of fuels, systems of generation and emissions. Background information about the study area, details of the power generation industry in the Kingdom of Saudi Arabia, and relevant data on emission inventory of power plants in the region are presented in Chapter3. Methods and techniques adopted for the study are described in Chapter 4. This includes detailed descriptions of the selected models, assumptions made and the data used. The results generated by the application of selected models and their analysis with their logical interpretation and discussion are presented in Chapter 5. Finally in Chapter 6, the findings and limitations of this work are summarized and suggestions and recommendations for further work are briefly discussed.

Chapter 2

Air Pollution-An Overview and Brief History

2.1. Introduction

Global climate change, air quality and acid rain, and stratospheric ozone depletion are some of the major issues of concern in the modern world. The problem of air pollution is not recent, in fact, this problem dates back centuries since man's discovery of fire. The ancient Romans complained of the odor and soot deposits due to combustion of coal and wood. Concerns about air quality were raised back in the thirteenth century when coal was first used in London, and as a result the use of coal was prohibited in London as being prejudicial to health (Boubel et al., 1994). Hence, historically, poor air quality has been associated with smoke, particulate matter and gaseous pollutants emitted during burning of coal and other fossil fuels.

The eighteenth century saw the industrial revolution with the invention of pumps and reciprocating engines, and these gave way to steam engines and turbines in the nineteenth century. The major source of fuel for steam engines and turbines was coal. By the middle of the nineteenth century, the atmosphere of major British cities was aggravated by regularly emitted coal smoke, which gave rise to an infamous mixture of fog and smoke known as smog. Thus, the industrial revolution era air pollution problems were mainly concerned with smoke and ash from the burning of coal or oil. These fuels were used in the furnaces of power plants, locomotives, and marine vessels, and also in residential heating, fireplaces, and furnaces.

Emissions from both stationary and mobile combustion sources are a major cause of deteriorating air quality in the modern world. Other sources of air pollution include chemical processes involved in acid, chemical and allied product manufacturing, fertilizer manufacturing processes, ore smelting, mining activities, pulp and paper mills, asbestos, and natural sources such as forest fires and volcanic eruptions.

The history of air pollution control and legislation is also very old, but due to a lack of understanding of the problem and also due to lack of public awareness, very little progress was made in this field. During the first half of the twentieth century, severe air pollution episodes such as The Meuse Valley (Belgium) episode in 1930 (Firket, 1931), the Donora Pennsylvania episode in 1948 (Schrenk et al., 1949) and the Poza Rica

Mexico episode in 1950 (McCabe and Clayton, 1952), drew public attention towards the disasters of air pollution and paved the way for massive air pollution research and legislation activities. After the London fog episode in the December of 1952, in which more than four thousand elderly and sick people died within a week, Great Britain passed the Clean Air Act. During the period of 1950-1980, almost every country in Europe alongwith Japan, Australia and New Zealand experienced serious air pollution problems in their cities, prompting these countries to enact air pollution control legislation.

In the United States, the first air pollution legislation was enacted in 1955, providing federal support for air pollution research, training and technical assistance. The legislation was administered under the Public Health Service (PHS) of the United States Department of Health, Education and Welfare. In 1970, the U. S. Congress introduced the National Environmental Policy Act and the United States Environmental Protection Agency (EPA) was established (Freedman and Jaggi, 1993). The EPA introduced the Clean Air Act during the first year of its formation, which set national ambient air quality standards for the six criteria pollutants (SO_2, NO_x, PM, CO, Pb, and O_3), with an objective to protect and enhance the air quality.

In 1977, the Clean Air Act was amended. This amendment addressed a number of issues related to national ambient air standards. Further, this amendment divided the clean air areas into three classes with the perspective of allowed deterioration ranging from very little to moderate and significant. The main goal was to preserve the pristine areas and protect further deterioration of those areas not meeting standards.

In 1990, a new Clean Air Act was passed by the United States Congress, with a much broader spectrum than the previous Acts. In addition to criteria pollutants, it also dealt with hazardous pollutants and the issues of acid rain and ozone depletion were also addressed. The 1990 Clean Air Act is considered very comprehensive, covering a variety of air quality issues. It is divided into eleven major titles, dealing with specific issues like criteria pollutants, pollution from mobile sources, hazardous pollutants acid rain, and ozone depletion.

The effects of air pollution on the atmosphere are well known and at times are much more severe than just visibility reduction. These effects include alteration in cloud and precipitation formation and processes associated with changes in the radiant energy received at the earth's surface or changes in the electrical properties of atmosphere (Robinson, 1977). One of the serious problem emerging from air pollution is global climate change. With the increased concentration of greenhouse gases in the atmosphere, changes in weather patterns and climate are becoming more evident. Greenhouse gases, such as carbon dioxide, methane, nitrous oxide and chlorofluorocarbons (CFCs) act as an opaque layer through which the sunlight passes and heats our earth, but it blocks the returning infrared radiation from the earth's surface, resulting in global warming, which means that earth retains most of the sun's heat over time. This increased heat produces more turbulence in the atmosphere and makes the weather system unstable. This extra heat is responsible for ever-changing and unexpected weather patterns, and is a driving force behind atmospheric changes.

2.1.1. Human health effects

Major air pollutants of concern are oxides of sulfur, particularly sulfur dioxide, oxides of nitrogen, particularly nitric oxide and nitrogen dioxide, particulate matter, carbon monoxide, ozone and lead, which are designated as criteria pollutants by the United States EPA. These are the pollutants, which are known or suspected to have adverse effects on human health. The human health effects of air pollution are very diverse, ranging from as mild as skin irritation to as severe as cancer or premature death. Substantial association has been established between critical air pollution episodes and a significant increase in mortality (U.S. EPA, 1982; Wichman et al., 1989). Also, non-episode pollutant concentrations have shown association with mortality (Fairley, 1990; Schwartz and Marcus, 1990, Schwartz, 1991; Schwartz and Dockery, 1992; Pope et al., 1992). Even after imposition of stricter air quality standards by regulatory agencies, human health studies and scientific evidence demonstrate that existing air quality standards do not adequately protect human health from smog and soot (Sierra Club, 1999). Even after more than two decades after the passage of the Clean Air Act, the EPA's 1996 National Air Quality Trends Report suggests that, 30% Americans still breathe unhealthy air (EPA, 1996). According to the National Resources Defense Council, approximately 64,000 premature deaths from cardiopulmonary causes may be attributable to particulate air pollution each year in the United States only (NRDC, 1996). Current levels of smog and soot in the air are posing severe threats to children with asthma and older people with heart and lung diseases. Studies have established a direct relationship between declines in air quality and increases in hospital admissions and emergency room visits for respiratory problems, especially among the young and the elderly (Pope, 1991; Delfino et al., 1998; Burnett et al., 1994; Gordian et al., 1996; Saldiva et al., 1994). An American Lung Association study of 13 cities found that hospitalization of people with asthma and heart disease doubled during the summer, when smog was the heaviest (Sierra Club, 1999). The following section presents a brief overview of the six criteria pollutants.

2.1.1.1. Sulfur dioxide (SO_2)

Sulfur dioxide is a colorless gas with a pungent and suffocating smell and is readily soluble in water. It is corrosive to organic materials and dissolves in water to form sulfurous acid (H_2SO_3). SO_2 is produced when sulfur contained in fuel, reacts with oxygen in air, during combustion of fossil fuels. Sulfur dioxide is capable of being transported on a regional scale, and during the process is transformed to sulfate, and contributes towards acid rain and deposition. Acid deposition lowers the pH of freshwater lakes and alters the composition of some soils, consequently affecting plant and aquatic life. SO_2 can create irritation of the eyes, nose and lungs, besides being a corrosive gas. SO_2 is a soluble gas and is capable of being absorbed in human nose and upper airway tract creating increased airway resistance in the lungs (Amin and Husain, 1994). High doses of SO_2 (i.e. 2-5 ppm or 5000-13000 μgm^{-3}) may cause severe impairment of lung functions (Nadel et al., 1965). It aggravates existing lung diseases, especially bronchitis and constricts breathing passages in asthmatic people. It also causes wheezing, shortness of breath, and coughing. Studies have shown significant association between increased hospital respiratory admission and higher ambient SO_2 concentrations (Bates and Sizto, 1983).

2.1.1.2. Nitrogen oxides (NO_x)

Nitrogen oxides are released into the atmosphere almost entirely by combustion processes, either due to thermal fixation of atmospheric nitrogen in the combustion air or due to the conversion of chemically bound nitrogen in fuel. Thus the major sources of nitrogen oxides are stationary and mobile combustion sources. At high levels, nitrogen oxides are known to cause lung damage and other respiratory illness, particularly in children and people suffering from asthma (American Lung Association, 1993). Nitrogen oxides also contribute to acid rain and deposition, affecting aquatic and plant life and material. Among several oxides of nitrogen released into the atmosphere, nitric oxide and nitrogen dioxide are known to have adverse human health effects (Amin and Husain, 1994). Nitrogen dioxide adversely affects the lung's defense mechanism and can cause lung damage in excessive doses (Gardener, 1984; Morrow, 1984; Pennington, 1988). Nitric oxide (NO) and nitrogen dioxide (NO_2) react in air to produce ozone and other pollutants that lead to the production of smog. Besides affecting plants and material, ozone also causes adverse human health effects such as eye irritation, shortness of breath, increased respiratory illness and decreased lung function, coughing, wheezing, chest tightness, dry throat, headache or nausea, intensification of asthma symptoms, and reduced resistance to infections.

2.1.1.3. Particulate matter (PM)

Air borne solid and liquid particles are referred to as particulate matter (PM). It includes products of combustion, such as soot or ashes, wind blown dust, and minute droplets of liquid termed as aerosols. Anthropogenic sources of PM include fuel combustion, industrial processes and transportation, whereas natural sources include wind, sea sprays and wildfires. PM is very diverse in character including both organic and inorganic substances. PM in air is formed either by condensation of gases and vapors in air, or by direct emission through mechanical and combustion processes. One of the important characteristics of PM is the particle size, as it ranges from 0.01μm - 100μm. Various terms are used to classify PM, such as suspended particles, PM_{10} or thoracic or inhalable particles and $PM_{2.5}$, particles which can penetrate deep into the human lungs and cause major damage to the respiratory system.

Apart from impairing visibility, PM poses serious threats to human health. Particles less than 10 micron in diameter (PM_{10}) are capable of breaking through human respiratory filtering mechanism to penetrate the lungs. These particles which enter the respiratory system progressively pass through the smaller airways until they reach alveoli, tiny air sacs where oxygen enters the blood stream. Particles that get trapped in these most sensitive tissues cause breathing problems by interfering with oxygen uptake. Toxic and carcinogenic compounds can also be carried into the lungs by these particles (American Lung Association, 1993).

2.1.1.4. Carbon monoxide (CO)

Carbon monoxide (CO) is a colorless and odorless gas, produced by incomplete combustion of carbon in fuels. In urban areas most of the carbon monoxide is released into the atmosphere by vehicle emissions. CO is capable of interfering with the blood's ability to transport oxygen to cells and tissues. High concentration exposures to CO can cause drowsiness, headaches and sometimes death. People with cardiac disease and lung conditions are at higher risk when exposed to elevated levels of CO.

2.1.1.5. Ozone (O_3)

Ozone (O_3) is found at two different levels in the atmosphere. The upper ozone shields the troposphere from the harmful ultraviolet radiation of the sun, and thus it is beneficial for life on earth, whereas high concentrations of ozone at lower or ground levels pose serious human health and environmental concerns. Ozone is a photochemical oxidant and a major constituent of smog. Ground level ozone is produced as a result of a series of complex reactions between precursor emissions of volatile organic compounds (VOCs) and oxides of nitrogen (NO_x) in the presence of sunlight. Higher ozone concentrations occur during summer because the sunlight and temperature are the main ingredients for its formation. The ability of ozone to react readily with the membrane of lung passage causes health problems. It can damage lung tissues, reduce lung function and also render lungs vulnerable to the effects of other irritants. It can also produce eye irritation, breathing problems, coughing, wheezing, chest tightness or pain, dry throat, headache or nausea. It also intensifies asthma symptoms and reduces the immune system. Children, older people, and those with pre-existing asthma are especially prone to the effects of ozone. Exposure to relatively low ozone concentrations for several hours has also been found to significantly reduce lung function and induce respiratory inflammation in normal and healthy people during vigorous physical activities.

Ground level ozone can react with VOCs and NO_x to form smog. The word smog is driven from the words smoke and fog. It is a general term which refers to a condition of deteriorated air quality. It is a chemical mixture of gases that form a brownish yellowish haze, that sometimes has odor and is usually found in urban areas. The compounds typically found in smog include ground level ozone, VOCs, NO_x, SO_2, acidic aerosols and gases and PM. Ground level ozone makes up almost 90% of all smog found in urban areas. In higher concentrations smog can cause extreme health problems for humans. London is known for its industrial smog episodes, the worst being one in December 1952, when five days of calm and foggy weather created a toxic smog that claimed about 4000 human lives.

2.2. Dispersion of Air Pollutants

The air pollutants released into the atmosphere are carried over long distances from the source by means of prevailing winds. The scales of air pollution transport can broadly be categorized as;

(a) Short range transport: typically within 10-50 km range of the source, where building wake affects and stack-tip down-wash take place, resulting in a maximum concentration of primary pollutants. In this case, the atmospheric chemistry does not play a significant role in the production of secondary pollutants.

(b) Long range transport: also termed as "regional" or "transboundary" or "interstate" transport is typically characterized by distances greater than 100 km from the source. During this transport of pollutants, various meteorological parameters influence the deposition and transformation rates of the pollutants.

2.2.1. Long range transport of air pollutants

Long range or transboundary air pollution refers to the air pollution caused in a region due to the sources, which do not usually come under the jurisdiction of that region or state. During the course of long range transport of air pollutants spanning several days and hundreds of kilometers, the contaminants undergo numerous chemical and physical transformations under various atmospheric conditions. Some of the important processes include pollutant transport, chemical and photochemical atmospheric reactions, vertical motion induced by terrain, washout and deposition. The effects of long range transport of air pollutants are evident in acidification of lakes in Scandinavia, as a result of sulfur dioxide emissions from Continental Europe and the British Isles (OECD, 1977). The growing problem of acid rain in Canada has been attributed to the emissions of sulfur dioxide in the United States (Whelpdale and Galloway, 1979; Shannon, 1979).

2.3. Air Quality Assessment

In order to assess the potentials of different air pollutants to cause human health risks, knowledge of atmospheric pollutant concentrations and deposition rates is essential. Monitoring and modeling are two basic techniques used by various agencies for air quality assessment. Monitoring includes taking measurements and analyzing the results, to estimate concentrations and it is considered as the most reliable method to assess the effects of any kind of pollution. With the evolution of modern technology, there have been dramatic improvements in devices for chemical analysis, but still the measurements in all the three media (air, water, and soil) are costly and rare. Due to these limitations, modeling has become a very efficient and widely acceptable tool for prediction of future concentrations. Air dispersion models may be defined as mathematical constructs that approximate the physical processes occurring in the atmosphere that directly influence the dispersion of gaseous and particulate emissions from a source.

Simulation models are used to estimate pollutant concentration, and their wet and dry deposition. Numerous mathematical and simulation models have been developed. These models have been successfully used over the years by regulatory and research agencies for various purposes, such as regulatory compliance and policy making, public information, development of air quality and emission standards, development of emission factors, impact assessment, designing of control strategies, research and development of modified and improved modeling systems, and human health risk assessment.

Almost all of the dispersion models require two basic input files: the source information and the meteorological information. The source information may include source location, emission rates, pollutant characteristics, height of stack, and other emission parameters such as exit velocity and temperature. The meteorological information required to run dispersion models might include wind speed, wind direction, pressure, relative humidity, temperature, and upper air data.

Most of the air quality models employ the Gaussian technique for estimating pollutant concentrations, and hence are referred to as Gaussian plume models. The Gaussian plume model is the most accepted computational approach for calculating the pollutant concentration at a certain point in the downwind direction of the source. This model describes the transport and mixing of the pollutant and assumes that dispersion in the horizontal and vertical direction takes the form of a normal Gaussian distribution with the maximum concentration being at the center of the plume. The other common methods, besides the Gaussian plume model are the Box Model, the Narrow plume hypothesis, Gradient transport models, Trajectory models, and numerical models (Boubel et al., 1994).

Pollutant concentrations calculated by air quality models are just estimations, and should not be confused with the absolute values, because there is a number of sources of inaccuracy involved in dispersion modeling. These inaccuracies include the uncertainty in the input parameters, approximations in models, and the natural variability involved in the dispersion process itself. Despite of these inaccuracies and uncertainties involved, dispersion modeling still provides invaluable results for various air quality applications.

Air pollution models can be categorized from very simple, which use only a few parameters, to very complex, characterized by a large number of parameters. The uncertainty components associated with dispersion models have not yet been studied in a comprehensive manner (Hanna, 1990). Assuming no correlation among the uncertainty components, Hanna (1990) defines the total model uncertainty as a sum of three components, i.e. model physics error, stochastic uncertainty, and data errors. Mathematically, it can be expressed as;

Total Model uncertainty = Model Physics Error + Stochastic Uncertainty + Data Errors

Figure 2-1 shows relationship between these uncertainty components and the number of model parameters. The figure illustrates that the natural or stochastic uncertainty and the model physics errors decrease with the greater number of model parameters, however the larger number of input parameter increases the data error. Figure 2-1 (Hanna, 1990) also indicates that there is an optimum number of model parameters that minimizes the total model uncertainty.

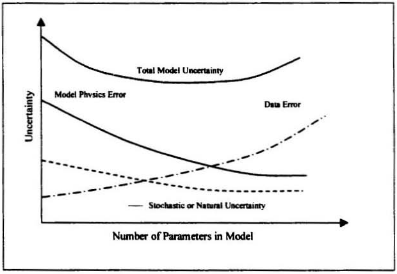

Figure 2-1, Relationship between Model Parameters and Uncertainty Components.

2.3.1. Long range transport modeling

Either statistical models, Lagrangian/trajectory models, or Eulerian models are used for analyzing the long range transport of pollutants. Statistical models, which either rely on a mean wind direction with plume standard deviation reflecting horizontal fluctuations on the synoptic scale, or direction frequency classes. Since these models use large-scale meteorology, they are suitable only for long term simulations.

Lagrangian/trajectory models, which are classified as more complex than statistical models, compute trajectories either forwards or backwards, using routinely obtained meteorological data on isobaric or isentropic surfaces or vertical motion to give a three dimensional wind field. Most of the Lagrangian models simulate a single layer, thus they do not take into account the diffusion and transport of pollutants at higher elevations. These models frequently estimate the plume or puff as a function of the downwind distance. These models are normally used for monthly, seasonal or annual average concentrations. Despite their computational simplicity, these models have been widely applied to simulate the long range transport of air pollutants (Eliassen and Saltbones, 1983; ApSimon et al., 1985; Pecyna et al., 1985; Renner et al., 1985; Ellenton et al., 1985).

Eulerian models enable detailed analysis of physical and chemical processes, but cannot provide good results without sufficient data on emission, meteorology, climate and geographical conditions, and an excellent computational environment. These models are suitable for episodal analysis within a limited period. Analyses for a period extending over at least one year are required to estimate the contributions towards deposition from domestic anthropogenic sources and volcanic eruptions (Ichikawa and Hayami, 1995).

Various studies have been conducted by different researchers and model developers around the world in order to assess and evaluate air quality models. Some of those studies along with a brief description of a few models are discussed in the following paragraphs.

To assess the effects of the long range transport of air pollutants from the United States into Canada, the Canadian Department of Environment initiated the Long-range Transport of Air Pollutants Program (LRTAP) in the mid seventies. As a part of this program, a Lagrangian model was developed to estimate the flux of sulfur across the United States-Canada border and the concentration/deposition patterns of SO_2 and sulfate over eastern Canada on a seasonal and annual basis. Voldner et al. (1981) carried out a study to compare the computed results of SO_2 with the observed values in eastern North America for the period of October 1977. The study established similar trends with respect to high and low values in the case of daily averages. However, the computed values were found to be higher than the measured ones. The study concluded that, despite being simple, the model was found a useful tool in assessing the long-range transport of air pollutants problem.

In a study conducted in Japan, the SO_x concentration in the air and the sulfate concentration in rain were estimated using a trajectory model developed by Yoichi and Hiroshi (Ichikawa, Hayami and Fujita, 1995). The results obtained from the models were compared with the acidic deposition observed at 21 stations throughout Japan for the period of one year (Oct. 1988-Sept. 1989). The predicted total wet deposition was 0.22 Tg/y of sulfur equivalent, while the observed total wet deposition was 0.29 Tg/y of sulfur equivalent.

Using 1990 emission data, the total SO_2 deposition was estimated using a hybrid model. A comparison of the predicted results with the observed values indicated that deposition was underpredicted by the hybrid model which did not take into account the influence of the local wind such as sea and land breeze and the emissions from the navigation sources. The estimated amount of the total sulfur deposition for Japan was 0.43 Tg/y of sulfur equivalent as compared to the observed amount of 0.53 Tg/y. The study concluded that both models calculated the deposition with high accuracy.

McDonald (1996) carried out a comparative study of two independently developed mathematical models; the AES (Atmospheric Environment Service) box-model and the RELAD (Regional Lagrangian Acidic Deposition) plume model. The rationale of the study was to observe similarities and differences in the model outputs, and identify those model components responsible. Meteorology and emission data from the province of Alberta, Canada was used for this purpose.

These two models use different techniques to model the physical and chemical processes of atmospheric transport and acidic deposition. The AES (Atmospheric Environment Service) model was developed by Environment Canada (Olson et al., 1978, 1979, 1982, 1990). It is a Lagrangian box model which assess the long range transport of air pollutants, computes atmospheric wind trajectories, and estimates the concentration and deposition of pollutants in parcels as they traverse emission and precipitation fields towards specified receptor points. The RELAD (Regional Lagrangian Acidic Deposition) model (McDonald et al. 1996) is derived from the NAPAP (National Acid Precipitation Assessment Program) RELMAP (Regional Lagrangian Model for Air Pollution), developed by U.S. EPA. It is a mass-conserving, regional scale model that simulates ground level ambient concentrations and wet and dry depositions. The RELAD model uses plume expansion to estimate the transport and deposition of pollutants (Cheng et al., 1995; Eder et al., 1986). This model works on the assumption that if the center of a puff advects from a receptor region to a neighboring region, the whole puff moves across the boundary between the two regions.

These models were used to simulate the physical and chemical processes of atmospheric transport and deposition in the Province of Alberta. The results of this study indicated that both models showed similarities in fluxes and concentration or deposition patterns, but notable differences were observed in the magnitudes. These differences could be attributed to different methods of emission input, and different meteorological analysis and model parameterization. Both models reasonably represented the air concentration of SO_2. Similar magnitudes for the air concentration were calculated by both the models over much part of the province, however, the values differed significantly.

Similar dry deposition spatial patterns were observed for the two models. Differences in the magnitude of deposition were found, which could be attributed to differences in the average monthly deposition velocities and mixing heights. The deposition is controlled by precipitation patterns such that the seasonal and spatial patterns are more smoothed in the box method than the plume model. Therefore, it was recommended that the plume model was suitable for studying seasonal or yearly variations, whereas the box model was more suitable for studying the long-term effects.

Wendum (1998) studied the performance of three different models of passive dispersion in the atmosphere using the meteorological data provided by the ECMWF (European Center for Medium Range Weather Forecast) for the simulation of the first ETEX (European Tracer Experiment) release. The three models compared were the DIFTRA (DIFfusion around TRAjectories) model, the DIFPAR (DIFfusion of PARticles) model, and the DIFEUL (abbreviation of French term DIFfusion EULerienne) model. DIFTRA is a Gaussian puff model, which is suitable for modeling atmospheric pollutant concentrations by the superposition of 3D Gaussian puffs. The center of the mass of the puffs is assumed to follow the trajectories of the air parcels transported by the wind.

DIFPAR is a Lagrangian particle model. This model simulates the evolution of a pollutant cloud by tracking a large number of particles following the Eulerian mean flow, and simulating the effects of turbulence. In this model, the parameterization in the horizontal direction of the effect of turbulence by a Gaussian density spread around the particle with standard deviation function of the particle travel time, could result in a significant reduction in the number of particles being tracked. This model permits analytical smoothness of the Gaussian puff models, while taking into account the full 3D meteorology.

DIFEUL is an Eulerian off-line dispersion model. It solves an advection-diffusion equation for a passive scalar. This technique is also widely used when dealing with a large number of species of pollutants interacting through chemistry terms.

These three models described above were used for the simulation of the first ETEX release. The meteorological data was input with a time difference of 6 h, beginning from October 23, 1994, 12 h UTC (Universal Coordinated Time/GMT) to October 27, 1994, 12 h UTC.

Three different scores were used in this study to compare the performance of these models. They are the FAX, the FMS, "efficiency" and "power". The FAX of a model is the percentage of calculated values lying within a factor x from measured values. The FMS (Figure of Merit Space) is an estimate of the percentage of overlap of the two regions where the models calculate values greater than 0.1 ngm^{-3}. "Efficiency" and "power" are pure statistical terms and are used in procedures called "tests of hypotheses". The efficiency is the proportion of the times the test will confirm the assumed hypothesis when the hypothesis is true, and the power is exactly the proportion of times the test will reject the hypothesis when the hypothesis is false.

After scaling the three models using the above scores, the study concluded that, DIFEUL and DIFPAR both gave a realistic description of passive dispersion in the atmosphere at a continental scale for the description of the first ETEX release. DIFEUL was found to be computationally cheaper, as it took the same time to simulate the whole episode, as taken by DIFPAR to track all the particles without doing any concentration calculations. Thus from a practical point, the study recommended that DIFEUL was the most adequate model for this type of simulations.

These studies demonstrate the confidence and validation of air pollution models. These studies also strengthen claims of modeling being a useful tool for estimating pollutant concentrations and deposition, and successfully simulating various processes of chemical and physical transformation in the atmosphere, taking into consideration various meteorological parameters. Although these models have a number of limitations and are not free from uncertainties, they are still the most economical means of conducting air quality studies. It has also been observed that model selection for a particular study involves several factors and assumptions and it requires a great deal of professional judgement backed up by literature. An improper application of a model can lead to serious misjudgments regarding source impacts or the effectiveness of control strategies whereas various studies have established that proper selection of a model after evaluation on case-by-case basis, and according to the application, have resulted in very similar estimates to the observed values.

2.4. Electric Power Generation

The majority of electric power generated worldwide these days is produced by facilities using fossil fuels. Fossil fuel fired electric generating systems can be categorized into steam turbines, gas turbines and internal combustion engines. In the United States, most of the power generation facilities use steam turbine systems (Healy, 1974). Fuel availability, power loads, power generation requirements and other economic factors and considerations determine the selection of the type of system to be employed at a facility.

In steam turbine systems, the heat energy is produced by combustion of coal, natural gas or oil to heat the boilers. The boilers generate steam in highly pressurized vessels. This high pressure and high temperature steam rotate the turbine blades in the low-pressure condenser, thus powering the electric generator and producing electric energy. The theoretical thermal efficiency of the turbine system depends on the high pressure and temperature in the boiler and the low pressure and temperature in the condenser. Such systems typically have a thermal efficiency of 35%.

Gas turbine systems are very similar to the steam systems. In this system combustion gases are used to turn the turbine blades instead of steam. The turbine drives an electric generator producing electricity, and a rotating compressor to pressurize the air. This pressurized air is then mixed with the fuel in a combustion chamber. The efficiency of this system is controlled by the compression, and is directly proportional to it. This system has a typical efficiency of 20-30%. Since this system does not employ a steam supply and boilers, the capital cost is much lower than for the steam system.

Internal combustion systems also known as diesel engines are similar to an automobile engine. This system requires a number of cylinders for fuel combustion to take place. In this system, the chemical energy of fuels is converted into mechanical energy, driving the shaft of the generator to produce electric energy. These units operate on either four or two stroke cycles. Internal combustion units are small and range in capacity from 2 to 6 megawatts. They are more efficient than gas turbines (DOE, 1995). In addition, their capital cost is very low, and they can be mobile and therefore are often used for small loads and for emergency power.

In all the systems discussed above, fossil fuels serve as an energy source to move the turbine for electricity generation. The fossil fuels used for this purpose are mainly coal, petroleum and gas. Other fuels being used are petroleum coke, refinery gas, coke oven gas, blast furnace gas, and liquefied petroleum gas, but their use is very rare and limited.

In the United States, more than 50% of all electricity generation facilities use coal fired units (DOE, 1995). The characteristics of coal used for power generation are very heterogeneous and vary from mine to mine. The major constituents of coal are carbon, hydrogen and oxygen with impurities like minerals and sulfur. These impurities contained in the coal contribute to the formation of pollutants during the combustion. The processing, handling, storage and loading-unloading requirements of coal are very extensive. Also, the coal firing requires the use of crushers, pulverizers, ash handling equipment, dust control, emission control equipment, and soot blowers (EPA, 1997).

Crude oil or petroleum is widely used as an energy source for power generation. Most of the petroleum products used for this purpose are pre-refined. Fuel oils are broadly classified as distillate oils and residual oils. These oils are further distinguished by grade numbers. Fuel oil numbers 1 and 2 being distillate oils, whereas No. 5 and 6 being residual oils that are also termed heavy oils. Distillate oils are more volatile and less viscous than the residual oils. They have a negligible amount of nitrogen, ash and sulfur. Distillate oils are mainly used in startup and flame stabilization of boilers and small commercial applications and include kerosene and diesel fuels. Residual oils are mainly used in electric power utilities and large commercial applications. These oils are produced from residue remaining after lighter fractions have been removed from crude oil, thus they contain significant amounts of nitrogen, ash and sulfur.

Fuel oils also require special handling, storage and loading-unloading facilities. In addition they also require ash handling equipment, dust control, emission control, soot blowers, and warming and heating facilities (EPA, 1997).

Gas is not so widely used as a source of energy for power generating facilities, however its use for industrial power generation is more common. Natural gas is mainly comprised of methane and ethane, and it must be treated to produce commercial fuel. The fuel gas for power generation must contain at least 70% methane, 60% propane or 25% hydrogen (EPA, 1997). Gas is the cleanest of the burning fuels and other handling and storage requirements are simple and economical.

2.4.1. Emissions

The selection of fuel used for power generation depends on various economic and environmental considerations, its availability and compliance with the regulatory statutes. The emissions from fossil fuel fired power plant stacks consist of oxides of nitrogen, sulfur dioxide, particulate matter, carbon monoxide, volatile organic compounds, organic hydrocarbons and traces of various metals. The first four pollutants being criteria pollutants regulated through the National Ambient Air Quality Standards (NAAQS) under the US EPA Clean Air Act (CAA). Other emissions regulated by the Clean Air Act commonly contained in emission gases are total organic carbon (TOC) as methane, non-methane hydrocarbons (NMHC) and volatile organic compounds.

The amount of sulfur dioxide emissions depends on the sulfur content of the fuel. The oxides of nitrogen released in air by combustion processes are either due to thermal fixation of atmospheric nitrogen in the combustion air, called thermal NO_x, or to the conversion of chemically bound nitrogen in the fuel known as fuel NO_x. The particulate matter emissions depend on the completeness of combustion and the fuel ash and sulfur contents. The amount of carbon monoxide depends on the oxidation efficiency of the fuel, and results principally from incomplete fuel combustion.

Test data from source specific emissions provides the best estimates of amounts of different pollutants being discharged into the atmosphere. However, this data is seldom available, and therefore the Emission Inventory and Factor Group (EIFG) and Office of Air Quality Planning and Standards (OAQPS) have developed emission estimating tools for various industrial sectors based on the analysis of available source specific emission data. These emission factors relate the amounts of different pollutants released in the atmosphere to the responsible activities. These emission factors are documented in the

AP-42 series for the use of variety of users including federal, state and local agencies, industry and consultants (EPA, 1995).

The U. S. Department of Energy (DOE) Energy Information Administration (EIA) annually conducts survey to collect emission data for fossil fuel fired steam electric utilities with capacity of ≥ 10 megawatts, in the United States. The emissions are calculated based on fuel consumption data and using emission factors from the EPA report AP-42. The 1995 estimated unit emissions (Short tons/1000 MW) for fossil fuel steam power generating utilities having generating capacity of 10 and more megawatts are listed in Table 2-1.

Table 2-1, Estimated 1995 Emissions From Fossil Fuel Steam Electric Generating Units per 1000 MW, by Fuel Type (short tons) (DOE, 1996).

Fuel	**SO_2 (Tons)**	**NO_x (Tons)**	**CO_2 (Tons)**
Coal	6.81	3.94	1060.27
Gas	0.0036	1.73	527.06
Petroleum	5.28	1.51	836.20

This table indicates that emissions from coal fired utilities are the highest for all the three pollutants, whereas those from gas fired utilities are the lowest. The higher SO_2 emissions from coal and petroleum combustion units are due to higher sulfur contents in the fuels. Very low SO_2 emission from gas combustion units indicates that the sulfur content in the gas is relatively small.

Table 2-2 shows the Aerometric Information Retrieval System (AIRS) annual estimated releases for various industrial sectors in the United States for the year 1997. According to this estimate, the electric generation industry is the leading contributor of SO_2, NO_2, and total particulate matter in the atmosphere.

The National Resources Defense Council compiled a report on air emissions from the Electric Utility Generators in the United States in 1998 (NRDC, 1998). This report concluded that:

- The hundred largest electric utility companies contribute to approximately 90% of the national NO_x, SO_2 and CO_2 emissions and the largest twenty companies accounted for approximately 50% of these emissions.
- Electric utility generating plants contributed significantly to health and environmental problems such as smog, acid rain, soot, eutrophication of lakes and streams, climate change and toxic air pollutants.

Table 2-2, Annual Pollutant Releases (tons/year) from Various Industrial Sectors in the U. S. A. (AIRS, 1997).

Industry Sector	CO	NO_2	PM_{10}	PT	SO_2	VOC
Metal Mining	4670	39849	63541	173566	17690	915
Nonmetal mining	25922	22881	40199	128661	18000	4002
Lumber and Wood Production	122061	38042	20456	64650	9401	55983
Furniture and Fixtures	2754	1872	2502	4827	1538	67604
Pulp and Paper	566883	358675	35030	111210	493313	127809
Printing	8755	3542	405	1198	1684	103018
Inorganic Chemicals	153294	106522	6703	34664	194153	65427
Organic Chemicals	112410	187400	14596	16053	176115	180350
Petroleum Refining	734630	355852	27497	36141	619775	313982
Rubber and Misc. Plastics	2200	9955	2618	5182	21720	132945
Stone, Clay and Concrete	105059	340639	192962	662233	308534	34337
Iron and Steel	1386461	153607	83938	87939	232347	83882
Nonferrous Metals	214243	31136	10403	24654	253538	11058
Fabricated Metals	4925	11104	1019	2790	3169	86472
Electronics and Computers	356	1501	224	385	741	4866
Motor vehicles, Parts and Accessories	15109	27355	1048	3699	20378	96338
Dry Cleaning	102	184	3	27	155	7441
Transportation	128625	550551	2569	5489	8417	104824
Metal Casting	116538	11911	10995	20973	6513	19031
Pharmaceuticals	6586	19088	1576	4425	21311	37214
Plastic Resins and Synthetic Fibers	16388	41771	2218	7546	67546	74138
Textiles	8177	34523	2028	9479	43050	27768
Fossil Fuel Electric Power Generation	366208	5986757	140760	464542	13827511	57384
Ship Building and Repair	105	862	638	943	3015	3967

Source: U. S. EPA Office of Air and Radiation, AIRS Database, 1997.

These statistics affirm that the electric power generation industry is one of the major contributors of air pollution, especially pollutants like NO_2 and SO_2, which are precursors of acid rain and smog. A recent study drawn from the data reported by the power companies themselves shows that (NRDC, 1998);

- The power sector is the largest industrial source of smog-creating chemicals
- The big smokestacks from the 50 largest power companies in the Eastern half of the U.S. produce 73 percent of the nitrous oxide pollution and 78 percent of the sulfur dioxide pollution, both chemicals that form smog.

Thus to improve air quality, it is imperative that emissions from power plants be reduced by applying the best control technology and management, and using clean and pure fuel.

Chapter 3

Area of Study

3.1. Saudi Arabia

The Kingdom of Saudi Arabia is the largest country in the Middle East, occupying around eighty percent of the Arabian Peninsula, and having an estimated area of 2.3 million square kilometers.

Saudi Arabia is bordered by the Red Sea and the Arabian Gulf on the west and the east respectively. In addition, the other bordering countries on the east are the United Arab Emirates (UAE), Qatar and Bahrain. In the south, it borders with Yemen and the Sultanate of Oman and in the north with Kuwait, Iraq and Jordan.

The topography of the country is highly varied from deserts to green mountainous areas in the southwest. After the winter rains, even the deserts come to life. Rub-al-Khali, the largest continuous sand desert in the world is located in the southern part of the country. Another large sandy desert, the Nafud is located in the north of the country. Mountains ranging over 9,000 feet high are located in the southwestern part of the country.

Before the exploration of oil reserves, the economy of Saudi Arabia relied heavily on pilgrimage to the holy cities Makkah and Medina, and on the export of dates. Saudi Arabia is still one of the largest producers and exporters of dates, but its modern day economy is largely oil based. In 1998, more than ninety percent of the country's export revenues were derived from the sale of crude oil, liquefied gas and other petroleum products. Besides oil and petroleum products, the country also produces iron and steel, processed foodstuffs, cement and minerals.

Saudi Arabia is the world's largest oil producer and exporter. Saudi Arabia's oil reserve capacity is 261.5 billion barrels, which is more than one-fourth of the world total. There are over 77 oil and gas fields and around 1430 wells in Saudi Arabia, but over half of its oil reserves are contained in only eight fields. Ghawar oil field located 80 km west of Dhahran is the world's largest on shore oil field, with estimated remaining reserves of 70 billion barrels and Safaniya located 250 km north of Dhahran is one of the world's largest offshore field, with estimated reserves of 19 billion barrels.

Figure 3-1, Map of the Gulf Region.

All the countries in the Gulf region are enriched in natural resources like oil and gas, as the region embodies more than half of the world's proven oil reserves. During the past three decades, these countries have achieved a remarkable development of industrial infrastructure, investing hundreds of billions of dollars in the energy sector, refineries and petrochemical industries, with the application of sophisticated and modern technology to control the impacts on the environment. Table 3-1 provides some of the statistics related to energy and the environment for the countries in the Gulf region.

Like every other development, development in the energy sector has come at the cost of the environment. Emissions from refineries, power plants and petrochemical industries are the largest source of air pollution in the region. According to the National Resources Defense Council's 1999 report (NRDC, 1999), Saudi Aramco alone produced 418.6 million metric tons (MMT) of carbon in 1997, which is higher than the combined carbon emissions of India, Pakistan, Bangladesh and South Korea, whereas the National Iranian Oil Co. contributed 187.8 MMT of carbon. According to this report, Saudi Aramco was ranked as the world leader in carbon production, followed in fourth place by the National Iranian Oil Co. while the Kuwait Petroleum Co. ranked thirteenth, producing 89.65 MMT of carbon, the Abu Dhabi National Oil Co. ranked sixteenth with 75.17 MMT of carbon, and the Iraq National Oil Co. with 55.64 MMT ranked twenty-fifth.

Since this study is only concerned with the energy sector in Saudi Arabia, this chapter presents in the following sections some in-depth details, supported by figures and statistics about this industry.

Table 3-1, Population, Energy and Environmental Statistics of the Gulf Countries (US EIA, 1999).

	KSA	Kuwait	Bahrain	Oman	UAE	Qatar	Iraq	Iran
Population:								
(Million)	20.5	2.0	0.63	2.4	2.3	0.7	22.4	66.5
Oil:								
Proven Reserves (10^9 Barrels)	263.5	96.5	0.2	5.3	97.8	3.7	112.5	90.0
Oil Production (10^6 Barrels/day)	8.5	2.0	0.16	0.906	2.34	0.59	2.88	3.6
Crude Oil Refining Capacity (10^3 Barrels/day)	1710	886	250	85	288	58	347.5	1450
Oil Consumption (10^3 Barrels/day)	1250	196	24	50	318	45	475	1130
Natural Gas:								
Reserves (10^{12} Cubic feet)	204.5	52.7	4.2	28.4	212	300	109.8	812.0
Production (10^9 Cubic feet)	1650	330	290	150	1310	630	104	1600
Consumption (10^9 Cubic feet)	1650	330	293	132	1070	531	104	1600
Electricity:								
Generation Capacity (GW)	21	7	1.1	2	5.5	1.4	6	25
Production (10^9 KWH)	110	25	4.7	9	20.1	6.3	28.4	79.6
Environmental Statistics:								
Per Capita Energy Consumption (10^6 Btu)	207.8	343.0		100	670.3	898.3	48.7	72.4
Energy Related Carbon Emissions (10^6 Metric ton/year)	63.8	12.3		4.1	31.3	9.4	19.4	79.4
Per Capita Carbon Emission (Metric ton/year)	3.2	6.1		1.7	11.5	13.1	0.9	1.3

3.1.1. Power sector in Saudi Arabia

Power generation is one of the fastest growing industries in Saudi Arabia. The electricity sector in Saudi Arabia is run by the Saudi Consolidated Electric Company (SCECO), which controls over 85% of country's power supply. The SCECO is divided into four regional sectors, the SCECO East, the SCECO West, the SCECO Central and the SCECO South. Apart from the SCECO, the Northern Electric Companies is responsible for providing electricity to the northern parts of the country.

3.1.1.1. Development in the power sector

The Kingdom of Saudi Arabia has made significant progress in the last two decades in the field of energy development with implementation of the best available technology. Since all other economic and industrial developments within the Kingdom are directly linked with the electricity, the generation capacity of electric companies in Saudi Arabia has increased 16 times within the last 20 years. This clearly demonstrates that the Kingdom is among the world leaders in electricity generation fulfilling the requirements of exponentially growing demands which will reach to 65,000 MW by the year 2020. To meet this growing power demand, the Saudi Arabian Government is initiating various developmental schemes, such as the $117 billion-25-Year Electrification Plan, possible merger of the Kingdom's four electricity companies into one entity, and restructuring of the power tariff to make investment in the sector commercially attractive to local and foreign investors.

At present, this sector is providing electricity to more than three million subscribers. Moreover, a notable increase in power consumption has been observed during the last two decades in Saudi Arabia. During this period, the sold power increased at an annual growth rate of 16%, and power consumption per subscriber grew at an annual rate of 5%, while the peak load increased at an annual rate of 15%. The total power generation and installed capacity had reached 81.1 TWH and 19,351 MW respectively by the end of year 1996. The power demand in the KSA will rise to 59,000 MW in the year 2020. However, in order to have a reserve capacity at peak periods of 17% of the total generating capacity, Saudi Arabia's power stations will be required to have an installed capacity of 65,000 MW by 2020. To achieve this, some 1500-2000 MW will be added to the existing capacity on an annual basis, over the course of next 25 years.

3.1.1.2. Power stations, generating units and capacities

The last two decades have witnessed a noticeable increase in the generating capacities of all electric companies and projects in the Kingdom of Saudi Arabia, as they doubled and reached 19,351 MW by the end of 1996, which is approximately seventeen times what they were in 1975. In the year 1996-97, there were seventy-five thermal power plants in the country with 662 generating units and 19,351 MW of actual generating capacity. More than sixty percent of the total electricity generated in the year 1996-97 was produced by units employing a gas turbine system. Table 3-2 shows the distribution of power plants, generating units and their capacities in different regions of the country for the year 1996-97, whereas Table 3-3 shows the distribution of generating capacity per type of generating unit and the percent of the total capacity for the same year.

Table 3-2, Power Plants, Generating Units and Capacities in Different Regions of the KSA for 1996-97.

	Eastern	Central	Southern	Western	Northern	Total
Power Plants	10	10	9	22	24	**75**
Number of Units	109	125	79	209	140	**662**
Actual Capacity (MW)	7182	4376	1337	5291	1165	**19351**

Table 3-4 shows the distribution of generating capacities classified according to the type of generating unit in the different regions including available capacities from desalination plants in the Kingdom of Saudi Arabia for the year 1996-97.

Table 3-3, Actual Generating Capacities of All Utilities in the KSA for 1996-97.

Type of generating unit	Generating Capacity (MW)	% of total KSA Capacity
Gas Turbines	13056	60.3
Steam Turbines	5573	25.7
Diesel Engines	722	3.3
Desalination plants	2309	10.7
Total	**21660**	**100.0**

Table 3-4, Actual Generating Capacities per Type of Unit (MW) for Different Regions of the KSA for 1996-97.

Region	Diesel Engines	Gas-Turbines	Steam-Turbines	*Des. Plants	Total
Eastern	29	3153	4000	1507	8689
Central	29	4347			4376
Southern	230	1107		32	1369
Western	277	3441	1573	770	6061
Northern	157	1008			1165
Total	722	13056	5573	2309	21660

* *Desalination*

3.1.1.3. Fuel consumption

In the year 1996-97, 9,414,586 tons of crude oil including heavy fuel oils, 5,362,478 tons of diesel and 8,674 million cubic meters of gas were consumed for the electricity generation purposes in Saudi Arabia (Electrical Affairs Agency, Ministry of Industry and Electricity, KSA, 1997).

Table 3-5, Fuel Consumption and Thermal Efficiency in Various Regions of the KSA.

Region	Fuel consumed (Tons)		Thermal Eff.
	Diesel	Crude Oil	(%)
Eastern	21,477	122,306	33.9
Central	861,853	4,692,703	25.4
Southern	1,483,139	544,123	25.6
Western	2,206,693	3,691,121	30.8
Northern	789,316	364,333	24.2
Total	5,362,478	9,414,586	29.8

These figures are incredibly high compared to fuels consumed for this purpose two decades ago, showing the great demand in energy consumption and the pace of development in this sector. The breakup of fuel consumed in different regions alongwith the respective thermal efficiencies are exhibited in Table 3-5.

3.2. Air Quality Modeling

Numerous air quality, atmospheric and meteorological models have been developed over the past few decades to simulate various chemical and physical processes. These models can be classified according to application, type of source, type of pollutant, averaging time, simulation time, scales, type of terrain, and region specific parameters. These models have been successfully used over the years by various regulatory and research agencies around the world for a variety of applications such as regulatory compliance and policy making and public information. Models are also used for the development of air quality and emission standards, the development of emission factors, impact assessment, designing of control strategies, research and development of modified and improved modeling systems, and human health risk assessment.

Some popular models used in the field of air pollution with their specific applications are listed below:

- The Industrial Source Complex (ISC) model for near the source short term and long term effects and human health risk assessment (EPA, 1995a)

- The Regional Acid Deposition Model (RADM) for long range transport and acidic deposition in North America
- The Regional Lagrangian Acid Deposition model (RELAD) for ground level ambient concentrations as well as wet and dry deposition of primary and secondary pollutants in North America (Eder et al, 1986; Cheng et al., 1995)
- The European Air quality Dispersion model (EURAD) for air quality assessment in Europe (Hass et al., 1997)
- The Atmospheric Dispersion Modeling System version 2 (ADMS-2) for the concentration of toxic pollutants in England
- The Sulfur Transport and dEposition Model (STEM) for sulfate transformation and deposition modeling, used in the US, Europe and Asia (Carmichael et al., 1990)

Various researchers and model developers have conducted series of modeling studies to predict future concentrations and deposition of different pollutants. Before selecting any model, it is necessary to define the objectives of the study and present a detailed analysis of the problem and cost effectiveness.

The Industrial Source Complex (ISC) model is approved by U. S. EPA for air quality modeling within the short range of 50 km from the source. This model has been used in Saudi Arabia for the evaluation of emission estimates and the prediction of future ambient concentrations from petroleum refineries' emissions. The estimated concentration values obtained from these models have been found to be in better agreement with the corresponding observed concentrations in Saudi Arabia. Khan et al. (1993) reviewed different available models and found the ISC model to be the most suitable model for industrial regions of Saudi Arabia.

When Iraq's invasion of Kuwait was brought to an end, over 700 oil wells were left on fire emitting tons of air pollutants into the atmosphere every day. This Gulf Environmental Crisis prompted the development of the Gulf Regional Air Monitoring Program (GRAMP) in 1991. Under this program numerous models were tested and used to study the local and regional scale environmental impacts of the plumes emitted from those burning oil wells (Husain, 1995).

Some of the air pollution models used to simulate the plume from the Kuwaiti oil fields, their applications and limitations are summarized in table 3-6 (WMO, 1992; Husain 1995).

During the course of this study, the available meteorological and climatological data for the region will be examined, the sources of concern will be identified, the emissions of concerned pollutants will be estimated, the effect of these emissions on ambient concentrations and their deposition will be predicted using dispersion models, and finally the computed results will be analyzed and compared with the local regulating agency's standards. This study will provide an estimate of different pollutants emitted from the power sector in Saudi Arabia and their deposition at various receptor points.

Table 3-6, Known Air Pollution Models Used for Air Quality Studies During Kuwaiti Oil Fires Episode in 1990 (WMO, 1992; Husain, 1995).

Group / Model	Application	Domain (km)	Meteorology Used	Species	Diffusion Techniques Used
KNMI/RIVM (Verver, 1992).	Regional real-time	3500 x3500 3-D	ECMWF global model	Soot	Multiple puff
LLNL/ARAC (Sullivan, 1992)	Regional real-time global	3000 x3000 3-D	USAF global + RWM (MATHEW)	Soot, Optical Depth	Particle in cell
NOAA HYSPLIT (Draxler, 1992, McQueen et al. 1992, Heffter, 1991)	Regional real-time	2000 x2000 3-D	NWS MRF	Soot, SO_2	Semi-langrangian PIC
U.K. Met Office	Regional	3-D	ECMWF	Soot, SO_2	Monte-Carlo
Max Planck Inst. STEM II	Regional	4000 x4000 3-D	Hydro-mesoscale	CO_2, VOC, NO_2, Ozone	----
EURAD (Hass et al., 1990)	Regional	3-D	Regional	Soot, SO_2, NO_x	Eulerian
CANARM (Pudykiewicz, 1991)	Regional Global	10000 x 10000 3-D	Regional	Soot, SO_2	Semi-langrangian PIC
TASC (Janota and Chase, 1991).	Regional Global	Hemi-spheric 2-D	Regional	Soot, SO_2	Semi-langrangian PIC
Meteorologie Nat. France MEDIA (Bompay, 1991)	Regional global	Hemi-spheric 3-D	Emeraude and Periodot	Soot	Eulerian
Sandia National Laboratory (Angi, 1991).	Regional	1000 x 1000 3-D	Climatology	Soot, SO_2, CO, H_2S	Gaussian plume

Chapter 4

Methods, Assumptions and Procedures

In order to assess the air quality impacts of a proposed, an existing or the expansion of any facility, modeling techniques are employed by the regulatory or permitting agencies. Despite extensive development in monitoring techniques and the availability of highly sophisticated measuring and monitoring equipment, there exist limitations in the spatial and temporal coverage of air quality measurements. Due to these limitations, the monitoring data is normally insufficient for demonstrating the adequacy of emission limits for sources. Numerous air quality simulation models using the latest and highly sophisticated and reliable techniques are available these days to perform this task. These models can be classified by the type of source, pollutant, transformations and removal, distance of transport and averaging time, and various other parameters.

4.1. Model Selection

Several methods have been suggested to measure model performance, but as a matter of fact, types of models and their uses for different purposes require different statistics to measure performance. As dispersion modeling results are governed by meteorological and topographical parameters, and there is a great diversity of these parameters under different scenarios and locations, therefore it would be justified to say that there is no single model available, which could possibly address all the different situations even within one category of sources. A single mathematical treatment is insufficient to express meteorological phenomena associated with pollutant dispersion and transformations. Thus, model selection for a particular scenario, relies heavily on a case by case analysis of various available models and experimental judgement. Finally, the model selected for a particular situation should be the most accurate representative of atmospheric transport, dispersion, and chemical transformations in the required area.

Some of the basic factors involved in the model selection process are;

1. The objective and nature of the study, such as urban air quality assessment, development of air quality standards or effect of long range transport. For each objective, there are several other parameters such as for urban air quality assessment the size of the airshed, types and numbers of sources, and types of pollutants.
2. The availability of resources and time.
3. The availability of qualified and trained personnel.

4. The availability of source and topographical information.
5. The availability and form of meteorological data.
6. Desired output options for further analysis.
7. The level of detail and accuracy needed for the analysis.
8. Most importantly, the validation of the model under a given situation and condition. This relies heavily on experience, judgement and literature.

Some of the basic requirements of an improved air quality modeling system as suggested by Hunt et al. (1991) are listed below.

1. It should be capable of optimal utilization of detailed meteorological information.
2. It should be well versed in dealing with complex effects such as buoyant gas emissions or dense gas emissions and dispersion from arbitrary heights in the atmosphere over irregular terrain, buildings and coastlines. It should also be able to calculate the vertical distribution of concentration, including ground level concentrations.
3. It must accommodate the complex dispersion processes associated with short time releases, deposition, and concentration fluctuations.
4. The model output should be in a form that is compatible with other calculation methodologies for various purposes such as health effect and risk assessment.

A model selection process as suggested by Zannetti is shown in Figure 4-1 (Zannetti, 1990).

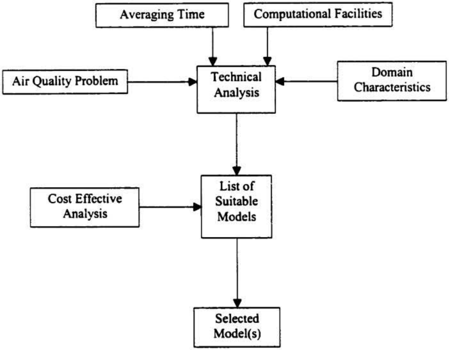

Figure 4-1, Model Selection Process (Zannetti, 1990).

After defining the study objectives and after a detailed analysis of the problem, the available models were reviewed as per guidelines and criteria discussed above, to select two models to accomplish the simulation at the local and regional scales. The two selected models are; (a) NOAA and ARL's HYsplit4 (HYbrid Single Particle Lagrangian Integrated Trajectory-Version 4) (Draxler, 1999) for long-range transport modeling, and (b) ISC3 (Industrial Source Complex-Version 3) (EPA, 1995) model for the short range modeling. These models were selected on the following criteria:

1. The availability of the model- both models are in the public domain and can be downloaded from the World Wide Web.
2. The availability of the resources- both models are available free of cost and do not require high computational facilities.
3. The availability of input data- the available source and meteorological data was compatible with the model requirements.
4. The validation studies of the model in the past- Both models have been exclusively used in the study area in the past and their application was validated (Husain, 1995).
5. Analysis of the problem- both models fulfill the requirements of the analysis to be performed.
6. Simplicity- both models are very user-friendly in operation, do not require enhanced computational facilities, and can easily be operated using personal computers.

The following sections describe the two selected models and the methods and procedures adopted in their application.

4.2. The HYbrid Single Particle Lagrangian Integrated Trajectory (HYsplit4) Model (Draxler, 1998 and 1999)

4.2.1. An overview and introduction

Eulerian and Lagrangian methods are the two main techniques employed by atmospheric dispersion models to estimate the air pollutant concentration. Eulerian models solve the advection-diffusion equation using a fixed reference system, such as with respect to the earth, and therefore are applicable to complex emission scenarios where solutions at all grid points is required. Lagrangian models deal with the advection and diffusion components independently, and follow the average atmospheric motion and thus are typically applicable when dealing with single-point-source emissions, when computations are required at only few grid points. The literature review reveals that, despite their limitations, both the models have been successfully used in a variety of different scenarios (Voldner et al., 1981; Olson et al., 1982; Iversen, 1989; Christensen, 1997).

The HYsplit4 is the latest version of HYbrid Single-Particle Lagrangian Integrated Trajectory model. This model uses the calculation method, which is hybrid between the Eulerian and the Lagrangian techniques. The model deals with the advection and diffusion components independently in a Lagrangian framework, while estimating the concentrations on a fixed grid. This model is a capable of estimating simple air parcel trajectories to complex dispersion and deposition simulations using either puff or particle approaches.

The puff model simulates the source as releasing pollutant puffs at regular intervals for the total duration of the release. An appropriate fraction of pollutant mass is contained in each puff. The puff is considered to move horizontally following the trajectory of its center position, and it expands both horizontally and vertically with time. Assuming a defined spatial concentration distribution, the air concentrations are estimated at grid points. The particle approach considers the source as releasing a number of particles during the whole duration of release. The dispersive nature of atmosphere is simulated with the expansion of particle clusters in space and time. The mass of all the particles are summed up at a grid point to estimate the air concentration.

As result of a joint effort between the National Oceanic and Atmospheric Administration (NOAA) and Australia's Bureau of Meteorology, the model has recently been upgraded and several significant new features have been introduced. These new features include improved advection algorithms, updated stability and dispersion equations, a new graphical user interface, and the option to include modules for more chemical transformations.

The model requires gridded meteorological data at regular time intervals. The model is capable of simulating multiple pollutants, by considering emissions consisting of one particle or puff associated with each pollutant type. A single puff contains different masses of various pollutants, and the model uses this approach for chemical transformation calculations.

The puff model simulates the expansion of a puff followed by its disintegration into several new puffs when it exceeds the grid size. In the particle model, a fixed number of initial particles are spread by the wind. However, with this approach, very few particles remain in a grid cell during longer simulations.

This model has been successfully tested in a variety of different situations, from inert tracer experiments such as the Cross-Appalachian Tracer Experiment (CAPTEX) (Draxler, 1988), and the Across North America Tracer Experiment (ANATEX) (Draxler et al., 1991), to more complex situations such as radiological deposition from the Chernobyl accident and various other cases involving real pollutants such as SO_x, NO_x, and PM. Other simulations have been conducted to evaluate the air quality during the Kuwait oil fires, trajectory methods during field studies, and source attribution techniques for major pollutants.

4.2.2. Technical description

HYsplit4 is able to simulate simple trajectories, complex concentrations at multiple levels, and ground deposition. We are not computing trajectories, and in this study, therefore our discussion will be limited to air concentration and deposition estimation, using this model.

4.2.2.1. Air concentrations

A Lagrangian model uses the puff or the particle approach for air concentration computation. A puff model simulates a source that releases pollutant puffs at regular intervals over the duration of the release. Each puff contains the appropriate fraction of pollutant mass. The advection takes place in a puff according to the trajectory of its center position, while the size of the puff expands, both horizontally and vertically with time, to account for the dispersive nature of a turbulent atmosphere. Air concentrations are then calculated at specific points by assuming that the concentrations within the puff have a defined spatial distribution. A particle model simulates a source that releases numerous particles over the duration of release and the air concentrations are calculated by summing the mass of all the particles in a grid cell.

Using the puff method, this model splits a puff into smaller components when they exceed meteorological grid size. This method allows the subgrid turbulence processes to be modeled by dispersion parameterizations while grid-scale processes are simulated by the puff splitting process. This approach results in the generation of a large number of puffs in the vertical direction when strong mixing occurs. In order to overcome this drawback, this model incorporates a novel approach developed by Hurley (1994), and thus uses particle dispersion in the vertical direction and puff dispersion in the horizontal direction.

For dispersion calculations, stability and mixing coefficients are computed from meteorological data.

4.2.2.2. Stability

The atmospheric stability plays an important role in pollutant dispersion. It is the capacity of atmosphere to enhance or resist vertical motion. The stability of the atmosphere is greatly affected by the wind speed and the lapse rate. Depending upon the degree of vertical motion, the stability of the atmosphere in categorized as stable, neutral or unstable. Empirical schemes used to estimate the atmospheric stability are provided in Appendix-F.

The model uses the heat and momentum fluxes from the meteorological model to estimate the boundary layer stability. At each grid point, the model estimates the boundary layer depth, z_i, assuming it as the height at which the potential temperature first exceeds the value of surface temperature by 2°K. The model computes the friction velocity u_* and the friction temperature T_* from the momentum flux and the sensible heat flux respectively, which are provided by the meteorological model (data). Using these friction parameters, the Obukhov length (L) is calculated, and then the stability parameter 'z/L' is computed as;

$$z/L = Z_2\, k\, g\, T_*\, (u_*^2\, T_2)^{-1} \qquad -2 \le z/L \le 10$$

Where

Z_2 is the height of the surface layer.

k is Von Karman's constant and its value is 0.40

g is acceleration due to gravity and equal to 9.8 m/s^2

4.2.2.3. Vertical and horizontal mixing coefficients

The pollutant vertical mixing coefficient (K_z) is assumed to follow the coefficients for heat. Within the Boundary Layer (BL), vertical mixing coefficients are computed following Troen and Mahrt (1986) and Holtslag and Boville (1993).

Once the K_z profile is established, the model computes a single average value for the entire BL from the profile, and that value replaces all the values within the BL.The model computes the subgrid-scale horizontal mixing coefficient using velocity deformation (Smagorinsky, 1963; Deardorff, 1973).

4.2.2.4. Particle and puff dispersion

The model formulates both the horizontal puff and vertical particle dispersion equations in terms of the turbulent velocity components. These velocity components are functions of diffusivities.

4.2.2.5. Pollutant air concentration

For each puff, the model sums concentrations at each time step to all grid points that fall within the puff defined for top-hat distributions as $\pm 1.54\sigma_h$ or $\pm 3.0\sigma_h$ for Gaussian distributions (where σ_h is the coefficient of horizontal distribution). The incremental concentration contribution by each top-hat puff of mass m to a grid point is;

$$\Delta c = m(\pi r^2 \Delta z)^{-1}$$

where the horizontal radius $r = 1.54\sigma_h$

All the grid nodes within the puff receive the same Δc.

For a Gaussian puff, the incremental concentration is calculated as;

$$\Delta c = m(2\pi\sigma_h^2 \Delta z)^{-1} \exp(-0.5\, x^2/\sigma_h^2)$$

where x is the distance from the puff center to grid-node with Δz defined as grid-cell height.

4.2.2.6. Meteorological input data

NOAA's Air Resources Laboratory archives the Global Data Assimilation System (GDAS), analysed by the National Weather Service's National Center for Environmental

Prediction (NCEP). These data files are archived using a 1-byte packing method, for the purpose of air quality transport and dispersion modeling. These archived data files, from January 1, 1997 and onwards are called FNL archive. The Hysplit4 model uses meteorological input fields only in "ARL packed" format.

Each archive file contains data on one hemisphere for the first half or the second half of the month. For each time period, an index record and surface data are recorded, followed by all data in each mandatory pressure level from the ground up. The data in the files called fnl.xh.mmmyy.00# contain either the first 15 days of the month (00# = 001) or the rest of the month (00# = 002), where xh refers to the northern (x=n) or southern (x=s) hemisphere, mmm is the month (e.g. jul) and yy is the year (97).

The archived data file only contains some of the fields normally produced by the model at NCEP. These were selected according to what is most relevant for transport and dispersion studies and disk space limitations.

The model identifies the meteorological variables by a unique four character identification that is written to the first 50 byte header portion of each data record. The meteorological data fields description, their units and the identification codes are provided in Appendix-F. Appendix-F also contains a number of meteorological parameters used in modeling.

4.2.3. Running the HYsplit4 model

The publicly available version of HYsplit4 model can either be run using a command line or Graphic User Interface (GUI). The use of GUI is the easiest way to edit the model's input control file. The GUI also contains options for converting model output files to either screen displays or postscript files, which can be viewed and printed.

The control file for air concentration and deposition estimation consists of four groups of input data. The first group of input data consists of source information for each source and its respective location in degrees of latitude and longitude, the calculation starting time, and modeling options such as selection of the vertical motion calculation method, the vertical limit and meteorological fields. The second group consists of pollutant definition entries including the numbers of pollutants to be simulated and their respective emission rates and starting times. The third group of data input defines the grid and provides the grid spacing and grid span, the number of vertical concentration levels and their respective heights above ground level, and the sampling interval. The fourth group consists of deposition definitions such as the number of depositing pollutants and their respective deposition parameters including the particle diameter, density, depositing velocity etc., and options to estimate both wet and dry deposition or dry deposition only. A sample control file is presented in Appendix-F.

The meteorological data files for the months of January-December 1999 (2 files/month) for the northern hemisphere were downloaded on a PC from READY web site: *http://www.arl.noaa.gov/ready.html*. Since these files were only available for 15 or 16 days periods, and the model version only allowed the use of 10 files at a time, therefore three runs were made for each four-month period and the results were dumped every twenty-four hour interval. A computer code in C++ was developed to sort the deposition values at each location and add the respective values to generate values for longer modeling periods. A separate run was made for each pollutant to estimate the deposition for total particulate and ambient concentrations of sulfur dioxide and oxides of nitrogen. A separate program was developed in C++ to estimate the annual concentrations of gaseous pollutants. The model version used for the simulation could accommodate thirty source locations at a time. The power generation data was available for each geographic region, but individual plant capacities and their respective locations in these regions could not be obtained. Thus twenty-three source locations were selected, five in each of the Eastern, Northern and Western regions and four in each of the Central and Southern regions. The power generation capacities of each region were uniformly distributed in the respective regions. Using power generation information (Electrical Affairs Agency, Ministry of Industry and Electricity KSA, 1997), fuel characteristics (Husain, 1995) and Emission factors (EPA, 1995), the emissions of different pollutants for each region were estimated assuming continuous and uncontrolled emissions. The AP-42 emission factors for power generation units having a capacity of more than 30 MW and using different fuels are presented in Table 4-1 and the estimated emission inventory for different regions of Saudi Arabia is presented in Table 4-2.

Table 4-1, AP-42 Emission Factors for Electric Utilities Using Different Fuels (EPA, 1990).

Pollutant	Crude Oil	Diesel	Natural Gas
	$kg/10^3$ lit	$kg/10^3$ lit	$kg/10^6\ m^3$
SO_2	18.84S	18.84S	9.6
NO_x	5.64	2.88	4480
CO	0.6	0.6	1344
PM	1.1 (S) + 0.3864	0.24	121.6

where S is % sulfur content in the oil.

In order to have a conservative estimate, only crude oil was assumed to be the fuel of combustion for the total generation capacity. The sulfur content was assumed to be 4.24% and a heating value of 18,550 Btu/ lb. was adopted (Husain, 1995). A typical thermal efficiency of 33.9% was used to obtain emission estimates.

Table 4-2, Emission Inventory for Different Regions of the KSA for 1996-97.

	Pollutant			
Region	SO_2	CO	NO_x	PM
	kg/hr	kg/hr	kg/hr	kg/hr
Eastern	155107	1165	10951	9829
Central	94507	710	6673	5989
Southern	28875	217	2039	1830
Western	114268	858	8068	7241
Northern	25160	189	1776	1594

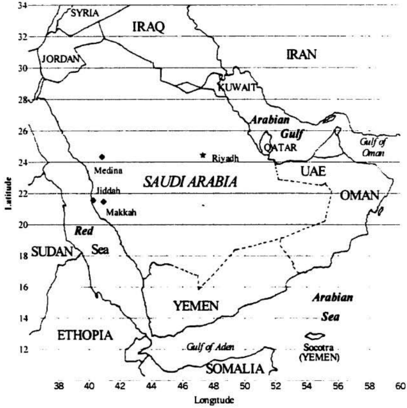

Figure 4-2, Concentration Grid for the HYsplit4 Model Runs.

The concentration grid selected for the HYsplit4 runs is shown in Figure 4-2. A concentration grid of 24° latitude x 24° longitude was selected to cover the whole Gulf region, and concentration and deposition values were estimated at all the grid point as shown in this figure.

4.3. The Industrial Source Complex (ISC) Model (EPA, 1995)

4.3.1. An overview

The ISC is a Gaussian plume model used to simulate the concentration and deposition of primary pollutants. This model can estimate both ambient concentrations and the deposition for various averaging periods from a variety of sources. This model takes into account the settling and dry deposition of particulate, downwash, area, volume, point and open-pit sources, plume rise as a function of downwind distances, and terrain adjustments.

The U.S. EPA recommends the use of this model for the following regulatory applications:

- Industrial source complexes.
- Rural or urban areas.
- Flat or rolling terrain.
- Transport distances less than 50 kilometers.
- One hour to annual averaging times.

The ISC model contains numerous options related to site specific wind profile exponents and vertical potential temperature gradients, source specific plume dispersion coefficients, time dependent exponential decay of pollutants, stack tip downwash, building wake effects, and dry deposition.

The ISC short term model is capable of estimating concentration and/or deposition values for the time periods of 1, 2, 3, 4, 6, 8, 12 or 24 hours. It can also estimate the annual values.

Like most of the dispersion models, this model also requires an input runstream file and a meteorological data file. The runstream file contains the selected modeling options, source locations and parameter data, the receptor locations, the meteorological data file specifications, and the output options.

4.3.2. Technical description

The ISC model employs a modified form of the Gaussian plume equation, using empirical dispersion coefficients and includes adjustments for plume rise, limited mixing height, and elevated terrain. Measured hourly values of wind speed and direction, and estimated hourly values of atmospheric stability and mixing height are used to compute pollutant concentrations. The ISC model is capable of simulating area, point, volume and open-pit type sources. In this study, the stacks emissions are considered as point sources.

The ISC short term model uses the steady-state Gaussian plume equation for computation of the pollutant concentrations from a continuous elevated point source. The model converts the fixed receptor locations to each stack's coordinate system for hourly concentration calculations. These concentrations calculated for each stack at each receptor are summed to obtain the total concentration at each receptor as a result of combined stack emissions.

The ISC short term model uses the following equation to calculate the hourly ground level concentration at a downwind distance 'x' and crosswind distance 'y' from the source,

$$\chi(x,y)=\frac{K.Q}{\pi.u(h)\sigma y.\sigma z}\exp\left\{-\frac{1}{2}\left(\frac{y}{\sigma y}\right)^2\right\}V.D$$

Where,

Q = pollutant emission rate (mass per unit time)

K = conversion factor to calculate concentration in desired units

σy = standard deviation of lateral concentration distribution (m)

σz = standard deviation of vertical concentration distribution (m)

u(h) = mean wind speed (m/sec) at stack height, h

V = vertical term, which includes the effects of source elevation, receptor elevation, plume rise, limited mixing in vertical, and the gravitational settling and dry deposition of particulate with diameter greater than 0.1μ

D = decay term

The Gaussian plum is schematically illustrated in Appendix-F.

ISC short term model uses a user specified polar or a Cartesian receptor network. In addition, the model also allows for the use of both types of receptor networks and multiple networks in a single run. For either type of receptor network, the user must define the location of each source with respect to the origin of the grid using Cartesian coordinates.

The ISC model uses the wind power law to adjust the measured wind speed u_{ref}, from a reference measurement height, z_{ref}, to the stack height, h. This calculated wind speed at the release or stack height, u_s, is then used in a Gaussian plume equation for the concentration estimation purposes and plume rise expressions. The power law equation used by the model is of the form:

$$u_s = u_{ref}\left(\frac{h_s}{z_{ref}}\right)^p$$

where p stands for wind profile exponent. The model allows the use of a default value of p, or users may specify the value of p as a function of stability category and wind speed class. The model does not allow the use of a stack height wind speed of less than 1.0 m/sec. Values of less than 1.0 m/sec are adjusted to 1.0m/sec by the model.

The ISC model uses the Briggs plume rise equations to calculate the plume height and takes into account the stack-tip downwash, momentum and buoyancy fluxes, and the stability parameter. The distance dependent momentum plume rise equations are used by the model to determine if the plume is affected by the wake region for building downwash calculations.

For the estimation of point source dispersion parameters σy and σz, the model uses the equations that approximately fit the Pasquill-Gifford curves.

4.3.3. Running the ISC model

The input file for the ISC models makes use of a keyword/parameter approach for specifying the options and input data for running the models. The keywords specify the type of option or input data being entered on each line of the input file, and the parameters following the keyword define the specific options selected or the actual input data. Figure 4-3 shows the schematics of the ISCST model program.

The runstream file of an ISC model consists of six functional pathways, which are identified by a two character pathway ID. These pathways can be seen as sub-input files. The runstream file accepts these pathways only in a definitive order. These pathways in order in which they are input in a runstream file are;

CO-Control Pathway, to specify overall job control options;

SO-Source Pathway, to specify source information;

RE-Receptor Pathway, to specify receptor information;

ME-Meteorology Pathway, to specify meteorology information;

TG-Terrain Grid Pathway, to specify terrain grid information; and

OU-Output Pathway, to specify output options

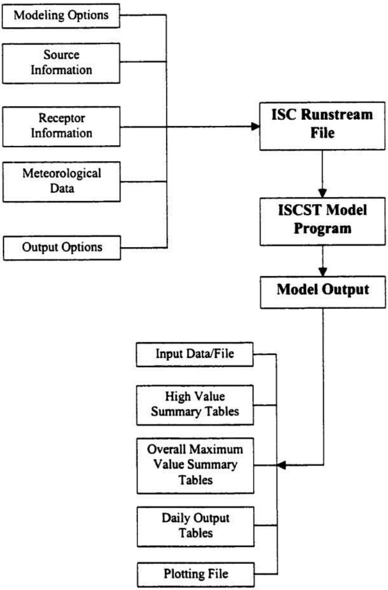

Figure 4-3, Schematic Diagram of the ISCST Program.

The various output options available with the ISC model are;

- Summaries of high values (highest, second highest, etc.) by receptor for each averaging period and source group combination.
- Summaries of overall maximum values for each averaging period and source group combination.
- Tables of concurrent values summarized by the receptor for each averaging period and source group combination for each day of data processed.
- The raw concentration values in unformatted binary files.
- File of all occurrences of concentration and/or deposition equaling or exceeding a user defined threshold.

In addition, the model also allows users to perform source contribution analyses, and it is also capable of creating a file for concentration contour plotting purposes.

4.3.3.1. Model input data

The ISC model requires two basic input data for a run, the meteorological data and the source and receptor information. The meteorological input file required for concentration calculations using ISC model must contain hourly sequential data for the following parameters;

Flow vector (wind direction) in degrees

Wind speed in m/sec

Ambient air temperature in degrees Kelvin (°K)

Pasquill stability category (A=1, B=2,......... F=6)

Rural and/or urban mixing height in meters

The meteorological data for the region was available for the year 1995. This data was processed to develop a meteorological data file compatible to the model and was used for the model runs.

4.3.4. Runstream file for the ISCST model

The ISCST model was used to simulate the ambient concentrations of different pollutants for various averaging periods, from Ghazlan Power Plant (GPP) emissions. GPP is located at about 50 km north-west of the eastern coastal city Ad Dammam in the eastern province of Saudi Arabia. It is one of the largest power plants in the country having a current generating capacity of 1200 MW. A $1.5 billion project, financed by an international syndicate is underway to expand the generating capacity of the GPP to 3600 MW by the year 2004. The ambient concentrations of primary pollutants as result of emissions from the GPP will be estimated considering both the generating capacities and assuming a worst case scenario of uncontrolled emissions.

4.3.4.1. Emission inventory

Using the AP-42 emission factors as shown in Table 4-1 on page 69, the complete emission inventory of primary pollutants from the thermal power plant, considering the generating capacities of 1200 and 3600 MW are listed in Tables 4-3.

Table 4-3, Emission Inventory for the GPP assuming 1200 MW and 3600 MW Capacities.

Items	Generation Capacity (MW)	
	1200	3600
Power Output (Btu/hr)	4.09×10^{9}	1.22×10^{10}
Fuel Consumption (gal/hr)	8.58×10^{4}	2.57×10^{5}
SO_2 Emission:		
kg/yr	2.27×10^{8}	6.81×10^{8}
g/sec	7200	21600
Filterable PM Emission:		
kg/yr	1.44×10^{7}	4.32×10^{7}
g/sec	456	1368
CO Emission:		
kg/yr	1.71×10^{6}	5.12×10^{6}
g/sec	54	162
NO_x Emission:		
kg/yr	1.6×10^{7}	4.81×10^{7}
g/sec	510	1525

4.3.4.2. Selected modeling options

The model was set up to calculate the ambient concentrations of different pollutants at selected receptor locations. The dispersion options selected were the default regulatory options, which invoke the following;

- stack-tip downwash
- buoyancy induced dispersion
- instantaneous final plume rise
- a routine for processing averages when calm winds occur
- default wind speed and temperature profiles, and

- upper bound estimates for super-squat buildings having a lateral dispersion of the plume.

In addition, rural dispersion coefficients were selected to estimate annual average concentrations of sulfur dioxide in a flat terrain.

4.3.4.3. Source input data

Two stacks were considered as two point sources located 20 meters apart. The Cartesian coordinates for the stacks were entered as (0.0, 0.0) and (0.0, 20.0) respectively. The other source parameters and their respective entries input in the model were;

- pollutant emission rates were used from Table 4-1
- a stack height of 85 meters
- a stack gas exit temperature assumed of 440°K
- a stack gas exit velocity of 12 m/sec which was assumed, and
- a stack inside diameter which was taken to be 1.5 meters.

Both the sources were grouped together to calculate the combined effects at the receptor locations.

4.3.4.4. Receptor information

A Cartesian grid receptor network was defined in the model input file to estimate short term and annual averages at various receptor grids. The receptor grid network extended

25 km in each direction from the source and included the towns of Al Jubail, Ras Tannurah, Al Jaemah, Safwa and Umm as Sahik, located near the GPP. The defined receptor network is shown in the Figure 4-4. The vertical axis in Figure 4-4, and all other figures (in Chapter 5), showing results of the ISC model represents the north south direction.

4.3.4.5. Selected output options

The ISC model allows users to select various output options for viewing the generated results. The following output options were selected for the short term model run;

- high value summary tables for different averaging times for separate receptors
- overall maximum value summary tables
- average annual values at all receptors, and
- tables showing exceedences of threshold values for different averaging periods.

A sample runstream file for the ISCST model is presented in Appendix-F.

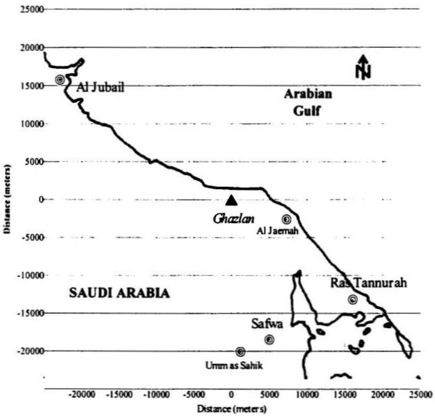

Figure 4-4, Receptor Grid for the ISCST3 Model Runs.

Chapter 5

Results and Analysis

5.1. Air Quality Standards

Environmental regulatory agencies around the world have established ambient air quality standards to set legal limits on the levels of air pollutants in the outdoor air, in order to protect the environment and the public health. These standards are implemented to restrict industries and facilities from discharging high amounts of air pollutants in the atmosphere, and thus to force them to employ air pollution control devices to avoid further deterioration of the atmosphere.

The Meteorological and Environmental Protection Agency (MEPA) is responsible for protection of the environment in Saudi Arabia. The National Ambient Air Quality Standards (NAAQS) for criteria pollutants for various averaging periods, as set by MEPA are presented in Table 5-1.

Table 5-1, MEPA Air Quality Standards (Amin, 1994).

Averaging time	Maximum concentration	Exceedences
Sulfur dioxide (SO_2)		
1-hr	730 $\mu g\ m^{-3}$ (0.28 ppm)	Twice a month
24-hr	365 $\mu g\ m^{-3}$ (0.14 ppm)	Once a year
Annual	80 $\mu g\ m^{-3}$ (0.03 ppm)	
Inhalable particulate		
24-hr	340 $\mu g\ m^{-3}$	Once a year
Annual	80 $\mu g\ m^{-3}$	
Photochemical oxidants (defined as ozone, O_3)		
1-hr	295 $\mu g\ m^{-3}$ (0.15 ppm)	Twice a month
Nitrogen oxides (defined as nitrogen dioxide, NO_2)		
1-hr	660 $\mu g\ m^{-3}$ (0.35 ppm)	Twice a month
Annual	100 $\mu g\ m^{-3}$ (0.05 ppm)	
Carbon monoxide (CO)		
1-hr	40 $mg\ m^{-3}$ (35.0 ppm)	Twice a month
8-hr	10 $mg\ m^{-3}$ (9.0 ppm)	Twice a month
Hydrogen sulfide (H_2S)		
1-hr	195 $\mu g\ m^{-3}$ (0.14 ppm)	Twice a month
24-hr	40 $\mu g\ m^{-3}$ (0.03 ppm)	Once a year
Fluorides (F^-)		
30-d	1 $\mu g\ m^{-3}$ (0.001 ppm)	

These standards are set by the regulatory agencies using the best scientific evidence available relating the levels of emissions to adverse effects on human health and the environment. The estimated concentrations will be compared with these standard values to quantify the adverse effects.

As discussed in earlier sections, two models were used for this study; the HYsplit4 model to assess the long range effects over the whole region as a result of emissions from the power generating industry in the Kingdom of Saudi Arabia; and the ISCST3 model to simulate the short-term effects emerging from the emissions as a result of current as well as expected emissions from the Ghazlan Thermal Power Generation Plant, as it is proposed to expand the capacity of this plant from 1200 MW to 3600 MW. The modeling results and the assumptions made are discussed in the following sections.

5.2. Long Range Transport Model Results

The HYsplit4 model was used to estimate the particulate deposition as well as the sulfur dioxide and NO_x concentrations in the Gulf region as a result of the long range transport of emissions from thermal power plants located in the Kingdom of Saudi Arabia.

As reported in earlier sections of this study, there are 75 thermal power plants in the Kingdom of Saudi Arabia, and 662 generating units located all around the country and possessing a total generating capacity of 19,351 MW. These generating units include steam, gas, diesel, and combined units. Over 60% of the electricity in Saudi Arabia is generated using gas systems, 25% using steam systems, and only 3.3% using diesel systems. In this study, it was assumed that all the sources used residual or Bunker C oil as fuel for the combustion purposes. The fuel characteristics such as density, ash, sulfur, nitrogen and carbon contents, and heating values were adopted from that of typical Kuwait Crude (Husain, 1995). Also, due to lack of information regarding individual plant locations and their respective generating capacities, cumulative generating capacities for the five geographic regions were used and evenly distributed throughout each region. The simulation was made for the year 1999, but due to insufficient computational facilities and model limitations, it was not possible to make a single run for the whole year. Instead, three runs were made for each four-month period, i.e. Jan-Apr, May-Aug and Sept-Dec and results were dumped at 24-hour intervals. Finally, the output files were merged together, and a program in C++ was developed to sort the data and estimate the total deposition and average concentration values at the end of the year.

5.2.1. Deposition parameters

Particulate deposition parameters were selected based on available literature. Typically, over 70% of particles from combustion sources using crude oil are less than 10 μm (EPA, 1995). Therefore for particulate deposition estimation, the particle diameter was taken to be 10 μm. It has also been observed that particles from combustion sources are predominantly sulfate particles (Husar and Wilson, 1993). Using the relationship developed by McMohan and Denison (1979), the deposition velocity for particles having diameter of 10 μm was estimated to be 0.7 cm/s. Also, the typical deposition velocities for SO_2 were also found to be in the range of 0.5-0.8 cm/s (Husar et al., 1978). Using the relationship between particle diameter, deposition velocity and particle density, as predicted by Sehmel (1980), the estimated density for the particles with 10 μm diameter and deposition velocity of 0.7 cm/s was in the order of 4 g/cm^3. The particle deposition parameters used for simulation are;

- Particle diameter 10 μm
- Deposition velocity 0.7 cm/s
- Particle density 4g/cm^3, and
- Residence time 4 days (Assuming sulfate particles (EPA, 1996))

5.2.2. Particulate deposition

The simulation results showing particulate deposition in the Gulf region resulting from thermal power plants emissions in the Kingdom of Saudi Arabia, for the year 1999 are shown in the following Figure5-1.

Table 5-2 shows the 10 highest deposition values at their respective locations in terms of latitude and longitude. The highest estimated deposition was 87.23 kg/km^2 occurring at latitude 26.00 and longitude 48.00. The average annual deposition in the region was estimated to be 11.48 kg/km^2. A statistical analysis of the deposition values revealed that, the 80^{th}, 85^{th}, 90^{th}, and 95^{th} percentiles were 15.34, 20.23, 29.22, and 45.57 kg/km^2 respectively.

It was also observed that the calculated deposition in the vicinity of the capital city Riyadh was high and in the order of 80 kg/km². The particulate deposition in the vicinities of some other major cities is reported in Table 5-3. The calculated deposition values in the Arabian Gulf ranged from 2-8 kg/km².

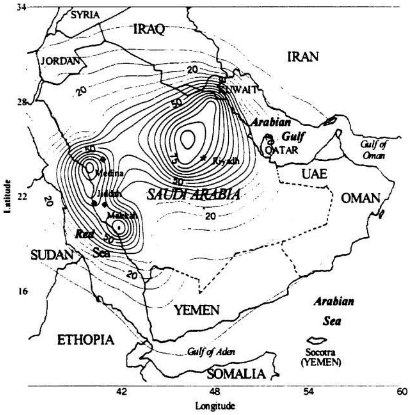

Figure 5-1, Particulate Deposition (kg/km²) Plot for the Year 1999.

Table 5-2, 10 Highest Particulate Deposition Values.

Rank	Filterable Particulate Deposition (kg/km^2)	Location	
		Latitude	Longitude
1	87.23	26	46
2	82.35	24	46
3	81.39	24	40
4	79.91	28	48
5	75.20	20	42
6	67.81	22	40
7	63.09	24	48
8	50.33	28	46
9	45.63	26	42
10	45.24	24	44

Table 5-3, Approximate Particulate Deposition Values for Different Regions.

Region	Deposition (kg/km^2)
Medina	50-60
Makkah and Jeddah	60-70
Dammam and Dharan	10-15
King Khalid Military City	50-55
Kuwait	30-50
Arabian Sea	1-4
Red Sea	8-15

5.2.3. SO_2 and NO_x concentrations

The SO_2 and NO_x results are reported in Figures 5-2 and 5-3 respectively. All the concentration results generated by the HYsplit4 model met the MEPA annual average standards for both the pollutants. The highest SO_2 concentration was estimated to be 76 $\mu g\text{-}m^{-3}$ at 26.00 latitude, 48.00 longitude, which is satisfactory compared to the MEPA allowable annual average of 80 $\mu g\text{-}m^{-3}$. The highest NO_x concentration was 8.5 μgm^{-3}, which is far less than the MEPA standard of 100 $\mu g\text{-}m^{-3}$.

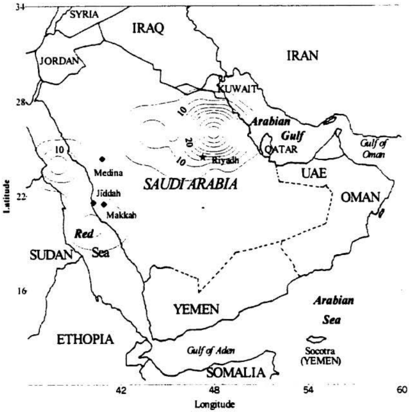

Figure 5-2, Annual SO_2 Concentration ($\mu g/m^3$) Plot for the Year 1999.

Figure 5-3, Annual NO_x Concentration ($\mu g/m^3$) Plot for the Year 1999.

5.3. Short Range Modeling Results

ISCST model was used to estimate the short-term ambient concentrations of SO_2, CO, NO_x and particulate matter, contributed by the Ghazlan Power Plant (GPP) facility using the meteorological data for the year 1995. Two scenarios were simulated, to consider the current generating capacity of 1200 MW and the future generating capacity of 3600 MW. An alternate fuel option was also considered to reduce the concentrations of pollutants of concern. Natural gas was considered as substitute for crude oil as a fuel for the combustion purposes. Various combinations of crude oil and natural gas were assumed in order to find the most suitable combination. The results generated for each pollutant are discussed in the following sections.

5.3.1. Sulfur dioxide results

Considering both the scenarios (current and future generation capacities), sulfur dioxide concentrations were simulated to estimate the following:

- 1 hour average concentrations for the year 1995
- 24 hour average concentrations for the year 1995
- Monthly average concentrations for each month of the year 1995
- Annual average concentrations for the year 1995

5.3.1.1. 1-hr average concentration results

The 1-hr average concentration results were estimated and compared against MEPA's maximum concentration standard of 730 $\mu g\ m^{-3}$. For the current generating capacity, 13,632 out of 1,059,960 values exceeded the standard maximum concentration, whereas for the future capacity of 3600 MW, the standard value was exceeded 23,271 times, which is 2.2% of the total values generated. Appendix-A contains the table showing the maximum 100 1-hr SO_2 concentrations for the two generation capacities.

5.3.1.2. 24-hr average concentration results

Appendix-A contains the summarized daily concentration results of SO_2 for present and future generating capacities, as a result of GPP emissions. These results were also compared against the standard maximum concentration of 365 $\mu g\ m^{-3}$ set by MEPA. At the current generating capacity, only 317 values exceeded the standard maximum concentration, whereas for the other scenario, the 24-hr average standard concentration was exceeded 3,407 times out of 44,165 results generated.

5.3.1.3. Monthly average concentration results

Monthly SO_2 average concentration results were only generated for the current capacity. These results for each month are shown in Figures 5-4 through 5-15. Figure 5-16 shows the plots of 20 maximum values for the months January-June, whereas Figure 5-17 shows the 20 maximum values for the months July-December 1995.

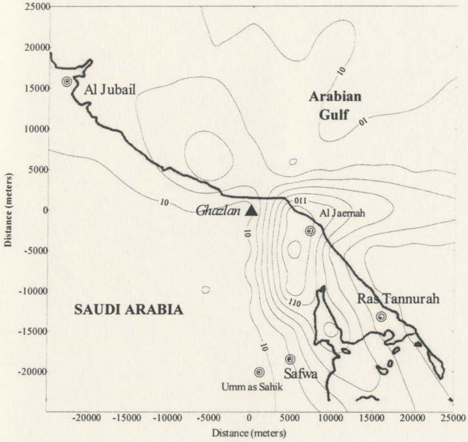

Figure 5-4, Average SO_2 Concentration Plot for the Month of January 1995.

It is evident from the Figure 5-4 that the higher concentrations were found in the region south east of the facility. The SO_2 concentrations for the month of January ranged from as low as 0.03 $\mu g/m^3$ to 164 $\mu g/m^3$. The highest concentration was found at a distance of about 7 km south east of the source.

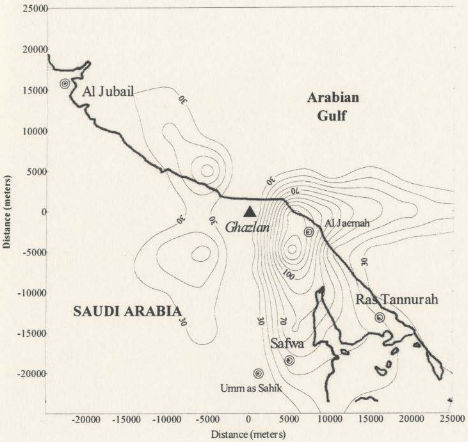

Figure 5-5, Average SO_2 Concentration Plot for the Month of February 1995.

The February period concentrations are shown in Figure 5-5. This figure shows that the higher concentrations during this month were also found south east of the source, the highest being 150 $\mu g/m^3$ and found at the same receptor as in the previous month.

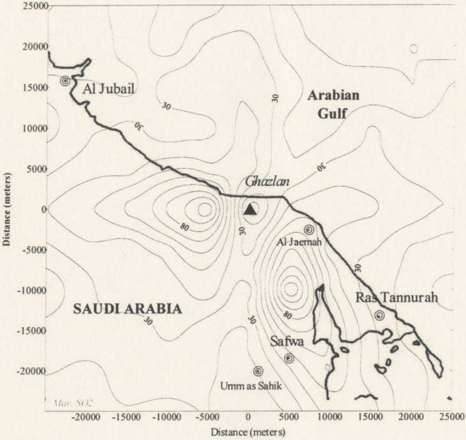

Figure 5-6, Average SO_2 Concentration Plot for the Month of March 1995.

Figure 5-6 shows the period concentration for the month of March. It shows that during that month, the concentration pattern is different from the previous two months and the higher concentrations were found south east and south west of the facility. However, the highest concentration of 123 $\mu g/m^3$ was found about 10 km from the source in the south east direction.

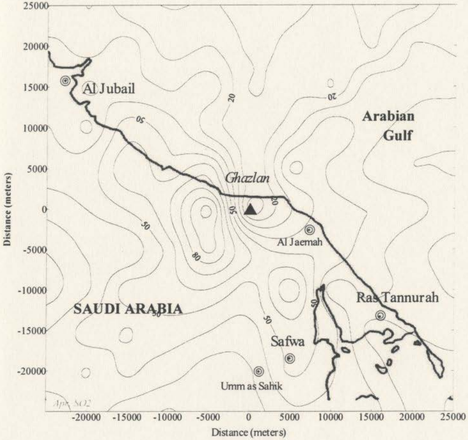

Figure 5-7, Average SO_2 Concentration Plot for the Month of April 1995.

The period concentrations for the month of April are shown in the Figure 5-7. The concentration pattern does not follow that of the precedent months. The higher concentrations were found south east and west of the source. The highest concentration was 107 $\mu g/m^3$ for this month, found at a distance of 5 km west of the source.

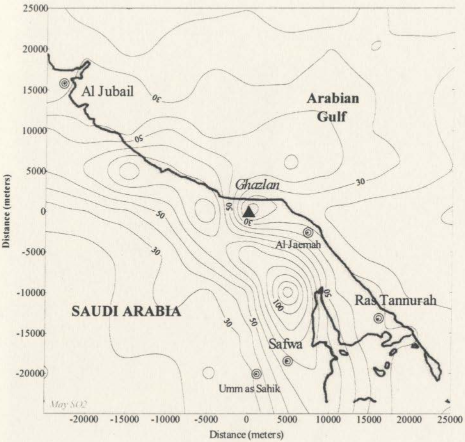

Figure 5-8, Average SO_2 Concentration Plot for the Month of May 1995.

The concentration plot for the period of May, as shown in Figure 5-8, resembles those of January and February, with higher concentrations found south east of the source. The highest concentration for this period was 130 $\mu g/m^3$ found about10 km from the source in south east direction.

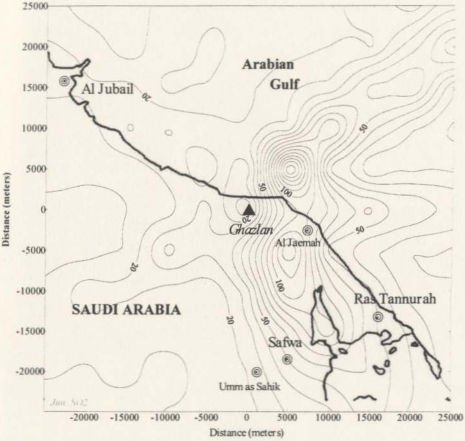

Figure 5-9, Average SO_2 Concentration Plot for the Month of June 1995.

Figure 5-9 shows the concentration plot of period averages for the month of June. This figure shows a shift in the concentration patterns again, as the higher concentrations are found north east and south east of the facility. The highest concentration was 170 $\mu g/m^3$ and occurred 5 km, north east of the source.

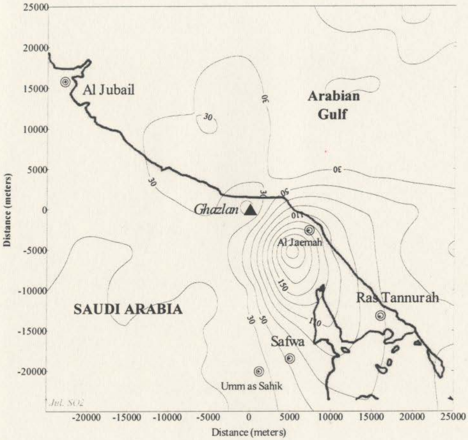

Figure 5-10, Average SO_2 Concentration Plot for the Month of July 1995.

Figure 5-10 shows that the higher concentrations for the month of July were found south east of the facility, following the pattern of the earlier months. Also, for this period, the highest concentration was 233 μg/m^3, found at receptor grid (5000, -5000) in the vicinity of the town of Al Jaemah.

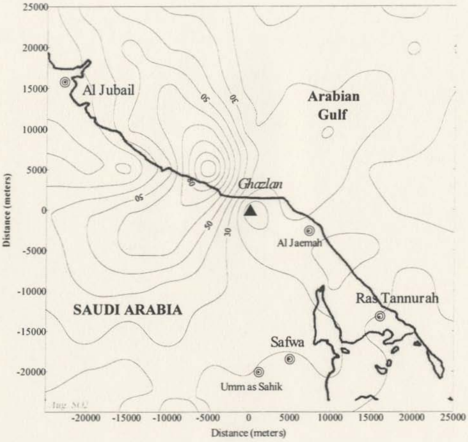

Figure 5-11, Average SO_2 Concentration Plot for the Month of August 1995.

The concentration plot for the month of August is shown in the Figure 5-11. It is evident that the higher concentration values were found north west of the source. The highest concentration for this period was 113 $\mu g/m^3$, and occurred 5 km north west of the source.

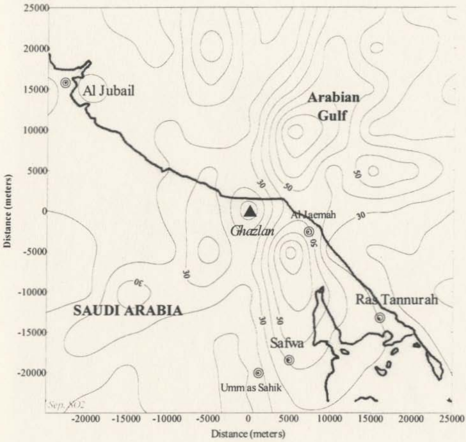

Figure 5-12, Average SO_2 Concentration Plot for the Month of September 1995.

Figure 5-12 shows the period concentration plot for the month of September. This figure shows the occurrence of higher concentrations south east and north east of the facility. The highest concentration for this period was 89 $\mu g/m^3$, and occurred 5 km, south east of the source.

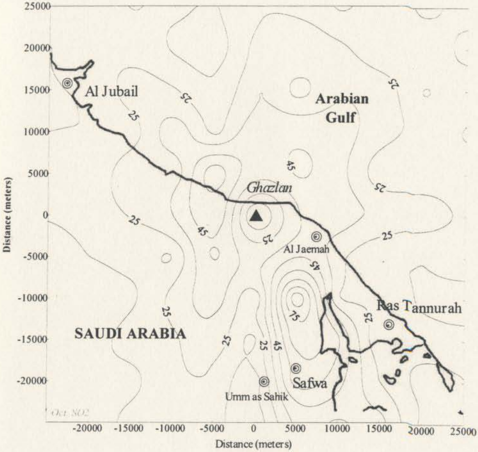

Figure 5-13, Average SO_2 Concentration Plot for the Month of October 1995.

The period concentration for the month of October is plotted in the Figure 5-13. The higher concentrations for this period were found south east of the source, the highest being 95µg/m^3 at the receptor grid (5000, -10000), south east of the source.

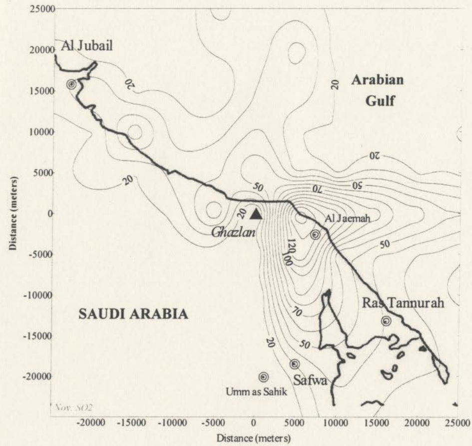

Figure 5-14, Average SO_2 Concentration Plot for the Month of November 1995.

The period concentration plot for the month of November is shown in the Figure 5-14. The higher concentrations for this period were found east and south east of the facility. The highest concentration for this period was 150 $\mu g/m^3$ and occurred 5 km east of the source.

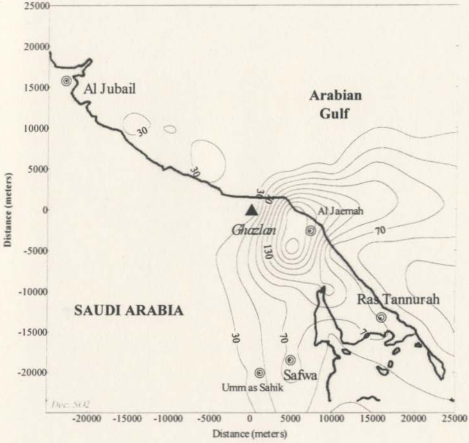

Figure 5-15, Average SO_2 Concentration Plot for the Month of December 1995.

Figure 5-15 shows the period concentrations for the month of December. It followed the pattern of the previous month, with higher concentrations found in the east and the south east of the source. The highest concentration for this period was 232 $\mu g/m^3$, found at the receptor grid (5000, -5000), south east of the facility.

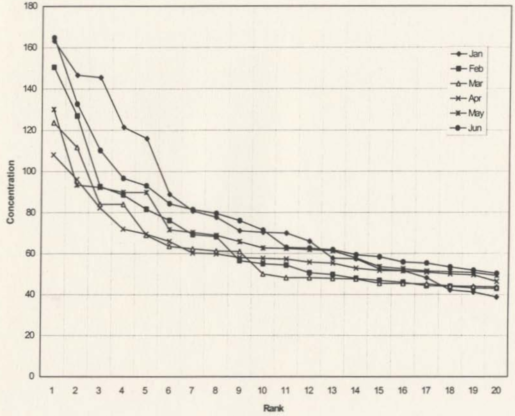

Figure 5-16, 20 Highest Monthly Concentrations ($\mu g/m^3$) for Jan-Jun 1995.

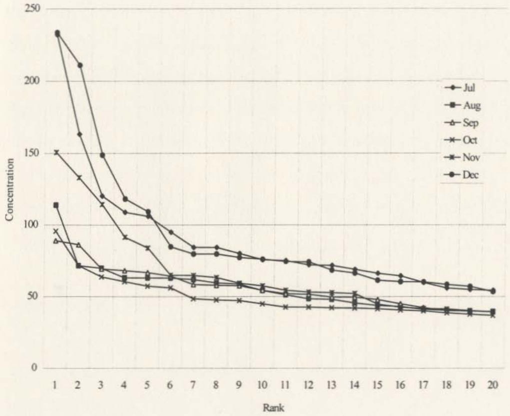

Figure 5-17, 20 Highest Monthly Concentrations ($\mu g/m^3$) for Jul-Dec 1995.

The analysis of these monthly plots clearly indicates that, most of the months followed a similar pattern, with higher concentrations found south east of the source.

5.3.1.4. Annual average concentration results

Annual average SO_2 concentration results of as a result of GPP emissions are shown in Figures 5-18 and 5-19 for the 1200 MW and 3600 MW generating capacities respectively. Figure 5-20 shows both of the plots. The 10 highest annual concentrations, along with their respective locations are shown in Tables 5-4 and 5-5 for the two generating capacities. Its obvious from Table 5-2 that only the first three values exceeded the MEPA standard of 80 $\mu g\ m^{-3}$ for the current generating capacity. For the future capacity of 3600 MW, the annual standard value was violated at forty-six out of total 121 receptor points.

Although these concentrations were estimated assuming uncontrolled emissions, it was observed that,

- only three annual concentrations violated the maximum standards at the current generating capacity.
- over ninety percent of the estimated daily averages were satisfactory for both the generating capacities.
- over ninety seven percent of hourly averages were found below the specified standard limits for both the current and the future generating capacities.

A sample run was made for the current generating capacity, assuming fifty percent reduction in SO_2 emission and the following observations were made,

- violation of the 1-hr average concentration was brought down to 6,468 (0.6% of total result values)
- 24-hr standard was exceeded only 38 times
- none of the annual average concentrations exceeded the specified standard maximum limit

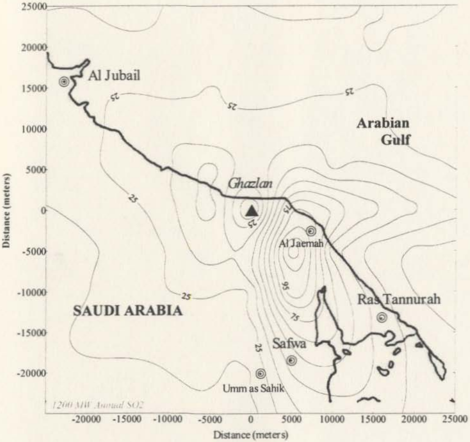

Figure 5-18, 1995 Annual SO_2 Concentration Plot for 1200 MW Generation Capacity.

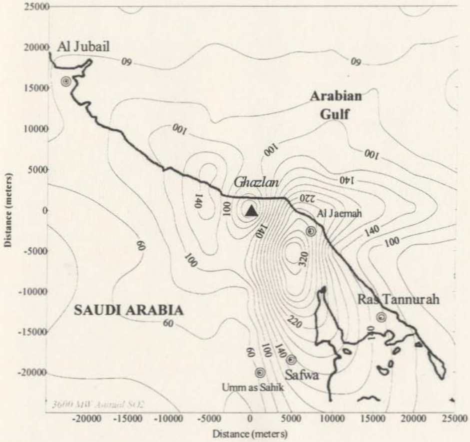

Figure 5-19, 1995 Annual SO_2 Concentration Plot for 3600 MW Generation Capacity.

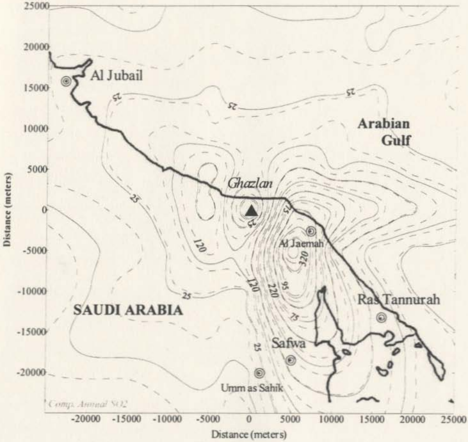

Figure 5-20, Comparison of Annual SO_2 Concentration Plots for 1200 and 3600 MW Generation Capacities.

The solid contours represent 1200 MW generation capacity, whereas the broken ones represent 3600 MW generation capacity.

Table 5-4, 10 Highest SO_2 Annual Concentrations for the Generating Capacity of 1200 MW.

Rank	Ave. Concentration ($\mu g\ m^{-3}$)	Location (X, Y, meters)
01	124.7	5000, -5000
02	104.0	5000, -10000
03	86.7	5000, 0
04	74.3	10000, 0
05	67.6	10000, -15000
06	65.6	10000, -10000
07	64.4	5000, -15000
08	58.2	15000, 0
09	52.6	10000, -20000
10	50.5	-5000, 0

Table 5-5, 10 Highest SO_2 Annual Concentrations for the Generating Capacity of 3600 MW.

Rank	Ave. Concentration ($\mu g\ m^{-3}$)	Location (X, Y, meters)
01	384.4	5000, -5000
02	321.4	5000, -10000
03	268.4	5000, 0
04	230.0	10000, 0
05	208.7	10000, -15000
06	202.4	10000, -10000
07	199.1	5000, -15000
08	180.0	15000, 0
09	162.4	10000, -20000
10	157.4	-5000, 0

5.3.2. Carbon monoxide results

The following results were generated to estimate the carbon monoxide ambient concentrations;

- 1 hour average concentrations for the year 1995
- 8 hour average concentrations for the year 1995

5.3.2.1. 1-hr average concentration results

The 1-hr average concentration results for CO are summarized in Appendix-B. These results were compared with the maximum concentration standard of 40 mg m^{-3} as specified by MEPA. None of the values exceeded the standard maximum 1-hr concentrations, the highest being as low as 84.14 and 253.3 $\mu g\ m^{-3}$ for 1200 MW and 3600 MW generation capacities respectively. Appendix-B contains the table showing maximum 1-hr estimated CO concentrations.

5.3.2.2. 8-hr average concentration results

The 8-hr average concentration values of CO at various grids of the receptor network are provided in Appendix-B. These results were also compared against the standard maximum concentration of 10 mg m^{-3} set by MEPA. None of the predicted values exceeded the limit; instead, they were very low compared to the standard limit, as the highest values were 24 and 72 $\mu g\ m^{-3}$ for the two generation capacities. The 100 highest 8-hr CO concentrations are also tabulated in Appendix-B.

5.3.3. Nitrogen oxides results

For both the scenarios, the following NO_x results were generated.

- 1 hour average concentrations for the year 1995
- Annual average concentrations for the year 1995

5.3.3.1. 1-hr average concentration results

The summary of 1-hr average concentration results of NO_x is provided in Appendix-C. These results were compared against MEPA's maximum concentration standard of 660 $\mu g\ m^{-3}$. Only six (out of 1,059,960) estimated values exceeded the specified allowable limit for the current generating capacity, whereas this limit was exceeded 1,241 times for the generating capacity of 3600 MW. Appendix-C also presents the tables showing maximum 1-hr concentrations at all the receptors.

5.3.3.2. Annual average concentration results

Annual average concentration results of NO_x as a result of GPP emissions for the two scenarios are shown in Figures 5-21 and 5-22 and both the plots are compared in Figure 5-23. These results were also compared with MEPA standard maximum 1 year NO_x concentration of 100 $\mu g\ m^{-3}$, and none of the results exceeded this limit. The 10 maximum annual concentrations, along with their respective locations are shown in Tables 5-6 and 5-7 for the two generation capacities.

The summary of NO_x concentrations as a result of GPP emissions is as follows;

- the annual average concentrations of NO_x did not exceed the specified allowable limit at any of the receptor grids. These values were found far below the standard limit, as all the generated concentrations were below 10 μg m^{-3} for the current generating capacity and for the future generating capacity the highest of the predicted concentrations was as low as 27 μg m^{-3}.
- more than ninety nine percent of 1-hr average concentration results were found within the specified regulatory limits of MEPA

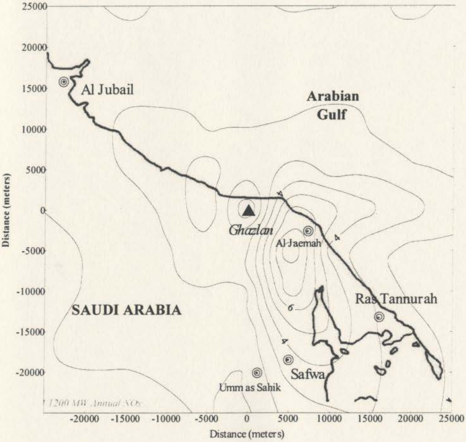

Figure 5-21, 1995 Annual NO_x Concentration Plot for 1200 MW Generation Capacity.

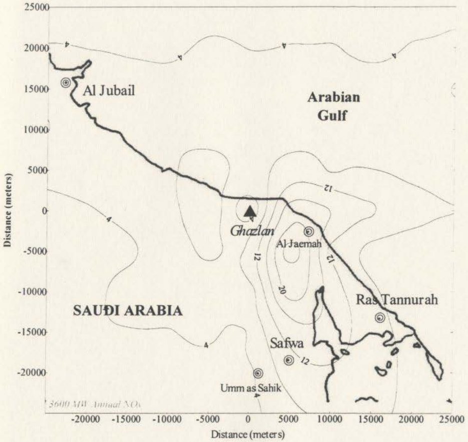

Figure 5-22, 1995 Annual NO_x Concentration Plot for 3600 MW Generation Capacity.

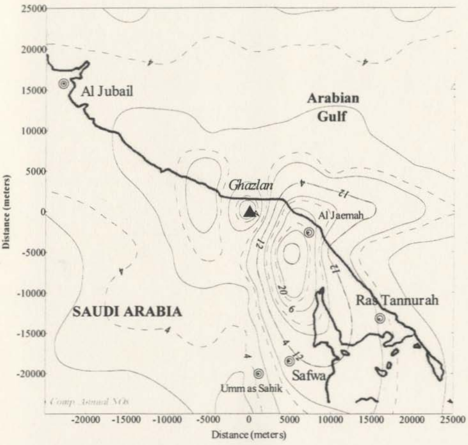

Figure 5-23, Comparison of Annual NO_x Concentration Plots for 1200 and 3600 MW Generation Capacities.

The solid contours represent 1200 MW generation capacity, whereas the broken ones represent 3600 MW generation capacity.

Table 5-6, 10 Highest NO_x Annual Concentrations for the Generating Capacity of 1200 MW.

Rank	Ave. Concentration ($\mu g\ m^{-3}$)	Location (X, Y, meters)
01	9.0	5000, -5000
02	7.6	5000, -10000
03	6.3	5000, 0
04	5.4	10000, 0
05	5.0	10000, -15000
06	4.8	10000, -10000
07	4.7	5000, -15000
08	4.2	15000, 0
09	3.8	10000, -20000
10	3.7	-5000, 0

Table 5-7, 10 Highest NO_x Annual Concentrations for the Generating Capacity of 3600 MW.

Rank	Ave. Concentration ($\mu g\ m^{-3}$)	Location (X, Y, meters)
01	27.1	5000, -5000
02	22.6	5000, -10000
03	18.8	5000, 0
04	16.1	10000, 0
05	14.7	10000, -15000
06	14.2	10000, -10000
07	14.0	5000, -15000
08	12.7	15000, 0
09	11.4	10000, -20000
10	11.0	-5000, 0

5.3.4. Particulate matter results

Ambient PM concentrations resulting from GPP emissions were simulated, and the following results were generated;

- 24 hour average concentrations for the year 1995
- Annual average concentrations for the year 1995

5.3.4.1. 24-hr average concentration results

The 24-hr average concentration results for PM were simulated and are summarized in Appendix-D. The comparison of generated results with the MEPA maximum concentration standard of 340 $\mu g\ m^{-3}$ shows there was no occurrence of violation of this limit. In other words, all the generated 24-hr values were within this limit. Also provided in Appendix-D, is the table showing maximum 24-hr concentrations of PM at all the receptor locations for both of the generation capacities.

5.3.4.2. Annual average concentration results

Figures 5-24 and 5-25 show the annual average concentration results for PM as a result of 1200 MW and 3600 MW generating capacity emissions respectively, whereas Figure 5-26 compares both of the concentration contours. Comparing the estimated annual PM concentrations with the MEPA standard of 80 $\mu g\ m^{-3}$, it was observed that all the values were far below this limit for the current as well as the future generating capacity. Tables 5-8 and 5-9, show the 10 highest particulate matter annual concentrations, along with their respective locations for the two scenarios.

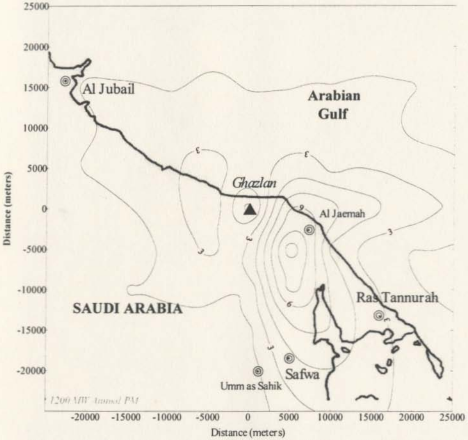

Figure 5-24, 1995 Annual PM Concentration Plot for 1200 MW Generation Capacity.

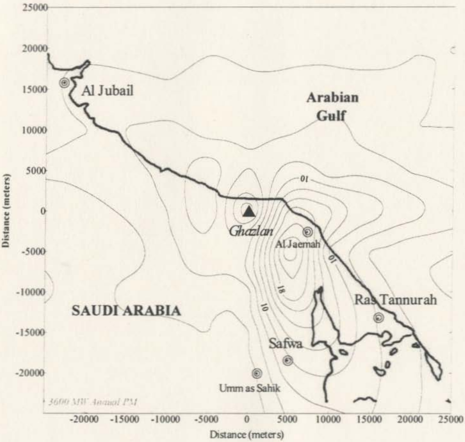

Figure 5-25, 1995 Annual PM Concentration Plot for 3600 MW Generation Capacity.

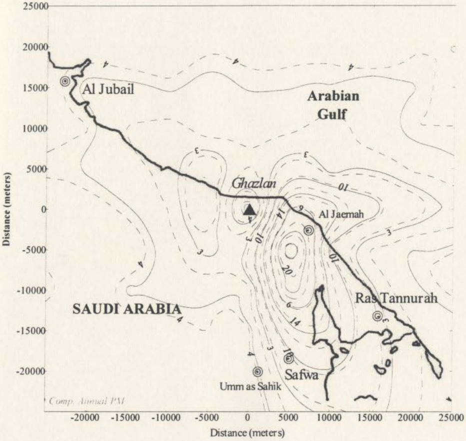

Figure 5-26, Comparison of Annual PM Concentration Plots for 1200 and 3600 MW Generation Capacities.

The solid contours represent 1200 MW generation capacity, whereas the broken ones represent 3600 MW generation capacity.

Table 5-8, 10 Highest PM Annual Concentrations for the Generating Capacity of 1200 MW.

Rank	Ave. Concentration ($\mu g\ m^{-3}$)	Location (X, Y, meters)
01	8.2	5000, -5000
02	6.8	5000, -10000
03	5.7	5000, 0
04	4.9	10000, 0
05	4.4	10000, -15000
06	4.3	10000, -10000
07	4.2	5000, -15000
08	3.8	15000, 0
09	3.5	10000, -20000
10	3.4	-5000, 0

Table 5-9, 10 Highest PM Annual Concentrations for the Generating Capacity of 3600 MW.

Rank	Ave. Concentration ($\mu g\ m^{-3}$)	Location (X, Y, meters)
01	24.2	5000, -5000
02	20.2	5000, -10000
03	16.9	5000, 0
04	14.5	10000, 0
05	13.1	10000, -15000
06	12.7	10000, -10000
07	12.5	5000, -15000
08	11.3	15000, 0
09	10.2	10000, -20000
10	9.9	-5000, 0

5.4. Analysis of the Results

The analysis of the results indicates that the pollutants of concern from the Ghazlan Power Plant were SO_2 and NO_x. The sulfur dioxide results showed exceedences for all the averaging periods for both the current and the future generating capacities, however the NO_x limits were only exceeded for the 24-hr averaging period, and there was no violation of the annual standard for both the scenarios. However, for the other two simulated pollutants, i.e. CO and PM, all the estimated concentrations were satisfactory and within the MEPA specified limits.

It was also observed that according to the concentration pattern, the higher concentrations tended to be found in the region south east of the source, where the towns of Al Jaemah, Ras Tannurah, Safwa and Umm as Sahik are located.

Besides, air pollution control equipment, the other ways to cut-back or reduce the emissions from the air pollution sources are;

- modification or change in process and/or operation routine, and
- use of alternate fuel.

5.4.1. Meteorological data analysis

In order to suggest any modification of the operation routine or use of the alternate fuel, the meteorological data of the area was analyzed and is presented in the following Tables 5-10 through 5-13.

Table 5-10, Frequency Distribution of Hourly Wind Direction ° (Towards).

Hr.	Wind Direction ° (Towards)							
	1-45	46-90	91-135	136-180	181-225	226-270	271-315	316-360
1	52	100	63	52	14	8	33	43
2	65	102	68	48	16	5	30	31
3	61	102	72	57	14	4	23	32
4	57	102	84	56	10	7	19	30
5	55	110	83	56	17	5	16	23
6	43	117	77	59	9	11	17	32
7	45	110	82	63	13	5	16	31
8	44	79	114	65	15	8	12	28
9	34	46	145	72	19	10	11	28
10	21	28	142	95	26	14	10	29
11	11	17	104	146	34	15	10	28
12	7	14	67	173	47	26	11	20
13	8	10	38	190	54	37	14	14
14	2	9	22	191	63	47	19	12
15	0	11	14	188	67	51	22	12
16	1	6	13	187	66	55	29	8
17	1	3	10	180	71	55	38	7
18	0	3	18	171	64	49	56	4
19	2	5	22	161	48	56	63	8
20	1	9	41	136	48	42	72	16
21	8	24	47	113	38	33	79	23
22	18	36	52	96	24	24	73	42
23	28	67	55	70	17	23	57	48
24	40	92	53	60	13	17	41	49
Total	604	1202	1486	2685	807	607	771	598

Table 5-11, Relative Frequency Distribution of Hourly Wind Direction ° (Towards).

Hr.	Wind Direction ° (Towards)							
	1-45	46-90	91-135	136-180	181-225	226-270	271-315	316-360
1	0.59	1.14	0.72	0.59	0.16	0.09	0.38	0.49
2	0.74	1.16	0.78	0.55	0.18	0.06	0.34	0.35
3	0.70	1.16	0.82	0.65	0.16	0.05	0.26	0.37
4	0.65	1.16	0.96	0.64	0.11	0.08	0.22	0.34
5	0.63	1.26	0.95	0.64	0.19	0.06	0.18	0.26
6	0.49	1.34	0.88	0.67	0.10	0.13	0.19	0.37
7	0.51	1.26	0.94	0.72	0.15	0.06	0.18	0.35
8	0.50	0.90	1.30	0.74	0.17	0.09	0.14	0.32
9	0.39	0.53	1.66	0.82	0.22	0.11	0.13	0.32
10	0.24	0.32	1.62	1.08	0.30	0.16	0.11	0.33
11	0.13	0.19	1.19	1.67	0.39	0.17	0.11	0.32
12	0.08	0.16	0.76	1.97	0.54	0.30	0.13	0.23
13	0.09	0.11	0.43	2.17	0.62	0.42	0.16	0.16
14	0.02	0.10	0.25	2.18	0.72	0.54	0.22	0.14
15	0.00	0.13	0.16	2.15	0.76	0.58	0.25	0.14
16	0.01	0.07	0.15	2.13	0.75	0.63	0.33	0.09
17	0.01	0.03	0.11	2.05	0.81	0.63	0.43	0.08
18	0.00	0.03	0.21	1.95	0.73	0.56	0.64	0.05
19	0.02	0.06	0.25	1.84	0.55	0.64	0.72	0.09
20	0.01	0.10	0.47	1.55	0.55	0.48	0.82	0.18
21	0.09	0.27	0.54	1.29	0.43	0.38	0.90	0.26
22	0.21	0.41	0.59	1.10	0.27	0.27	0.83	0.48
23	0.32	0.76	0.63	0.80	0.19	0.26	0.65	0.55
24	0.46	1.05	0.61	0.68	0.15	0.19	0.47	0.56
Total	6.89	13.72	16.96	30.65	9.21	6.93	8.80	6.83

Table 5-12, Frequency Distribution of Hourly Wind Speed (m/sec).

	Wind Speed Category (m/sec)									
	0-2.0		2.1-4.0		4.1-6.0		6.1-8.0		>8.0	
Hr.	Freq.	Rel. Freq. %	Freq.	Rel. Freq. %	Freq.	Rel. Freq. %	Freq.	Rel. Freq. %	Freq.	Rel. Freq. %
1	57	0.65	173	1.97	76	0.87	26	0.30	33	0.38
2	50	0.57	168	1.92	85	0.97	29	0.33	33	0.38
3	56	0.64	159	1.82	71	0.81	35	0.40	44	0.50
4	61	0.70	148	1.69	71	0.81	39	0.45	46	0.53
5	66	0.75	137	1.56	78	0.89	35	0.40	49	0.56
6	62	0.71	149	1.70	77	0.88	34	0.39	43	0.49
7	58	0.66	150	1.71	84	0.96	28	0.32	45	0.51
8	54	0.62	139	1.59	91	1.04	34	0.39	47	0.54
9	46	0.53	101	1.15	103	1.18	60	0.68	55	0.63
10	34	0.39	92	1.05	112	1.28	57	0.65	70	0.80
11	19	0.22	90	1.03	102	1.16	78	0.89	76	0.87
12	10	0.11	87	0.99	113	1.29	81	0.92	74	0.84
13	8	0.09	71	0.81	133	1.52	72	0.82	81	0.92
14	4	0.05	62	0.71	145	1.66	75	0.86	79	0.90
15	5	0.06	50	0.57	152	1.74	80	0.91	78	0.89
16	4	0.05	65	0.74	145	1.66	74	0.84	77	0.88
17	5	0.06	83	0.95	146	1.67	66	0.75	65	0.74
18	12	0.14	116	1.32	131	1.50	53	0.61	53	0.61
19	26	0.30	148	1.69	108	1.23	37	0.42	46	0.53
20	56	0.64	142	1.62	91	1.04	31	0.35	45	0.51
21	78	0.89	144	1.64	68	0.78	34	0.39	41	0.47
22	82	0.94	154	1.76	68	0.78	30	0.34	31	0.35
23	81	0.92	163	1.86	67	0.76	24	0.27	30	0.34
24	65	0.74	179	2.04	67	0.76	23	0.26	31	0.35
Total	**999**	**11.40**	**2970**	**33.90**	**2384**	**27.21**	**1135**	**12.96**	**1272**	**14.52**

Table 5-13, Joint Frequency Distribution of Wind Speed and Wind Direction.

Hr.	Dir. °	Wind Speed Category (m/s)					Total	Hr.	Dir. °	Wind Speed Category (m/s)					Total
		0-2.1	2.1-4	4.1-6	6.1-8	>8				0-2.1	2.1-4	4.1-6	6.1-8	>8	
1	0-90	14	101	36	1	0	152	7	0-90	28	90	36	0	1	155
	91-180	14	18	27	23	33	115		91-180	5	34	39	24	43	145
	181-270	8	7	7	0	0	22		181-270	5	4	6	2	1	18
	271-360	21	47	6	2	0	76		271-360	20	22	3	2	0	47
		57	**173**	**76**	**26**	**33**				**58**	**150**	**84**	**28**	**45**	
2	0-90	24	95	48	0	0	167	8	0-90	26	72	25	0	0	123
	91-180	5	26	27	25	33	116		91-180	9	40	55	31	44	179
	181-270	7	6	7	1	0	21		181-270	10	6	3	3	1	23
	271-360	14	41	3	3	0	61		271-360	9	21	8	0	2	40
		50	**168**	**85**	**29**	**33**				**54**	**139**	**91**	**34**	**47**	
3	0-90	28	98	36	1	0	163	9	0-90	13	43	22	2	0	80
	91-180	4	26	25	30	44	129		91-180	15	34	67	51	50	217
	181-270	8	3	6	1	0	18		181-270	9	12	3	4	1	29
	271-360	16	32	4	3	0	55		271-360	9	12	11	3	4	39
		56	**159**	**71**	**35**	**44**				**46**	**101**	**103**	**60**	**55**	
4	0-90	30	93	35	1	0	159	10	0-90	15	19	14	1	0	49
	91-180	10	20	29	35	45	139		91-180	10	37	77	49	64	237
	181-270	4	9	3	1	0	17		181-270	9	20	8	2	1	40
	271-360	17	26	4	2	1	50		271-360	0	16	13	5	5	39
		61	**148**	**71**	**39**	**46**				**34**	**92**	**112**	**57**	**70**	
5	0-90	36	92	35	2	0	165	11	0-90	6	11	9	2	0	28
	91-180	10	18	32	30	49	139		91-180	5	45	68	60	72	250
	181-270	6	8	6	2	0	22		181-270	4	25	14	6	0	49
	271-360	14	19	5	1	0	39		271-360	4	9	11	10	4	38
		66	**137**	**78**	**35**	**49**				**19**	**90**	**102**	**78**	**76**	
6	0-90	27	96	35	2	0	160	12	0-90	2	4	15	0	0	21
	91-180	12	20	33	29	42	136		91-180	4	35	65	65	71	240
	181-270	4	8	6	1	1	20		181-270	3	43	23	4	0	73
	271-360	19	25	3	2	0	49		271-360	1	5	10	12	3	31
		62	149	77	34	43				10	87	113	81	74	

Table 5-13, Joint Frequency Distribution of Wind Speed and Wind Direction (continued).

Hr.	Dir. °	Wind Speed Category (m/s)					Total	Hr.	Dir. °	Wind Speed Category (m/s)					Total
		0-2.1	2.1-4	4.1-6	6.1-8	>8				0-2.1	2.1-4	4.1-6	6.1-8	>8	
13	0-90	2	3	12	1	0	18	19	0-90	2	1	3	1	0	7
	91-180	2	23	70	55	78	228		91-180	6	46	54	31	46	183
	181-270	4	38	43	6	0	91		181-270	8	64	32	0	0	104
	271-360	0	7	8	10	3	28		271-360	10	37	19	5	0	71
		8	71	133	72	81				26	148	108	37	46	
14	0-90	0	3	8	0	0	11	20	0-90	5	2	3	0	0	10
	91-180	0	19	59	58	77	213		91-180	18	42	45	28	44	177
	181-270	4	34	66	5	1	110		181-270	16	47	25	1	1	90
	271-360	0	6	12	12	1	31		271-360	17	51	18	2	0	88
		4	62	145	75	79				56	142	91	31	45	
15	0-90	0	2	9	0	0	11	21	0-90	11	17	4	0	0	32
	91-180	1	12	56	56	77	202		91-180	17	42	31	30	40	160
	181-270	3	34	70	10	1	118		181-270	12	39	18	1	1	71
	271-360	1	2	17	14	0	34		271-360	38	46	15	3	0	102
		5	50	152	80	78				78	144	68	34	41	
16	0-90	0	1	6	0	0	7	22	0-90	18	29	7	0	0	54
	91-180	0	24	53	50	73	200		91-180	14	38	39	26	31	148
	181-270	2	35	72	12	0	121		181-270	11	26	10	1	0	48
	271-360	2	5	14	12	4	37		271-360	39	61	12	3	0	115
		4	65	145	74	77				82	154	68	30	31	
17	0-90	0	0	4	0	0	4	23	0-90	28	54	13	0	0	95
	91-180	1	22	63	44	60	190		91-180	11	32	32	21	29	125
	181-270	3	52	58	11	2	126		181-270	10	20	8	2	0	40
	271-360	1	9	21	11	3	45		271-360	32	57	14	1	1	105
		5	83	146	66	65				81	163	67	24	30	
18	0-90	0	0	3	0	0	3	24	0-90	21	87	22	2	0	132
	91-180	5	33	56	42	53	189		91-180	9	27	28	19	30	113
	181-270	5	56	48	4	0	113		181-270	10	13	6	1	0	30
	271-360	2	27	24	7	0	60		271-360	25	52	11	1	1	90
		12	116	131	53	53				65	179	67	23	31	
									Total	999	2970	2384	1135	1272	8760

The analysis of wind direction indicates that the prevailing wind direction is towards the south east during the hours 8 though 23, and during the remaining hours, the prevailing wind is towards the north east. The wind speed analysis shows that the highest occurrences of wind speed greater than 6.0 m/sec took places between hr 9 and hr 18. The meteorological data analysis is summarized in the following Table 5-14.

Based on above findings, it was suggested that during the hours of lower wind speed and when it was directed towards the south east, the emissions should be controlled by switching to alternate fuel, which would produce less amounts of SO_2 and NO_x. The available alternate fuel at the site is natural gas, which produces a far less amount of SO_2 and PM as compared to crude oil.

Table 5-14, Summarized Meteorological Data Analysis.

Hr.	Most Occurrences	
	Wind Speed Category (m/sec)	Wind Direction (towards-degrees)
1	2.1-4.0	0-90 N-E
2	2.1-4.0	0-90 N-E
3	2.1-4.0	0-90 N-E
4	2.1-4.0	0-90 N-E
5	2.1-4.0	0-90 N-E
6	2.1-4.0	0-90 N-E
7	2.1-4.0	0-90 N-E
8	2.1-4.0	91-180 S-E
9	4.1-6.0	91-180 S-E
10	4.1-6.0	91-180 S-E
11	4.1-6.0	91-180 S-E
12	4.1-6.0	91-180 S-E
13	4.1-6.0	91-180 S-E
14	4.1-6.0	91-180 S-E
15	4.1-6.0	91-180 S-E
16	4.1-6.0	91-180 S-E
17	4.1-6.0	91-180 S-E
18	4.1-6.0	91-180 S-E
19	2.1-4.0	91-180 S-E
20	2.1-4.0	91-180 S-E
21	2.1-4.0	91-180 S-E
22	2.1-4.0	91-180 S-E
23	2.1-4.0	91-180 S-E
24	2.1-4.0	0-90 N-E

5.5. Alternate Fuel Option

Using the natural gas as an alternate fuel to the crude oil, emissions of pollutants from thermal power generating stations can be reduced significantly. The comparison of the two fuels, using the common thermal efficiency is provided in Table 5-15.

Table 5-15, Comparison of Crude Oil and Natural Gas.

Parameters	Crude Oil	Natural Gas
Thermal Conversion Factor	18550 Btu/lb	3.91×10^{7} J/m^{3}
Fuel Consumption/Watt Energy	2.71×10^{-4} lit/hr	2.72×10^{-4} m^{3}/hr
SO_2 Emission/Watt Energy	2.17×10^{-5} kg/hr	2.6×10^{-9} kg/hr
Filterable PM Emission/Watt Energy	1.37×10^{-6} kg/hr	8.0×10^{-9} kg/hr
NO_x Emission/Watt Energy	1.79×10^{-6} kg/hr	1.22×10^{-6} kg/hr

It is evident from the above table that the difference in NO_x emissions is not significant, but the SO_2 emissions can be reduced by the order of 10^4 and the reduction in the Filterable PM is in the order of 10^3.

Based on the above discussion, concentration levels were estimated assuming the use of natural gas as the combustion fuel for the added generation capacity of 2400 MW, and another simulation was made using a variable emission rate based on the two fuels. In the later run, crude oil was selected as the combustion fuel during the hours of high wind and/or when winds were directed towards the Gulf (north east), and natural gas was employed as a source of combustion when the wind speed was low and/or the wind was directed towards the towns of Al Jaemah, Ras Tannurah, Safwa and Umm as Sahik (south east). The results thus generated in both the cases are discussed in the following section.

5.5.1. Case I. 1200MW generated using crude oil and 2400MW generated using natural gas.

5.5.1.1. SO_2 results

The 1-hr standard value exceedences were brought down from 23,271 times, when only crude oil was used as fuel, to 13,968 times when both fuels were used. Also, the 24-hr standard value violation was only 348 times as compared to 3,407 in case of crude oil only.

The annual concentration plot for SO_2 is shown in Figure 5-27, and the 10 highest concentrations along with their respective locations are provided in Table 5-16. It is obvious from Table 5-16 that the annual average concentration exceeded the standard concentration of 80$\mu g/m^3$ at only three receptors. Figure 5-27 is similar to Figure 5-18, as the annual SO_2 concentration for 1200 MW generation capacity is only slightly less than annual concentrations when 2400 MW generation using natural gas is added. This clearly demonstrates the low SO_2 level due natural gas combustion.

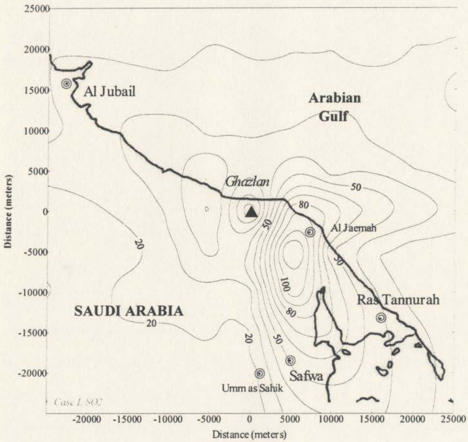

Figure 5-27, Annual SO_2 Concentrations Plot for Case I.

Table 5-16, 10 Highest SO_2 Annual Concentrations Using Crude Oil and Natural Gas.

Rank	Ave. Concentration ($\mu g\ m^{-3}$)	Location (X, Y, meters)
01	128.8	5000, -5000
02	107.4	5000, -10000
03	89.6	5000, 0
04	76.8	10000, 0
05	69.9	10000, -15000
06	67.8	10000, -10000
07	66.6	5000, -15000
08	60.2	15000, 0
09	54.3	10000, -20000
10	52.2	-5000, 0

5.5.1.2. NO_x results

1-hr average NO_x exceedences of the standard value were found only 1,010 times when crude oil and natural gas were combined, as compared to 1,241 violations for the use of crude oil only. The annual NO_x concentrations are shown in Figure 5-28 and the 10 highest annual concentrations are shown in Table 5-17. None of the annual concentration values exceeded the standard concentration of 100 $\mu g/m^3$, and the highest concentration was as low as 25 $\mu g/m^3$.

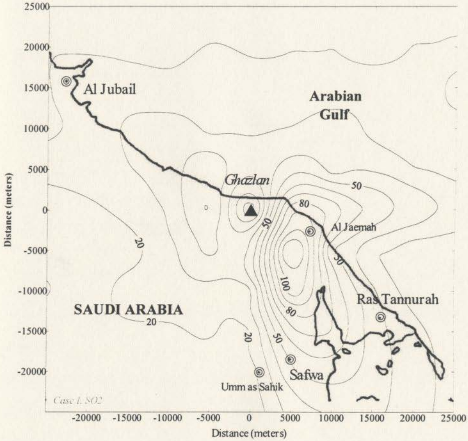

Figure 5-28, Annual NO_x Concentrations Plot for Case I.

Table 5-17, 10 Highest NO_x Annual Concentrations Using Crude Oil and Natural Gas.

Rank	Ave. Concentration ($\mu g\ m^{-3}$)	Location (X, Y, meters)
01	25.1	5000, -5000
02	20.9	5000, -10000
03	17.5	5000, 0
04	15.0	10000, 0
05	13.6	10000, -15000
06	13.2	10000, -10000
07	13.0	5000, -15000
08	11.7	15000, 0
09	10.6	10000, -20000
10	10.2	-5000, 0

5.5.2. Case II. Using alternate fuels based on the hourly meteorological data analysis.

5.5.2.1. Case II (a). Using gas during the hours when wind speed was low and directed towards south east

As shown in Table 5-14, hours 8 and 19-23 were critical when the wind speed was low and directed towards the population south east of the source. Therefore, the following simulation was based on using the natural gas as the fuel for combustion during hours 19-23, and crude oil for the rest of hours. The results thus generated are discussed in the following section.

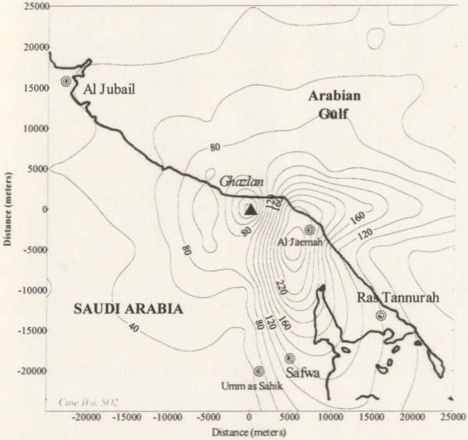

Figure 5-29, Annual SO_2 Concentrations Plot for Case II (a).

Using the routine of operation, as discussed in the previous section, i.e. using alternate fuels during different hours of operation, the annual SO_2 concentration plot is shown in Figure 5-29. It is evident from the plot that the higher concentrations occurred near the towns located south east of the source. Thus, this routine of operation did not achieve the desired results of reducing the SO_2 concentrations south east of the source.

5.5.2.2. Case II (b). Using gas during the hours of wind directed towards south east

In this simulation, natural gas was considered as the fuel for combustion during hours 8-23, when the wind was directed towards the south east and the results are presented in the following section.

Figure 5-30 shows the annual concentration plot for SO_2, using crude oil during hours 24-7, and natural gas during hours 8-23. It is obvious from this figure, that the higher concentrations were confined to a region near the source and towards the east of the source over the waters of the Arabian Gulf, and comparatively lesser concentrations were observed in the vicinities of the towns like Ras Tannurah, Safwa and Umm as Sahik. Thus, this analysis shows that changes in the operation pattern of a facility can achieve a reduction in the ambient concentrations of pollutants of concern at desired locations.

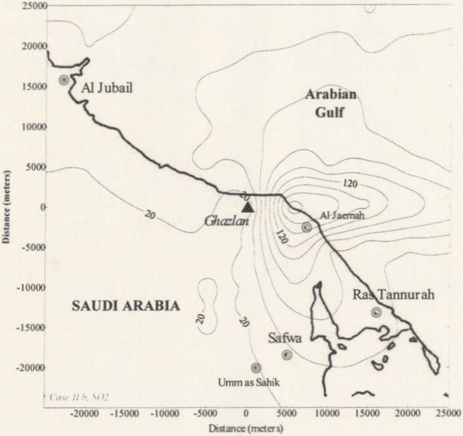

Figure 5-30, Annual SO_2 Concentrations Plot for Case II (b).

5.5.3. Case III. Using only natural gas as the combustion fuel

Switching to a less polluting fuel has been an ideal solution for many air pollution situations. It is sometimes more economical to use alternate fuel than to use air pollution control equipment, to reduce the emissions to standard regulatory limits. Thus, a simulation run was made using the natural gas as the sole fuel for generation of whole 3600 MW output. The results thus generated are discussed below.

5.5.3.1. SO_2 results

5.5.3.1.1. 1-hr average concentration results

The 1-hr average concentrations of SO_2 were estimated and compared against the standard value of 730 $\mu g/m^3$ as set by MEPA, and it was found that this standard concentration was only exceeded 1,467 times as compared to 23,271 violations, when crude oil was used as the combustion fuel.

5.5.3.1.2. 24-hr average concentration results

Comparing the 24-hr average concentration results with the MEPA standard value, only two incidences of violation of this limit were observed, whereas this limit was violated over 3,400 times, when crude oil was assumed as the combustion fuel.

5.5.3.1.3. Annual average concentration results

The annual concentration plot for SO_2 using natural gas as the fuel is shown in Figure 5-31, and the 10 highest annual concentrations are provided in Table 5-18.

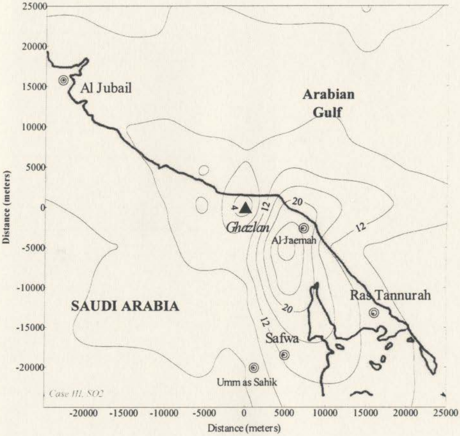

Figure 5-31, Annual SO_2 Concentrations Plot For Natural Gas Combustion

(Case III).

Table 5-18, 10 Highest SO_2 Annual Concentrations Using Natural Gas Only.

Rank	Ave. Concentration ($\mu g\ m^{-3}$)	Location (X, Y, meters)
01	31.9	5000, -5000
02	26.6	5000, -10000
03	22.2	5000, 0
04	19.0	10000, 0
05	17.3	10000, -15000
06	16.8	10000, -10000
07	16.5	5000, -15000
08	14.9	15000, 0
09	13.4	10000, -20000
10	12.9	-5000, 0

It is clear from the Figure 5-31 and Table 5-18 that when using natural gas as the combustion fuel for the power generation, the SO_2 annual concentrations were very low and acceptable when compared to the MEPA standards.

5.5.3.2. NO_x results

5.5.3.2.1. 1-hr average concentration results

1-hr average concentration results of NO_x, using natural gas as the combustion fuel were estimated and compared with the MEPA 1-hr standard of 660 $\mu g/m^3$. It was found that only 682 exceedences of this limit occurred as compared to 1,241 exceedences when crude oil was used.

5.5.3.2.2. Annual average concentration results

Figure 5-32 shows the average annual concentration plot for NO_x, and the 10 highest annual concentration values are presented in Table 5-19. It is clear from Figure 5-32 and Table 5-19 that the annual average concentrations of NO_x are very low and none of the values exceeded the standard maximum concentration of 100 $\mu g/m^3$. Also, Figure 5-32 is similar to Figure 5-21, which shows the annual NO_x concentrations using crude oil as the combustion fuel.

Table 5-19, 10 Highest NO_x Annual Concentrations Using Natural Gas Only.

Rank	Ave. Concentration ($\mu g\ m^{-3}$)	Location (X, Y, meters)
01	21.7	5000, -5000
02	18.1	5000, -10000
03	15.1	5000, 0
04	12.9	10000, 0
05	11.8	10000, -15000
06	11.4	10000, -10000
07	11.2	5000, -15000
08	10.1	15000, 0
09	9.2	10000, -20000
10	8.8	-5000, 0

Chapter 6

Conclusions and Recommendations

6.1. Conclusions

The overview of the world energy development shows that the power generation sector is growing very fast in Saudi Arabia, fulfilling the rapidly growing power demand, which will reach 65,000 MW by the year 2020. In order to assess the environmental effects of development in the energy sector in Saudi Arabia, this study simulated the ambient concentrations of different pollutants as a result of emissions from power plants in Saudi Arabia. On the basis of findings of this study, the following conclusions are drawn.

- The power generation industry in general is capable of introducing millions of tons of different pollutants into the atmosphere, if not controlled efficiently or properly. According to a rough estimate, power generation industry in Saudi Arabia, having a total generation capacity of around 20,000 MW can emit over 3 million tons of SO_2, 0.2 million tons of NO_x, and 0.2 million tons of particulate matter yearly under the uncontrolled scenario.

- The highest particulate deposition as estimated by the HYsplit4 model was 87.23 kg/km^2, the deposition near Capital City of Riyadh was estimated to be in the order of 80 kg/km^2. However the estimated particulate deposition in the Arabian Gulf was low and in the range of 2-8 kg/km^2.
- All the estimated annual SO_2 concentrations as a result of power plants' emissions in Saudi Arabia were less than the MEPA annual SO_2 standard concentration of 80μg/m^3. The highest estimated annual SO_2 concentration was 60 μg/m^3.
- The annual NO_x concentrations as estimated by HYsplit4 were very low, and far less than the MEPA annual NO_x standard of 100 μg/m^3. The highest estimated NO_x annual concentration was as low as 8.5 μg/m^3.
- PM and CO ambient concentrations as a result of Ghazlan Power Plant, as estimated by ISCST3 model were fairly low. None of the estimated concentrations for both the pollutants exceeded the MEPA standard value for any averaging period, for both the existing and the future generation capacities.
- NO_x results were fairly satisfactory. None of the estimated annual concentrations exceeded the MEPA standard value for both the generation capacities. However, estimated 1-hr average concentrations for NO_x exceeded the MEPA standard value of 660 μg/m^3 on a number of occasions. Overall, 99 percent of estimated 1-hr NO_x concentrations were within the MEPA permissible limits.
- For the current generation capacity of 1200 MW for the Ghazlan Power Plant, the estimated pollutant concentrations of all the pollutants were within the permissible

limits most of the time. Over 98 percent of the estimated 1-hr and 24-hr average concentrations of SO_2 were acceptable for this generation capacity. However, the annual average SO_2 concentration level was exceeded at three receptors out of total 121 receptors. None of the estimated annual NO_x average concentrations exceeded the allowable limit, and over 99 percent of 1-hr NO_x concentrations were within the limit.

- SO_2 was found to be the major source of concern from power plants' emissions. The estimated annual SO_2 concentrations exceeded the MEPA standard of 80 μg/m3 at over 35 percent locations for the future generation capacity of 3600 MW when using crude oil as the only fuel of combustion. However, none of the estimated SO_2 annual concentrations exceeded the MEPA standard for the same generation capacity, when natural gas was assumed to be the combustion fuel.
- 1-hr average and 24-hr average violations of the MEPA standards were also observed for both the generation capacities with crude oil as fuel of combustion. Overall, over 95 percent of the estimated values were within the permissible limits as specified by MEPA.
- The comparison of crude oil and natural gas indicated that SO_2, and PM emissions were very low for natural gas, the NO_x emissions were relatively comparable for both the fuels, whereas the CO emissions using natural gas were double the values as obtained for crude oil.
- The analysis of the meteorological data of the eastern region of Saudi Arabia showed that most of the time the wind was directed towards the southeast.

- Change in operational routine and alternate fuel options were found effective in reducing the pollutant concentrations at desired locations.

6.2. Recommendations

Finally, on basis of the findings of this study, following recommendations are made.

- Most of the time, the estimated emission levels were found to be within the regulatory permissible limits. However, uncertainty is involved in estimation because a number of assumptions were used when there was a lack of information. Therefore, for decision making purposes, a detailed study should be conducted using accurate source locations and emission inventories based on source specific data.
- Metal emissions from thermal power plants present a serious human health concern, but due to lack of information about the combustion practices and fuel characteristics, it was not possible to estimate these emissions from the power generation industry in Saudi Arabia. Therefore, this study also recommends the simulation of metal concentrations from power plant emissions followed by a detailed risk assessment to assess human health effects.
- It is also recommended that a detailed analysis using at least five years meteorological data be performed to establish trends in wind speed and wind direction. These trends can be very useful in designing altered operational routines to reduce the pollutant concentrations at the desired locations.
- The change in operational routine and the alternate fuel options were found to be effective in reducing pollutant concentrations at critical locations. Therefore, this

study also recommends a detailed investigation to determine the applicability and feasibility of introducing alternate fuel options.

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APPENDIX-A

100 Highest 1-hr SO_2 Concentrations in $\mu g/m^3$ for 1200 MW Generation Capacity Estimated by ISCST3.

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	$\mu g/m^3$	YYMMDDHH	X	Y		$\mu g/m^3$	YYMMDDHH	X	Y
1	10946.9	95011310	0	5000	41	7566.6	95070721	-25000	-5000
2	10197.8	95073011	0	-5000	42	7566.4	95053101	-25000	5000
3	9356.4	95121018	-5000	-5000	43	7551.9	95091722	-5000	20000
4	9304.4	95102408	0	5000	44	7550.9	95091723	-5000	20000
5	9270.2	95021104	5000	0	45	7531.2	95022807	5000	0
6	9168.5	95080321	-10000	-10000	46	7528.7	95051617	0	-5000
7	9065.0	95021409	5000	0	47	7515.7	95100404	5000	20000
8	9057.6	95013110	5000	0	48	7508.8	95081623	-15000	-15000
9	8802.8	95042904	-5000	15000	49	7496.6	95112801	5000	0
10	8737.7	95052021	-15000	5000	50	7496.3	95111923	-25000	-5000
11	8720.6	95121020	15000	5000	51	7459.6	95010509	5000	0
12	8711.4	95042301	-5000	-15000	52	7458.5	95043022	15000	15000
13	8704.3	95110722	-15000	-10000	53	7412.3	95050923	5000	-5000
14	8580.2	95120301	-5000	10000	54	7404.3	95031905	15000	10000
15	8523.3	95092424	-5000	-10000	55	7396.8	95070807	5000	0
16	8507.7	95091721	-5000	20000	56	7372.4	95022706	15000	15000
17	8504.3	95101122	5000	20000	57	7324.9	95080408	5000	0
18	8453.8	95042203	5000	-20000	58	7305.2	95112802	5000	0
19	8451.2	95102303	10000	15000	59	7282.9	95011508	5000	0
20	8425.8	95080321	-15000	-15000	60	7265.7	95120821	5000	-20000
21	8423.4	95120921	-15000	10000	61	7256.3	95020117	-5000	0
22	8336.5	95080322	-5000	10000	62	7247.3	95121403	5000	0
23	8291.1	95120918	-5000	5000	63	7233.2	95053024	10000	15000
24	8257.0	95081207	-5000	0	64	7222.3	95053103	-5000	-25000
25	8232.6	95081623	-10000	-10000	65	7218.8	95060422	15000	-10000
26	8190.5	95111408	5000	0	66	7213.1	95080321	-20000	-20000
27	8153.8	95043022	10000	10000	67	7184.4	95062605	10000	-10000
28	8136.3	95030508	5000	0	68	7184.3	95111821	-5000	25000
29	8025.6	95022706	10000	10000	69	7180.2	95120622	5000	0
30	7984.4	95120301	-10000	20000	70	7161.8	95042903	0	-15000
31	7960.3	95052508	0	5000	71	7159.7	95030806	-15000	-5000
32	7891.2	95092424	-10000	-20000	72	7137.1	95102110	-5000	5000
33	7690.7	95091823	-5000	20000	73	7132.1	95021604	-20000	-5000
34	7676.2	95031010	-5000	-5000	74	7129.5	95010208	5000	0
35	7663.3	95032524	-20000	-5000	75	7122.8	95032103	15000	0
36	7641.0	95122607	5000	0	76	7104.5	95060517	0	-5000
37	7622.1	95040209	5000	5000	77	7093.9	95080503	-25000	10000
38	7618.7	95080322	-10000	20000	78	7080.5	95091822	10000	25000
39	7618.4	95032111	0	-5000	79	7060.7	95060303	10000	5000
40	7590.5	95062124	-5000	10000	80	7041.6	95051208	-5000	0

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
81	7036.6	95052106	15000	20000	91	6948.6	95032103	10000	0
82	7028.2	95052104	25000	-15000	92	6912.0	95102812	0	-5000
83	7020.1	95050524	5000	-15000	93	6895.5	95041303	15000	5000
84	7012.5	95052612	-5000	0	94	6887.2	95091819	-5000	0
85	7005.0	95042903	0	-10000	95	6880.1	95032101	-5000	-25000
86	6982.1	95080922	-5000	25000	96	6858.9	95081124	-20000	15000
87	6980.0	95040218	-5000	0	97	6766.3	95041421	-15000	20000
88	6968.1	95081921	5000	25000	98	6766.2	95051118	0	-5000
89	6954.7	95013024	-25000	-15000	99	6752.8	95032423	-10000	-5000
90	6953.7	95022202	15000	20000	100	6752.6	95052608	-5000	5000

100 Highest 24-hr SO_2 Concentrations in μg/m^3 for 1200 MW Generation Capacity Estimated by ISCST3.

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
1	1703.6	95061224	5000	5000	41	724.0	95052024	-5000	0
2	1536.1	95061324	5000	5000	42	720.7	95061324	20000	15000
3	1086.0	95080824	5000	-5000	43	706.5	95032924	5000	-10000
4	1049.8	95102124	-5000	5000	44	704.9	95030524	5000	-10000
5	1034.9	95091724	-5000	20000	45	695.6	95022824	10000	0
6	981.3	95021224	5000	-5000	46	695.2	95050724	5000	-10000
7	976.7	95022824	5000	0	47	690.2	95111624	5000	-5000
8	944.4	95072424	-5000	5000	48	666.3	95111224	5000	-5000
9	932.8	95121424	5000	0	49	655.4	95070524	5000	-10000
10	917.7	95112724	5000	0	50	655.0	95052424	-15000	5000
11	908.2	95061224	25000	20000	51	650.7	95031024	-5000	0
12	902.4	95112824	5000	0	52	650.4	95101924	-5000	0
13	899.3	95122224	5000	-15000	53	648.9	95120624	5000	0
14	897.1	95070224	5000	-5000	54	639.9	95012424	10000	-15000
15	884.5	95031224	-5000	0	55	632.4	95121124	-5000	5000
16	874.2	95111324	5000	0	56	623.0	95041324	10000	0
17	873.5	95011124	-5000	5000	57	622.0	95121724	5000	-25000
18	861.1	95021124	5000	0	58	621.9	95121624	0	-5000
19	861.1	95071124	5000	-5000	59	621.3	95071624	10000	-5000
20	847.0	95061724	5000	0	60	615.3	95112824	10000	0
21	833.5	95061324	25000	20000	61	613.4	95102124	-10000	10000
22	823.5	95021524	-5000	5000	62	612.9	95123024	5000	0
23	820.0	95091724	-5000	25000	63	606.2	95122224	5000	-20000
24	810.1	95061224	10000	10000	64	605.7	95121224	5000	-5000
25	808.9	95012424	5000	-10000	65	599.2	95041324	15000	0
26	807.4	95122924	5000	-5000	66	595.7	95050824	0	-5000
27	805.9	95052024	-15000	5000	67	594.4	95011324	0	5000
28	792.2	95061224	20000	15000	68	593.5	95071324	5000	-5000
29	783.0	95110324	0	5000	69	588.9	95120924	-5000	5000
30	769.4	95083124	5000	-5000	70	585.8	95012324	5000	-5000
31	765.7	95081224	-5000	0	71	584.2	95031224	-10000	0
32	757.8	95122824	5000	-5000	72	579.5	95092324	5000	0
33	751.4	95071924	5000	-5000	73	579.5	95072424	-10000	10000
34	750.4	95111424	5000	-10000	74	574.5	95122724	5000	-5000
35	741.2	95061124	10000	-15000	75	572.3	95012724	5000	0
36	740.9	95122724	5000	0	76	570.7	95051124	0	-5000
37	739.3	95052524	0	5000	77	566.9	95090124	5000	-5000
38	732.8	95122624	5000	0	78	566.0	95121424	10000	0
39	732.5	95121724	5000	-20000	79	564.7	95011024	-5000	5000
40	728.5	95061324	10000	10000	80	563.3	95122624	5000	-5000

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
81	562.1	95011124	-5000	10000	91	545.4	95081224	-10000	-5000
82	562.0	95102424	-5000	-5000	92	545.1	95111324	10000	0
83	561.1	95120524	5000	-5000	93	541.7	95060724	0	-5000
84	559.2	95031024	-5000	-5000	94	537.1	95040424	-5000	5000
85	556.1	95061024	5000	-5000	95	536.9	95052624	-5000	5000
86	551.9	95080824	10000	-10000	96	532.6	95042924	0	-10000
87	550.3	95061724	10000	0	97	531.1	95111424	5000	0
88	550.0	95042924	0	-15000	98	531.0	95081724	10000	15000
89	549.0	95111524	5000	-5000	99	530.0	95041324	20000	0
90	547.0	95121024	15000	5000	100	529.4	95112724	10000	0

100 Highest 1-hr SO_2 Concentrations in $\mu g/m^3$ for 3600 MW Generation Capacity Estimated by ISCST3.

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
1	33779.0	95011310	0	5000	41	23348.4	95070721	-25000	-5000
2	31467.6	95073011	0	-5000	42	23347.6	95053101	-25000	5000
3	28871.1	95121018	-5000	-5000	43	23302.9	95091722	-5000	20000
4	28710.7	95102408	0	5000	44	23299.8	95091723	-5000	20000
5	28605.2	95021104	5000	0	45	23239.2	95022807	5000	0
6	28291.2	95080321	-10000	-10000	46	23231.5	95051617	0	-5000
7	27971.9	95021409	5000	0	47	23191.3	95100404	5000	20000
8	27949.1	95013110	5000	0	48	23170.1	95081623	-15000	-15000
9	27162.9	95042904	-5000	15000	49	23132.3	95112801	5000	0
10	26962.0	95052021	-15000	5000	50	23131.5	95111923	-25000	-5000
11	26909.3	95121020	15000	5000	51	23018.1	95010509	5000	0
12	26880.9	95042301	-5000	-15000	52	23014.9	95043022	15000	15000
13	26859.0	95110722	-15000	-10000	53	22872.2	95050923	5000	-5000
14	26476.1	95120301	-5000	10000	54	22847.4	95031905	15000	10000
15	26300.3	95092424	-5000	-10000	55	22824.3	95070807	5000	0
16	26252.5	95091721	-5000	20000	56	22749.1	95022706	15000	15000
17	26241.8	95101122	5000	20000	57	22602.6	95080408	5000	0
18	26086.1	95042203	5000	-20000	58	22541.9	95112802	5000	0
19	26078.1	95102303	10000	15000	59	22472.9	95011508	5000	0
20	25999.6	95080321	-15000	-15000	60	22420.0	95120821	5000	-20000
21	25992.3	95120921	-15000	10000	61	22391.0	95020117	-5000	0
22	25724.1	95080322	-5000	10000	62	22363.0	95121403	5000	0
23	25584.0	95120918	-5000	5000	63	22319.6	95053024	10000	15000
24	25478.9	95081207	-5000	0	64	22286.1	95053103	-5000	-25000
25	25403.4	95081623	-10000	-10000	65	22275.2	95060422	15000	-10000
26	25273.5	95111408	5000	0	66	22257.6	95080321	-20000	-20000
27	25160.3	95043022	10000	10000	67	22169.1	95062605	10000	-10000
28	25106.3	95030508	5000	0	68	22168.8	95111821	-5000	25000
29	24764.9	95022706	10000	10000	69	22156.1	95120622	5000	0
30	24637.4	95120301	-10000	20000	70	22099.1	95042903	0	-15000
31	24563.1	95052508	0	5000	71	22092.8	95030806	-15000	-5000
32	24350.1	95092424	-10000	-20000	72	22022.9	95102110	-5000	5000
33	23731.4	95091823	-5000	20000	73	22007.5	95021604	-20000	-5000
34	23686.6	95031010	-5000	-5000	74	21999.7	95010208	5000	0
35	23646.7	95032524	-20000	-5000	75	21978.8	95032103	15000	0
36	23577.9	95122607	5000	0	76	21922.5	95060517	0	-5000
37	23519.6	95040209	5000	5000	77	21889.8	95080503	-25000	10000
38	23509.0	95080322	-10000	20000	78	21848.5	95091822	10000	25000
39	23508.2	95032111	0	-5000	79	21787.2	95060303	10000	5000
40	23422.2	95062124	-5000	10000	80	21728.3	95051208	-5000	0

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
81	21712.9	95052106	15000	20000	91	21441.3	95032103	10000	0
82	21687.1	95052104	25000	-15000	92	21328.5	95102812	0	-5000
83	21661.9	95050524	5000	-15000	93	21277.6	95041303	15000	5000
84	21638.7	95052612	-5000	0	94	21251.8	95091819	-5000	0
85	21615.6	95042903	0	-10000	95	21230.1	95032101	-5000	-25000
86	21544.7	95080922	-5000	25000	96	21164.6	95081124	-20000	15000
87	21538.2	95040218	-5000	0	97	20878.7	95041421	-15000	20000
88	21501.6	95081921	5000	25000	98	20878.6	95051118	0	-5000
89	21460.3	95013024	-25000	-15000	99	20837.1	95032423	-10000	-5000
90	21457.1	95022202	15000	20000	100	20836.7	95052608	-5000	5000

100 Highest 24-hr SO_2 Concentrations in μg/m^3 for 360000 MW Generation Capacity Estimated by ISCST3.

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
1	5256.8	95061224	5000	5000	41	2234.2	95052024	-5000	0
2	4740.0	95061324	5000	5000	42	2223.9	95061324	20000	15000
3	3351.0	95080824	5000	-5000	43	2180.1	95032924	5000	-10000
4	3239.5	95102124	-5000	5000	44	2175.0	95030524	5000	-10000
5	3193.4	95091724	-5000	20000	45	2146.3	95022824	10000	0
6	3028.0	95021224	5000	-5000	46	2145.3	95050724	5000	-10000
7	3013.7	95022824	5000	0	47	2129.8	95111624	5000	-5000
8	2914.3	95072424	-5000	5000	48	2055.9	95111224	5000	-5000
9	2878.3	95121424	5000	0	49	2022.2	95070524	5000	-10000
10	2831.7	95112724	5000	0	50	2021.0	95052424	-15000	5000
11	2802.5	95061224	25000	20000	51	2008.0	95031024	-5000	0
12	2784.6	95112824	5000	0	52	2006.9	95101924	-5000	0
13	2775.0	95122224	5000	-15000	53	2002.4	95120624	5000	0
14	2768.3	95070224	5000	-5000	54	1974.7	95012424	10000	-15000
15	2729.4	95031224	-5000	0	55	1951.3	95121124	-5000	5000
16	2697.6	95111324	5000	0	56	1922.5	95041324	10000	0
17	2695.2	95011124	-5000	5000	57	1919.3	95121724	5000	-25000
18	2657.2	95021124	5000	0	58	1918.9	95121624	0	-5000
19	2657.0	95071124	5000	-5000	59	1917.1	95071624	10000	-5000
20	2613.6	95061724	5000	0	60	1898.7	95112824	10000	0
21	2572.0	95061324	25000	20000	61	1892.8	95102124	-10000	10000
22	2541.0	95021524	-5000	5000	62	1891.2	95123024	5000	0
23	2530.4	95091724	-5000	25000	63	1870.6	95122224	5000	-20000
24	2499.7	95061224	10000	10000	64	1869.1	95121224	5000	-5000
25	2496.0	95012424	5000	-10000	65	1848.8	95041324	15000	0
26	2491.4	95122924	5000	-5000	66	1838.3	95050824	0	-5000
27	2486.8	95052024	-15000	5000	67	1834.0	95011324	0	5000
28	2444.6	95061224	20000	15000	68	1831.4	95071324	5000	-5000
29	2416.2	95110324	0	5000	69	1817.1	95120924	-5000	5000
30	2374.3	95083124	5000	-5000	70	1807.6	95012324	5000	-5000
31	2362.9	95081224	-5000	0	71	1802.7	95031224	-10000	0
32	2338.3	95122824	5000	-5000	72	1788.2	95092324	5000	0
33	2318.5	95071924	5000	-5000	73	1788.0	95072424	-10000	10000
34	2315.4	95111424	5000	-10000	74	1772.9	95122724	5000	-5000
35	2287.2	95061124	10000	-15000	75	1766.0	95012724	5000	0
36	2286.2	95122724	5000	0	76	1760.9	95051124	0	-5000
37	2281.4	95052524	0	5000	77	1749.4	95090124	5000	-5000
38	2261.2	95122624	5000	0	78	1746.4	95121424	10000	0
39	2260.4	95121724	5000	-20000	79	1742.4	95011024	-5000	5000
40	2248.1	95061324	10000	10000	80	1738.2	95122624	5000	-5000

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
81	1734.4	95011124	-5000	10000	91	1683.0	95081224	-10000	-5000
82	1734.1	95102424	-5000	-5000	92	1682.1	95111324	10000	0
83	1731.4	95120524	5000	-5000	93	1671.4	95060724	0	-5000
84	1725.6	95031024	-5000	-5000	94	1657.5	95040424	-5000	5000
85	1715.9	95061024	5000	-5000	95	1656.8	95052624	-5000	5000
86	1703.0	95080824	10000	-10000	96	1643.3	95042924	0	-10000
87	1698.2	95061724	10000	0	97	1638.9	95111424	5000	0
88	1697.1	95042924	0	-15000	98	1636.5	95081724	10000	15000
89	1694.1	95111524	5000	-5000	99	1635.4	95041324	20000	0
90	1687.8	95121024	15000	5000	100	1633.5	95112724	10000	0

The Annual Estimated SO_2 concentrations for 1200 MW Generation Capacity.

*** THE ANNUAL (1 YRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00	0.00	5000.00	10000.00	15000.00
25000.00	14.57631	14.72235	12.03915	15.59666	15.92925	14.80939	12.83500	13.43656	16.22078
20000.00	18.98991	18.23553	16.81189	16.31591	19.92624	18.06227	19.06376	19.18331	13.58326
15000.00	19.09426	24.13053	23.98588	21.60176	25.62194	22.31474	22.53222	23.08559	26.01797
10000.00	18.16624	20.16544	31.45844	33.48673	26.01661	27.66246	29.43638	35.05722	26.64600
5000.00	22.21666	23.52409	28.63549	33.32180	49.21605	30.44574	45.61332	33.11343	37.09653
0.00	13.94482	17.22356	22.15389	30.57327	50.54785	0.00000	86.67986	74.25869	58.19814
-5000.00	11.39144	14.29245	15.48541	25.49145	41.32838	40.25508	124.64448	47.05831	29.54223
-10000.00	9.08039	14.49252	23.39981	24.87381	26.59264	25.31212	103.92630	65.58400	40.89708
-15000.00	12.91226	17.10805	17.67955	17.56712	20.95824	18.42732	64.44879	67.61648	43.83281
-20000.00	13.01995	13.53348	13.46105	14.92999	16.93817	14.34632	46.07852	52.57300	44.55052
-25000.00	10.91037	10.25016	10.48469	12.23016	14.54300	11.61623	32.29671	39.33140	41.92259

Y-COORD (METERS)	X-COORD (METERS) 20000.00	25000.00
25000.00	10.37958	16.17391
20000.00	20.07313	20.82206
15000.00	23.10549	17.86488
10000.00	20.57551	20.80808
5000.00	29.15939	24.32257
0.00	46.56077	38.12975
-5000.00	22.29671	20.74312
-10000.00	24.84217	19.79583
-15000.00	32.10969	25.23498
-20000.00	32.74016	26.69972
-25000.00	32.29094	26.09324

The Highest Three SO2 Concentrations at all Receptors for 1200 MW Generation Capacity.

*** THE 1ST HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	2432.04541 (95052606)	3435.08008 (95120919)	2991.07007 (95030903)	6138.64307 (95020302)	7184.31738 (95111821)
20000.0	6549.81689 (95060401)	2926.82568 (95052606)	6766.25879 (95041421)	7984.35449 (95120301)	8507.74316 (95091721)
15000.0	6092.47852 (95070322)	6858.90234 (95081124)	3619.82837 (95052606)	5738.08887 (95081522)	8802.77734 (95042904)
10000.0	7093.91309 (95080503)	5399.64551 (95011704)	8423.44531 (95120921)	4444.85742 (95120918)	8580.23047 (95120301)
5000.0	7566.35449 (95053101)	4629.42090 (95112221)	8737.70117 (95052021)	6457.65088 (95011704)	8291.11914 (95120918)
0.0	4785.76611 (95042824)	5486.72363 (95042824)	6098.86621 (95042824)	6166.47803 (95042824)	8257.03613 (95081707)
-5000.0	7566.61816 (95070721)	7663.29443 (95032524)	7159.69189 (95030806)	6752.77246 (95032423)	9356.36035 (95121018)
-10000.0	4240.36719 (95110723)	6120.37061 (95032423)	8704.30273 (95110722)	9168.45313 (95080321)	8523.25000 (95092424)
-15000.0	6954.71143 (95013024)	4400.95801 (95042706)	8425.80176 (95080321)	3724.17676 (95052920)	8711.40820 (95042301)
-20000.0	4352.52051 (95111921)	7213.12109 (95080321)	3515.59961 (95040122)	7891.23584 (95092424)	5436.84473 (95053103)
-25000.0	6233.70020 (95080321)	3401.63306 (95042202)	1931.16565 (95102913)	3386.79297 (95091221)	7222.33496 (95053103)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	4386.52393 (95030904)	6968.12402 (95081921)	7080.51709 (95091822)	4733.68359 (95091003)	6308.95410 (95070722)
20000.0	5044.10645 (95030904)	8504.28223 (95101122)	5284.38525 (95091622)	7036.59082 (95052106)	6350.17773 (95043022)
15000.0	5638.80127 (95030904)	6356.27930 (95053023)	8451.23340 (95102303)	7458.54590 (95043022)	3805.72656 (95091903)
10000.0	5819.36230 (95011310)	6205.97461 (95091622)	8153.81250 (95043022)	7404.25195 (95031905)	6014.23584 (95060303)
5000.0	10946.89060 (95011310)	7622.09961 (95040209)	7060.67871 (95060303)	8720.61426 (95121020)	5300.57227 (95121102)
0.0	0.00000 (00000000)	9270.20801 (95021104)	6948.57129 (95032103)	7122.75098 (95032103)	6539.03711 (95032103)
-5000.0	10197.83200 (95073011)	7412.29395 (95050923)	5593.16943 (95032105)	5272.25684 (95073121)	5855.15234 (95042605)
-10000.0	7005.03906 (95042903)	5897.05908 (95120822)	7184.43359 (95062605)	7218.80664 (95060422)	4662.60693 (95032105)
-15000.0	7161.75098 (95042903)	7020.06006 (95050524)	4292.68652 (95101904)	6374.98633 (95062605)	4512.17969 (95020206)
-20000.0	6565.87012 (95042903)	8453.82422 (95042203)	4913.18652 (95120822)	4419.14990 (95081920)	5350.64941 (95062605)
-25000.0	5784.92773 (95042903)	6218.29785 (95040123)	6240.25879 (95050523)	3787.64502 (95101904)	6296.77930 (95081920)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	5459.76123 (95043022)
20000.0	5397.36719 (95040905)
15000.0	5278.65186 (95041304)
10000.0	5082.87598 (95041303)
5000.0	3166.82910 (95082323)
0.0	5764.93066 (95032103)
-5000.0	3995.90186 (95121101)
-10000.0	5706.27539 (95032323)
-15000.0	7028.24219 (95052104)
-20000.0	5488.87891 (95080504)
-25000.0	4556.90137 (95062605)

*** THE 2ND HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	2298.91992 (95091322)	3361.61963 (95112223)	2852.78564 (95032206)	5158.05908 (95072803)	6982.06348 (95080922)
20000.0	5115.99609 (95091024)	2761.27832 (95091322)	4175.25195 (95120919)	7618.66699 (95080322)	7690.72803 (95091823)
15000.0	4515.82764 (95060402)	4846.27637 (95091821)	3412.96924 (95091322)	5453.70508 (95102503)	5297.57764 (95073006)
10000.0	5514.66748 (95070321)	4198.25195 (95060402)	6581.06543 (95062620)	4416.54346 (95052606)	8336.50000 (95080322)
5000.0	6343.35742 (95072521)	4511.29834 (95052823)	6711.90625 (95043001)	5226.00000 (95101119)	7137.06445 (95102110)
0.0	2635.99023 (95073003)	3103.01782 (95073003)	3495.49121 (95073003)	4513.58789 (95081207)	7256.33154 (95020117)
-5000.0	7496.32520 (95111923)	7132.07227 (95021604)	4845.58105 (95091223)	6676.24268 (95050610)	7676.22217 (95031010)
-10000.0	3627.25342 (95072520)	5047.49512 (95051224)	6236.31445 (95081622)	8232.57617 (95081623)	6149.13867 (95042901)
-15000.0	2668.54419 (95090821)	4089.42090 (95092521)	7508.84375 (95081623)	3598.33887 (95091621)	4261.90430 (95042902)
-20000.0	3588.19580 (95081205)	6385.22217 (95081623)	3017.42578 (95120224)	5028.37939 (95042901)	5184.94531 (95032101)
-25000.0	5485.53467 (95081623)	3231.97900 (95040122)	1837.79883 (95120912)	2989.22388 (95042301)	6880.11523 (95032101)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	4088.13208 (95030805)	5497.71973 (95100404)	3604.32861 (95062706)	4591.01709 (95020204)	3813.78662 (95060101)
20000.0	4713.78418 (95030805)	7515.70410 (95100404)	5020.74268 (95042604)	6953.70020 (95022202)	6289.52246 (95022706)
15000.0	5208.65137 (95030805)	5463.47754 (95052901)	7233.21777 (95053024)	7372.39648 (95022706)	3804.47168 (95081904)
10000.0	5758.09961 (95030904)	6126.66943 (95042604)	8025.64648 (95022706)	5910.22363 (95030706)	4011.13257 (95080424)
5000.0	9304.38281 (95102408)	5783.24805 (95112209)	5842.92773 (95113019)	6895.53418 (95041303)	4505.04395 (95080124)
0.0	0.00000 (00000000)	9064.95703 (95021409)	6521.92285 (95041223)	6560.03613 (95041223)	5957.98096 (95041223)
-5000.0	7618.40723 (95032111)	6524.46729 (95122714)	5001.58594 (95040210)	4200.27051 (95112201)	3731.39551 (95081704)
-10000.0	5776.32959 (95042906)	5080.71094 (95033111)	5416.64355 (95050601)	4064.36475 (95052104)	3616.73096 (95040404)
-15000.0	6038.10498 (95042906)	5445.98877 (95022122)	4158.04688 (95090721)	4561.32227 (95050601)	3935.21729 (95080504)
-20000.0	5564.88721 (95042906)	7265.73828 (95120821)	3634.49512 (95051323)	4076.70996 (95052902)	3747.80151 (95050601)
-25000.0	4873.80176 (95042906)	5267.15918 (95120821)	5093.01270 (95050524)	2822.61621 (95061122)	2260.16309 (95021412)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	5414.91504 (95022706)
20000.0	4820.33203 (95043005)
15000.0	3949.69092 (95051123)
10000.0	3871.80518 (95053124)
5000.0	3130.23145 (95070723)
0.0	5222.88770 (95041223)
-5000.0	3576.92090 (95051121)
-10000.0	3131.37354 (95031102)
-15000.0	3697.43555 (95040404)
-20000.0	4148.09473 (95020206)
-25000.0	3152.05151 (95050601)

*** THE 3RD HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	2071.76807 (95102504)	3231.01147 (95102824)	2653.90601 (95102503)	3888.54712 (95072801)	5669.31836 (95060103)
20000.0	2964.21924 (95070324)	2522.71631 (95043021)	4063.25000 (95081422)	6689.26660 (95062124)	7551.88184 (95091722)
15000.0	4278.27539 (95120921)	4574.23340 (95060401)	3166.09521 (95043021)	5278.09863 (95080122)	5027.87500 (95030122)
10000.0	4902.27881 (95043001)	3777.99121 (95072723)	5658.34961 (95040406)	4190.27539 (95091322)	7590.54199 (95062124)
5000.0	4079.75049 (95021606)	3195.16675 (95021606)	5525.24219 (95052403)	4925.34375 (95060402)	6752.62793 (95052608)
0.0	2258.20679 (95102024)	2675.96338 (95102024)	3180.43994 (95081207)	3904.84961 (95020117)	7041.57910 (95051208)
-5000.0	5270.87939 (95021604)	5617.71680 (95042703)	4826.40234 (95042703)	6186.74658 (95051224)	6488.51367 (95020209)
-10000.0	3001.63086 (95112220)	3865.91016 (95110723)	5731.11475 (95090520)	4836.80078 (95121018)	5454.79785 (95041402)
-15000.0	2390.52417 (95110722)	3434.09741 (95031008)	3409.87549 (95092520)	3409.80322 (95041401)	3814.71338 (95032302)
-20000.0	2984.73047 (95121018)	2742.57544 (95092520)	2985.66357 (95011613)	4309.91113 (95041402)	4196.84766 (95110423)
-25000.0	2260.60352 (95092520)	2219.33838 (95011613)	1793.99353 (95022701)	2492.23145 (95032302)	3287.79175 (95042905)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	3201.08252 (95070404)	4928.93359 (95073004)	3596.52441 (95041123)	4315.75000 (95081702)	2927.63477 (95102906)
20000.0	3740.52148 (95070404)	5614.29785 (95072904)	3399.16260 (95072902)	6718.02197 (95070722)	3343.56787 (95040422)
15000.0	4293.33008 (95070404)	4928.59766 (95072904)	5082.82910 (95052106)	4104.11523 (95040422)	3800.23438 (95040905)
10000.0	5151.82715 (95102408)	4620.48145 (95010912)	4926.01758 (95040422)	4961.41943 (95081710)	3560.58496 (95101802)
5000.0	7960.26660 (95052508)	5628.61816 (95121609)	5196.12891 (95080424)	5357.10645 (95020305)	4142.82520 (95031902)
0.0	0.00000 (00000000)	9057.58887 (95013110)	6084.17871 (95031903)	6039.66895 (95031903)	5444.73828 (95031903)
-5000.0	7528.71777 (95051617)	6332.39600 (95010714)	4520.50977 (95123012)	4042.03125 (95032323)	2880.47900 (95030406)
-10000.0	5569.41309 (95073011)	4714.51172 (95051323)	4381.05029 (95081721)	3928.16992 (95042606)	2785.11572 (95082520)
-15000.0	4064.16260 (95032320)	3536.69580 (95050609)	4136.37305 (95061123)	3597.47461 (95081721)	3820.23438 (95041501)
-20000.0	3524.44385 (95032320)	3935.37988 (95081823)	3385.72705 (95050521)	3367.14209 (95051301)	2912.29321 (95081721)
-25000.0	3016.02222 (95032320)	4741.93359 (95081822)	3544.65039 (95081104)	2516.64502 (95030907)	2244.99658 (95082222)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	2792.15234 (95040422)
20000.0	3619.36060 (95020705)
15000.0	3934.72339 (95020306)
10000.0	3842.95947 (95040721)
5000.0	2559.14600 (95092406)
0.0	4754.32031 (95031903)
-5000.0	2997.50977 (95090223)
-10000.0	2323.44580 (95071021)
-15000.0	3657.42041 (95060422)
-20000.0	3235.02002 (95052221)
-25000.0	2421.84082 (95081721)

*** THE 1ST HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	266.85434 (95102124)	235.40312 (95120924)	239.14514 (95011124)	378.11044 (95072824)	820.02856 (95091724)
20000.0	272.91220 (95060424)	328.85007 (95102124)	281.92746 (95041424)	332.68143 (95120324)	1034.89526 (95091724)
15000.0	266.17584 (95072724)	448.22473 (95110324)	428.73511 (95102124)	431.72485 (95011124)	487.31546 (95011224)
10000.0	455.96176 (95052024)	281.03830 (95051924)	524.89764 (95121124)	613.40729 (95102124)	562.07660 (95011124)
5000.0	413.19931 (95072524)	397.13358 (95051924)	805.90601 (95052024)	490.65152 (95052024)	1049.82751 (95102124)
0.0	266.30170 (95031224)	328.33258 (95031224)	422.82764 (95031224)	584.21051 (95031224)	884.53253 (95031224)
-5000.0	325.92719c(95111924)	388.51218 (95042724)	381.45163 (95030824)	545.41577c(95081224)	561.97729 (95102424)
-10000.0	242.57278c(95081224)	299.18341c(95081224)	362.69492 (95110724)	384.29663c(95081624)	458.09439 (95102324)
-15000.0	289.77963 (95013024)	367.15222 (95042724)	351.07507 (95080324)	319.68173c(95032224)	431.35767 (95042324)
-20000.0	315.12277 (95042724)	300.54672 (95080324)	314.84323 (95041324)	328.90695 (95092424)	251.60445 (95050824)
-25000.0	259.73752 (95080324)	218.39873 (95041324)	166.56006c(95032224)	204.16588 (95102324)	341.09360 (95032124)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	263.42056 (95030824)	328.88556 (95081924)	365.27521c(95091824)	339.65189 (95091024)	270.21603 (95070724)
20000.0	306.49658 (95030824)	354.34509 (95101124)	270.47351 (95072924)	303.07343 (95052124)	371.75305 (95061224)
15000.0	346.35880 (95030824)	397.51706 (95112324)	531.00970c(95081724)	514.62207 (95061224)	792.23993 (95061224)
10000.0	447.96664 (95110324)	365.75720 (95072924)	810.10083 (95061224)	457.84531 (95102824)	346.75027 (95101824)
5000.0	783.02734 (95110324)	1703.58240 (95061224)	502.47363 (95101824)	546.95844 (95121024)	320.46097 (95121024)
0.0	0.00000 (00000000)	976.67505 (95022824)	695.56561 (95022824)	599.15643 (95041324)	529.99475 (95041324)
-5000.0	621.87482 (95121624)	1085.98792 (95080824)	621.27618 (95071624)	371.52161 (95072024)	254.57184c(95042624)
-10000.0	532.55939 (95042924)	808.87787 (95012424)	551.89740 (95080824)	405.40646c(95080124)	311.28299 (95071624)
-15000.0	549.99475 (95042924)	899.31055 (95122224)	741.22125 (95061124)	360.53955 (95080824)	347.63260 (95121324)
-20000.0	505.44852 (95042924)	732.53290 (95121724)	391.02353 (95012424)	370.19705 (95012424)	267.07391 (95080824)
-25000.0	444.11386 (95042924)	621.99939 (95121724)	521.58636 (95050524)	400.39822 (95061124)	262.36581 (95081924)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	288.21945 (95061224)
20000.0	908.21564 (95061224)
15000.0	219.94398 (95041324)
10000.0	309.00516 (95121024)
5000.0	237.21863 (95121824)
0.0	457.20865 (95041324)
-5000.0	227.03044 (95100824)
-10000.0	271.67053 (95071524)
-15000.0	375.31348 (95071624)
-20000.0	300.96054 (95121324)
-25000.0	212.35539 (95080824)

*** THE 2ND HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	258.01309 (95072424)	229.60475 (95102124)	145.88808c(95032224)	294.85992 (95011224)	299.35980 (95111824)
20000.0	235.34108 (95110324)	317.73535 (95072424)	271.54022 (95031624)	317.46918 (95080324)	334.37949c(95091824)
15000.0	254.61090 (95041024)	314.64969c(95091924)	412.31741 (95072424)	265.05417 (95052724)	366.78238 (95042924)
10000.0	295.58041 (95080524)	271.54898 (95052024)	485.11691 (95110824)	579.45776 (95072424)	445.15170 (95011224)
5000.0	315.26477 (95053124)	378.83768 (95052424)	654.96405 (95052424)	462.80807 (95051924)	944.44305 (95072424)
0.0	265.50891 (95042824)	308.34805 (95042824)	364.76666c(95081224)	493.91708c(95081224)	765.74701c(95081224)
-5000.0	315.27576 (95070724)	319.30392 (95032524)	257.84592 (95042724)	483.07230 (95060324)	559.22101 (95031024)
-10000.0	187.32988 (95072524)	288.94574 (95060324)	357.11584 (95030924)	382.01889 (95080324)	371.03592 (95022624)
-15000.0	200.46678 (95030924)	291.25562 (95030924)	342.45538c(95081624)	272.94174 (95041324)	308.18222 (95032324)
-20000.0	218.07426c(95081224)	288.66473c(95081624)	209.60811 (95041524)	262.07468 (95102324)	249.80981 (95042424)
-25000.0	246.71225c(95081624)	177.03717 (95102424)	148.19835 (95022624)	172.59358 (95091224)	300.93066 (95053124)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	215.40338 (95072324)	239.14610c(95100424)	202.60712 (95010924)	330.30002c(95081724)	170.97765 (95112224)
20000.0	261.43668 (95072324)	326.77026c(95100424)	255.13530 (95091624)	290.40189 (95022224)	331.98544 (95061324)
15000.0	325.71768 (95110324)	368.30814 (95030224)	352.13474 (95102324)	460.89963 (95061324)	720.70044 (95061324)
10000.0	412.20547 (95072324)	365.04483 (95010924)	728.53540 (95061324)	438.11499 (95031924)	250.59315 (95060324)
5000.0	739.33179 (95052524)	1536.09656 (95061324)	379.37378 (95012924)	396.99915 (95021424)	264.20642 (95090224)
0.0	0.00000 (00000000)	932.78735 (95121424)	623.02148 (95041324)	516.75171 (95022824)	405.44833 (95022824)
-5000.0	595.74823 (95050824)	981.29657 (95021224)	421.77002 (95022424)	317.55301 (95071524)	189.89276 (95090224)
-10000.0	480.88132 (95120224)	750.35547 (95111424)	490.58325 (95071124)	373.80676 (95071624)	219.76093 (95082524)
-15000.0	381.29819 (95120224)	501.28952 (95112524)	639.93329 (95012424)	336.84030 (95071124)	313.36514 (95052224)
-20000.0	305.15707 (95120224)	606.20929 (95122224)	385.12024 (95111424)	321.68542 (95061124)	254.49989 (95071124)
-25000.0	249.48482 (95120224)	448.28262 (95040124)	426.49988 (95112824)	367.02005 (95012424)	239.84314 (95080824)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	256.88516 (95061324)
20000.0	833.51044 (95061324)
15000.0	192.14478 (95051124)
10000.0	263.71405 (95012924)
5000.0	227.44476 (95121024)
0.0	331.24460 (95022824)
-5000.0	204.12708 (95013024)
-10000.0	237.76152 (95032324)
-15000.0	292.84561 (95052124)
-20000.0	267.95865 (95052224)
-25000.0	203.82190 (95071124)

*** THE 3RD HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	204.86003 (95062724)	205.03206 (95031624)	138.95813 (95020724)	266.89752c(95020324)	290.91931 (95080924)
20000.0	227.55017c(95091924)	253.42210 (95062724)	240.85162 (95102124)	293.07590 (95011124)	225.44688 (95111824)
15000.0	253.87822 (95070324)	297.69766 (95121124)	325.41519 (95062724)	249.48213c(95081524)	336.60724 (95040424)
10000.0	269.72421 (95043024)	252.80560 (95072724)	372.52881 (95110324)	473.59509 (95021524)	357.50961 (95120324)
5000.0	261.58316 (95020424)	300.13995 (95052824)	480.17783 (95043024)	414.46048 (95041024)	873.45953 (95011124)
0.0	237.68881c(95081224)	288.27240c(95081224)	351.38794 (95042824)	423.24466 (95052024)	724.04462 (95052024)
-5000.0	219.61998 (95021624)	297.16968 (95021624)	232.34709c(95081224)	365.06644 (95042824)	477.40964 (95042724)
-10000.0	176.68196 (95110724)	255.01544 (95032424)	312.25058 (95042824)	326.21985 (95042724)	363.12766 (95041424)
-15000.0	169.65752 (95042824)	279.46024 (95092524)	243.75139 (95042724)	238.84575 (95041524)	282.70206 (95021824)
-20000.0	212.56981 (95030924)	189.18481 (95042724)	189.49078c(95032224)	248.46875 (95041424)	227.89302 (95032124)
-25000.0	153.07643 (95042724)	142.58754 (95022624)	144.41003 (95042024)	164.09572 (95042324)	218.14073 (95042424)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	209.94228 (95110324)	225.51306 (95073024)	195.06682 (95091724)	201.68195 (95062724)	167.15994 (95060124)
20000.0	256.36148 (95110324)	236.37073 (95072924)	218.29317c (95042624)	281.13528 (95070724)	268.21594 (95043024)
15000.0	324.56451 (95072324)	348.51587 (95103124)	346.55997 (95052124)	316.62219 (95043024)	298.93228 (95040924)
10000.0	410.04199 (95052524)	324.57199 (95022224)	371.57358 (95102924)	359.54550 (95061224)	230.30800 (95012924)
5000.0	594.35223 (95011324)	481.92752 (95061424)	342.15091 (95060624)	338.75217 (95113024)	222.76100 (95123124)
0.0	0.00000 (00000000)	917.68213 (95112724)	615.31958 (95112824)	441.22876 (95112824)	342.56833 (95112824)
-5000.0	570.66180 (95051124)	897.14862 (95070224)	415.65842 (95071524)	288.00342 (95112824)	177.68108 (95100824)
-10000.0	369.91928 (95121624)	706.51904 (95032924)	459.64563 (95021224)	330.45920 (95080824)	209.71698 (95071524)
-15000.0	273.60672 (95060524)	455.57486 (95101424)	438.72745 (95083124)	306.77628 (95070224)	235.46642 (95071924)
-20000.0	224.07051 (95060524)	494.85257 (95101424)	367.03601 (95030524)	280.62979 (95083124)	231.59633 (95070224)
-25000.0	187.10710 (95060524)	366.61380 (95050824)	319.65170 (95051324)	271.21201 (95083124)	218.64766 (95122724)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	229.88611 (95043024)
20000.0	393.70932 (95061424)
15000.0	188.25142 (95102824)
10000.0	227.55214 (95040724)
5000.0	224.65845 (95083024)
0.0	279.43851 (95112824)
-5000.0	187.62828 (95090224)
-10000.0	232.72102 (95072024)
-15000.0	214.74524c (95080124)
-20000.0	228.70329 (95080524)
-25000.0	192.57880 (95050624)

The Annual Estimated SO_2 concentrations for 1200 MW Generation Capacity.

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*** THE ANNUAL (   1 YRS) AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP: ALL      ***
    INCLUDING SOURCE(S):      01     , 02      ,

  *** NETWORK ID: 001      ;  NETWORK TYPE: GRIDCART ***

    ** CONC OF SO2       IN MICROGRAMS/M**3                    **
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Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00	0.00	5000.00	10000.00	15000.00
25000.00	44.97829	45.42892	37.14940	48.12690	49.15313	45.69754	39.60514	41.46135	50.05272
20000.00	58.59745	56.26963	51.87671	50.34621	61.48672	55.73503	58.82536	59.19423	41.91406
15000.00	58.91940	74.45988	74.01365	66.65692	79.06202	68.85697	69.52805	71.23550	80.28403
10000.00	56.05581	62.22479	97.07175	103.33049	80.27980	85.35851	90.83221	108.17645	82.22195
5000.00	68.55431	72.58868	88.36087	102.82157	151.86679	93.94679	140.74974	102.17854	114.46938
0.00	43.02974	53.14700	68.36057	94.34037	155.97621	0.00000	267.46924	229.14108	179.58284
-5000.00	35.15074	44.10240	47.78353	78.65933	127.52756	124.21580	384.61749	145.20848	91.15882
-10000.00	28.01948	44.71978	72.20510	76.75349	82.05725	78.10603	320.68637	202.37357	126.19681
-15000.00	39.84354	52.79055	54.55405	54.20712	64.67120	56.86142	198.87050	208.64510	135.25572
-20000.00	40.17585	41.76045	41.53695	46.06963	52.26633	44.26868	142.18521	162.22508	137.47011
-25000.00	33.66629	31.62908	32.35276	37.73875	44.87558	35.84443	99.65851	121.36548	129.36128

Y-COORD (METERS)	X-COORD (METERS) 20000.00	25000.00
25000.00	32.02840	49.90805
20000.00	61.93995	64.25092
15000.00	71.29691	55.12594
10000.00	63.49015	64.20781
5000.00	89.97757	75.05247
0.00	143.67325	117.65755
-5000.00	68.80128	64.00732
-10000.00	76.65582	61.08423
-15000.00	99.08131	77.86800
-20000.00	101.02696	82.38778
-25000.00	99.64063	80.51618

The Highest Three SO2 Concentrations at all Receptors for 3600 MW Generation Capacity.

*** THE 1ST HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	7504.59668 (95052606)	10599.67580 (95120919)	9229.58789 (95030903)	18942.09770 (95020302)	22168.75200 (95111821)
20000.0	20210.86330 (95060401)	9031.34863 (95052606)	20978.74020 (95041421)	24637.43550 (95120301)	26252.46480 (95091721)
15000.0	18799.64840 (95070322)	21164.61330 (95081124)	11169.75590 (95052606)	17706.10350 (95081522)	27162.85550 (95042904)
10000.0	21889.78910 (95080503)	16661.76370 (95011704)	25992.34570 (95120921)	13715.55960 (95120918)	26476.14060 (95120301)
5000.0	23347.60940 (95053101)	14285.07030 (95112221)	26962.04880 (95052021)	19926.46480 (95011704)	25584.02540 (95120918)
0.0	14767.50780 (95042824)	16930.46290 (95042824)	18819.35740 (95042824)	19027.98830 (95042824)	25478.85550 (95081207)
-5000.0	23348.42190 (95070721)	23646.73830 (95032524)	22092.76370 (95030806)	20837.12500 (95032423)	28871.05470 (95121018)
-10000.0	13084.56150 (95110723)	18885.71480 (95032423)	26858.99020 (95110722)	28291.22460 (95080321)	26300.31640 (95092424)
-15000.0	21460.25390 (95013024)	13580.09960 (95042706)	25999.61720 (95080321)	11491.74610 (95052920)	26880.91800 (95042301)
-20000.0	13430.63480 (95111921)	22257.62890 (95080321)	10848.13670 (95040122)	24350.09770 (95092424)	16776.55080 (95053103)
-25000.0	19235.41800 (95080321)	10496.46780 (95042202)	5959.02539 (95102913)	10450.67480 (95091221)	22286.06250 (95053103)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	13535.55860 (95030904)	21501.64060 (95081921)	21848.45310 (95091822)	14606.79300 (95091003)	19467.63090 (95070722)
20000.0	15564.67190 (95030904)	26241.78520 (95101122)	16306.10350 (95091622)	21712.91020 (95052106)	19594.83590 (95043022)
15000.0	17399.73050 (95030904)	19613.66020 (95053023)	26078.09180 (95102303)	23014.94140 (95043022)	11743.38480 (95091903)
10000.0	17956.89060 (95011310)	19149.86520 (95091622)	25160.33590 (95043022)	22847.40630 (95031905)	18558.21480 (95060303)
5000.0	33778.97660 (95011310)	23519.62110 (95040209)	21787.23630 (95060303)	26909.32420 (95121020)	16356.05180 (95121102)
0.0	0.00000 (00000000)	28605.21480 (95021104)	21441.30660 (95032103)	21978.77340 (95032103)	20177.60160 (95032103)
-5000.0	31467.59380 (95073011)	22872.22070 (95050923)	17258.92190 (95032105)	16268.67770 (95073121)	18067.32620 (95042605)
-10000.0	21615.55080 (95042903)	18196.63870 (95120822)	22169.10940 (95062605)	22275.17580 (95060422)	14387.47270 (95032105)
-15000.0	22099.11720 (95042903)	21661.89840 (95050524)	13246.00590 (95101904)	19671.38670 (95062605)	13923.29790 (95020206)
-20000.0	20260.39840 (95042903)	26086.08590 (95042203)	15160.69040 (95120822)	13636.23440 (95081920)	16510.57620 (95062605)
-25000.0	17850.63480 (95042903)	19187.89060 (95040123)	19255.65430 (95050523)	11687.59080 (95101904)	19430.06250 (95081920)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	16847.26170 (95043022)
20000.0	16654.73440 (95040905)
15000.0	16288.41110 (95041304)
10000.0	15684.30370 (95041303)
5000.0	9771.92969 (95082323)
0.0	17788.92970 (95032103)
-5000.0	12330.21090 (95121101)
-10000.0	17607.93750 (95032323)
-15000.0	21687.14840 (95052104)
-20000.0	16937.11330 (95080504)
-25000.0	14061.29490 (95062605)

*** THE 2ND HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	7093.80957 (95091322)	10372.99800 (95112223)	8802.88184 (95032206)	15916.29690 (95072803)	21544.65230 (95080922)
20000.0	15786.50290 (95091024)	8520.51563 (95091322)	12883.63480 (95120919)	23509.03130 (95080322)	23731.38870 (95091823)
15000.0	13934.55470 (95060402)	14954.22460 (95091821)	10531.44730 (95091322)	16828.57620 (95102503)	16346.81150 (95073006)
10000.0	17016.68750 (95070321)	12954.60550 (95060402)	20307.28910 (95062620)	13628.19140 (95052606)	25724.05660 (95080322)
5000.0	19573.78910 (95072521)	13920.57810 (95052823)	20711.02540 (95043001)	16125.94140 (95101119)	22022.94140 (95102110)
0.0	8133.91211 (95073003)	9575.02734 (95073003)	10786.08690 (95073003)	13927.64160 (95081207)	22390.96480 (95020117)
-5000.0	23131.51950 (95111923)	22007.53520 (95021604)	14952.07910 (95091223)	20600.97660 (95050610)	23686.62890 (95031010)
-10000.0	11192.66800 (95072520)	15575.12890 (95051224)	19243.48440 (95081622)	25403.37890 (95081623)	18974.48440 (95042901)
-15000.0	8234.36523 (95090821)	12618.78520 (95092521)	23170.14650 (95081623)	11103.44530 (95091621)	13151.01760 (95042902)
-20000.0	11072.14750 (95081205)	19702.97270 (95081623)	9310.91406 (95120224)	15516.14260 (95042901)	15999.25880 (95032101)
-25000.0	16926.79300 (95081623)	9972.96289 (95040122)	5670.92188 (95120912)	9223.89063 (95042301)	21230.07030 (95032101)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	12614.80760 (95030805)	16964.39260 (95100404)	11121.92870 (95062706)	14166.56640 (95020204)	11768.25590 (95060101)
20000.0	14545.39060 (95030805)	23191.31640 (95100404)	15492.57710 (95042604)	21457.13280 (95022202)	19407.66800 (95022706)
15000.0	16072.41020 (95030805)	16858.73050 (95052901)	22319.64450 (95053024)	22749.10940 (95022706)	11739.51270 (95081904)
10000.0	17767.85160 (95030904)	18905.15230 (95042604)	24764.85160 (95022706)	18237.26170 (95030706)	12377.20900 (95080424)
5000.0	28710.66800 (95102408)	17845.44920 (95112209)	18029.60550 (95113019)	21277.64840 (95041303)	13901.27930 (95080124)
0.0	0.00000 (00000000)	27971.86720 (95021409)	20124.78910 (95041223)	20242.39840 (95041223)	18384.62700 (95041223)
-5000.0	23508.23050 (95032111)	20132.64060 (95122714)	15433.46480 (95040210)	12960.83590 (95112201)	11514.02050 (95081704)
-10000.0	17824.10160 (95042906)	15677.62210 (95033111)	16714.21480 (95050601)	12541.46780 (95052104)	11160.19730 (95040404)
-15000.0	18631.86720 (95042906)	16804.76560 (95022122)	12830.54490 (95090721)	14074.93750 (95050601)	12142.95610 (95080504)
-20000.0	17171.65230 (95042906)	22419.99220 (95120821)	11215.01370 (95051323)	12579.56250 (95052902)	11564.64450 (95050601)
-25000.0	15039.15820 (95042906)	16252.94730 (95120821)	15715.58110 (95050524)	8709.78711 (95061122)	6974.21777 (95021412)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	16708.88090 (95022706)
20000.0	14874.16800 (95043005)
15000.0	12187.61820 (95051123)
10000.0	11947.28420 (95053124)
5000.0	9659.00000 (95070723)
0.0	16116.33980 (95041223)
-5000.0	11037.35550 (95051121)
-10000.0	9662.52344 (95031102)
-15000.0	11409.22950 (95040404)
-20000.0	12799.83400 (95020206)
-25000.0	9726.33105 (95050601)

*** THE 3RD HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00		-20000.00		-15000.00		-10000.00		-5000.00	
25000.0	6392.88428	(95102504)	9969.97852	(95102824)	8189.19580	(95102503)	11998.94530	(95072801)	17493.89840	(95060103)
20000.0	9146.73438	(95070324)	7784.38232	(95043021)	12538.02830	(95081422)	20641.16410	(95062124)	23302.94920	(95091722)
15000.0	13201.53520	(95120921)	14114.77730	(95060401)	9769.66602	(95043021)	16286.70510	(95080122)	15514.58500	(95030122)
10000.0	15127.03130	(95043001)	11657.80080	(95072723)	17460.05080	(95040406)	12929.99410	(95091322)	23422.24410	(95062124)
5000.0	12588.94340	(95021606)	9859.37109	(95021606)	17049.32030	(95057403)	15198.20410	(95060402)	20836.68160	(95052608)
0.0	6968.18115	(95102024)	8257.25977	(95102024)	9813.92871	(95081207)	12049.25000	(95020117)	21728.30080	(95051208)
-5000.0	16264.42870	(95021604)	17334.66990	(95042703)	14892.90040	(95042703)	19090.53130	(95051224)	20021.69920	(95020209)
-10000.0	9262.17480	(95112220)	11929.09380	(95110723)	17684.58200	(95090520)	14924.98540	(95121018)	16831.94730	(95041402)
-15000.0	7376.47461	(95110722)	10596.64360	(95031008)	10521.90230	(95092520)	10521.67770	(95041401)	11771.11620	(95032302)
-20000.0	9210.02539	(95121018)	8462.80469	(95092520)	9212.90430	(95011613)	13299.15430	(95041402)	12950.27250	(95110423)
-25000.0	6975.57617	(95092520)	6848.24414	(95011613)	5535.75146	(95022701)	7690.31396	(95032302)	10145.18550	(95042905)

Y-COORD (METERS)	X-COORD (METERS) 0.00		5000.00		10000.00		15000.00		20000.00	
25000.0	9877.62598	(95070404)	15209.28130	(95073004)	11097.84670	(95041123)	13317.17190	(95081702)	9033.84473	(95102906)
20000.0	11542.17970	(95070404)	17324.11910	(95072904)	10488.84380	(95072902)	20729.89450	(95070722)	10317.29590	(95040422)
15000.0	13247.98930	(95070404)	15208.24610	(95072904)	15684.15920	(95052106)	12664.12700	(95040422)	11726.43750	(95040905)
10000.0	15897.06640	(95102408)	14257.48630	(95010912)	15200.28320	(95040422)	15309.52250	(95081710)	10986.94820	(95101802)
5000.0	24563.10940	(95052508)	17368.30860	(95121609)	16033.76860	(95080424)	16530.50000	(95020305)	12783.57420	(95031902)
0.0	0.00000	(00000000)	27949.13280	(95013110)	1[illegible]74.03710	(95031903)	18636.69530	(95031903)	16800.90630	(95031903)
-5000.0	23231.47270	(95051617)	19539.96480	(95010714)	13949.00200	(95123012)	12472.55270	(95032323)	8888.33398	(95030406)
-10000.0	17185.61720	(95073011)	14547.63480	(95051323)	13518.66890	(95081721)	12121.21000	(95042606)	8594.07129	(95082520)
-15000.0	12540.84570	(95032320)	10913.23240	(95050609)	12763.66600	(95061123)	11100.77930	(95081721)	11788.15230	(95041501)
-20000.0	10875.42680	(95032320)	12143.45700	(95081823)	10447.38670	(95050521)	10390.03910	(95051301)	8986.50488	(95081721)
-25000.0	9306.58301	(95032320)	14632.25290	(95081822)	10937.77830	(95081104)	7765.64697	(95030907)	6927.41797	(95082222)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	8615.78516 (95040422)
20000.0	11168.31250 (95020705)
15000.0	12141.43160 (95020306)
10000.0	11858.27540 (95040721)
5000.0	7896.79346 (95092406)
0.0	14670.47270 (95031903)
-5000.0	9249.45898 (95090223)
-10000.0	7169.48975 (95071021)
-15000.0	11285.75390 (95060422)
-20000.0	9982.34766 (95052221)
-25000.0	7473.10938 (95081721)

*** THE 1ST HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)			X-COORD (METERS)		
	-25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	823.43646 (95102124)	726.38678 (95120924)	737.93359 (95011124)	1166.74060 (95072824)	2530.37402 (95091724)
20000.0	842.12909 (95060424)	1014.73749 (95102124)	869.94751 (95041424)	1026.55981 (95120324)	3193.39136 (95091724)
15000.0	821.34259 (95072724)	1383.09363 (95110324)	1322.95422 (95102124)	1332.17957 (95011124)	1503.71619 (95011224)
10000.0	1406.96765 (95052024)	867.20386 (95051924)	1619.68506 (95121124)	1892.79980 (95102124)	1734.40735 (95011124)
5000.0	1275.01489 (95072524)	1225.44080 (95051924)	2486.79565 (95052024)	1514.01013 (95052024)	3239.46704 (95102124)
0.0	821.73102 (95031224)	1013.14044 (95031224)	1304.72522 (95031224)	1802.70667 (95031224)	2729.41528 (95031224)
-5000.0	1005.71826c(95111924)	1198.83740 (95042724)	1177.05054 (95030824)	1682.99707c(95081224)	1734.10120 (95102424)
-10000.0	748.51038c(95081224)	923.19421c(95081224)	1119.17273 (95110724)	1185.82971c(95081624)	1413.54846 (95102324)
-15000.0	894.17725 (95013024)	1132.92712 (95042724)	1083.31738 (95080324)	986.44647c(95032224)	1331.04651 (95042324)
-20000.0	972.37885 (95042724)	927.40118 (95080324)	971.51617 (95041324)	1014.91290 (95092424)	776.37946 (95050824)
-25000.0	801.47577 (95080324)	673.91608 (95041324)	513.95679c(95032224)	629.99750 (95102324)	1052.51721 (95032124)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	812.84058 (95030824)	1014.84692 (95081924)	1127.13501c(95091824)	1048.06860 (95091024)	833.80957 (95070724)
20000.0	945.76093 (95030824)	1093.40771 (95101124)	834.60406 (95072924)	935.19800 (95052124)	1147.12341 (95061224)
15000.0	1068.76428 (95030824)	1226.62415 (95112324)	1638.54443c(95081724)	1587.97656 (95061224)	2444.62622 (95061224)
10000.0	1382.29688 (95110324)	1128.62219 (95072924)	2499.73950 (95061224)	1412.77979 (95102824)	1069.97205 (95101824)
5000.0	2416.19897 (95110324)	5256.76855 (95061224)	1550.48987 (95101824)	1687.75720 (95121024)	988.85101 (95121024)
0.0	0.00000 (00000000)	3013.74048 (95022824)	2146.31714 (95022824)	1848.82532 (95041324)	1635.41248 (95041324)
-5000.0	1918.92773 (95121624)	3351.04907 (95080824)	1917.08069 (95071624)	1146.40979 (95072024)	785.53595c(95042624)
-10000.0	1643.32617 (95042924)	2495.96606 (95012424)	1702.99719 (95080824)	1250.96851c(95080124)	960.53033 (95071624)
-15000.0	1697.12659 (95042924)	2775.01563 (95122224)	2287.19678 (95061124)	1112.52173 (95080824)	1072.69495 (95121324)
-20000.0	1559.66956 (95042924)	2260.38696 (95121724)	1206.58655 (95012424)	1142.32239 (95012424)	824.11359 (95080824)
-25000.0	1370.40833 (95042924)	1919.31250 (95121724)	1609.46643 (95050524)	1235.51465 (95061124)	809.58594 (95081924)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	889.36304 (95061224)
20000.0	2802.49414 (95061224)
15000.0	678.68433 (95041324)
10000.0	953.50171 (95121024)
5000.0	731.98895 (95121824)
0.0	1410.81543 (95041324)
-5000.0	700.55109 (95100824)
-10000.0	838.29767 (95071524)
-15000.0	1158.11023 (95071624)
-20000.0	928.67822 (95121324)
-25000.0	655.26807 (95080824)

*** THE 2ND HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	796.15472 (95072424)	708.49463 (95102124)	450.16895c(95032224)	909.85370 (95011224)	923.73895 (95111824)
20000.0	726.19537 (95110324)	980.44067 (95072424)	837.89551 (95031624)	979.51932 (95080324)	1031.79956c(95091824)
15000.0	785.65643 (95041024)	970.91907c(95091924)	1272.29395 (95072424)	817.88135 (95052724)	1131.78564 (95042924)
10000.0	912.07672 (95080524)	837.92267 (95052024)	1496.93213 (95110824)	1788.04114 (95072424)	1373.61084 (95011224)
5000.0	972.81708 (95053124)	1168.98486 (95052424)	2021.03186 (95052424)	1428.09326 (95051924)	2914.28149 (95072424)
0.0	819.28467 (95042824)	951.47394 (95042824)	1125.56567c(95081224)	1524.08691c(95081224)	2362.87646c(95081224)
-5000.0	972.85089 (95070724)	985.28076 (95032524)	795.63892 (95042724)	1490.62305 (95060324)	1725.59656 (95031024)
-10000.0	578.04645 (95072524)	891.60400 (95060324)	1101.95728 (95030924)	1178.80103 (95080324)	1144.91101 (95022624)
-15000.0	618.58325 (95030924)	898.73169 (95030924)	1056.71948c(95081624)	842.22021 (95041324)	950.96222 (95032324)
-20000.0	672.91479c(95081224)	890.73694c(95081624)	646.79083 (95041524)	808.68750 (95102324)	770.84180 (95042424)
-25000.0	761.28345c(95081624)	546.28607 (95102424)	457.29785 (95022624)	532.57452 (95091224)	928.58612 (95053124)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	664.67334 (95072324)	737.93658c(95100424)	625.18768 (95010924)	1019.21149c(95081724)	527.58807 (95112224)
20000.0	806.71893 (95072324)	1008.31970c(95100424)	787.27466 (95091624)	896.09723 (95022224)	1024.41199 (95061324)
15000.0	1005.07178 (95110324)	1136.49377 (95030224)	1086.58716 (95102324)	1422.20422 (95061324)	2223.87573 (95061324)
10000.0	1271.94836 (95072324)	1126.42419 (95010924)	2248.05200 (95061324)	1351.89758 (95031924)	773.25897 (95060324)
5000.0	2281.36694 (95052524)	4739.95557 (95061324)	1170.63904 (95012924)	1225.02588 (95021424)	815.26544 (95090224)
0.0	0.00000 (00000000)	2878.31543 (95121424)	1922.46619 (95041324)	1594.54797 (95022824)	1251.09753 (95022824)
-5000.0	1838.30920 (95050824)	3028.00024 (95021224)	1301.46179 (95022424)	979.87793 (95071524)	585.95483 (95090224)
-10000.0	1483.86218 (95120224)	2315.38257 (95111424)	1513.79980 (95071124)	1153.46069 (95071624)	678.11938 (95082524)
-15000.0	1176.57715 (95120224)	1546.83643 (95112524)	1974.65149 (95012424)	1039.39282 (95071124)	966.95532 (95052224)
-20000.0	941.62738 (95120224)	1870.58887 (95122224)	1188.37109 (95111424)	992.62939 (95061124)	785.31396 (95071124)
-25000.0	769.83893 (95120224)	1383.27209 (95040124)	1316.05701 (95112824)	1132.51904 (95012424)	740.08722 (95080824)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	792.67438 (95061324)
20000.0	2571.97485 (95061324)
15000.0	592.90387 (95051124)
10000.0	813.74609 (95012924)
5000.0	701.82959 (95121024)
0.0	1022.12640 (95022824)
-5000.0	629.87781 (95013024)
-10000.0	733.66406 (95032324)
-15000.0	903.63776 (95052124)
-20000.0	826.84381 (95052224)
-25000.0	628.93610 (95071124)

*** THE 3RD HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF SO2 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	632.13947 (95062724)	632.67029 (95031624)	428.78506 (95020724)	823.56946c(95020324)	897.69385 (95080924)
20000.0	702.15479c(95091924)	781.98822 (95062724)	743.19928 (95102124)	904.34845 (95011124)	695.66461 (95111824)
15000.0	783.39575 (95070324)	918.60986 (95121124)	1004.13824 (95062724)	769.83057c(95081524)	1038.67383 (95040424)
10000.0	832.29181 (95043024)	780.08588 (95072724)	1149.51746 (95110324)	1461.37939 (95021524)	1103.17249 (95120324)
5000.0	807.17072 (95020424)	926.14606 (95052824)	1481.69153 (95043024)	1278.90674 (95041024)	2695.24658 (95011124)
0.0	733.43976c(95081224)	889.52618c(95081224)	1084.28271 (95042824)	1306.01208 (95052024)	2234.19482 (95052024)
-5000.0	677.68451 (95021624)	916.98065 (95021624)	716.95654c(95081224)	1126.49072 (95042824)	1473.14978 (95042724)
-10000.0	545.19012 (95110724)	786.90479 (95032424)	963.51605 (95042824)	1006.62128 (95042724)	1120.50818 (95041424)
-15000.0	523.51459 (95042824)	862.33447 (95092524)	752.14722 (95042724)	737.00970 (95041524)	872.33771 (95021824)
-20000.0	655.92957 (95030924)	583.77026 (95042724)	584.71436c(95032224)	766.70361 (95041424)	703.21283 (95032124)
-25000.0	472.35019 (95042724)	439.98441 (95022624)	445.60815 (95042024)	506.35254 (95042324)	673.11993 (95042424)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	647.82208 (95110324)	695.86890 (95073024)	601.92047 (95091724)	622.33282 (95062724)	515.80780 (95060124)
20000.0	791.05835 (95110324)	729.37256 (95072924)	673.59033c (95042624)	867.50311 (95070724)	827.63788 (95043024)
15000.0	1001.51343 (95072324)	1075.42029 (95103124)	1069.38501 (95052124)	977.00568 (95043024)	922.41962 (95040924)
10000.0	1265.27258 (95052524)	1001.53644 (95022224)	1146.56995 (95102924)	1109.45471 (95061224)	710.66473 (95012924)
5000.0	1834.00110 (95011324)	1487.09070 (95061424)	1055.77991 (95060624)	1045.29248 (95113024)	687.37689 (95123124)
0.0	0.00000 (00000000)	2831.70508 (95112724)	1898.70032 (95112824)	1361.50562 (95112824)	1057.06787 (95112824)
-5000.0	1760.89954 (95051124)	2768.34497 (95070224)	1282.60315 (95071524)	888.69629 (95112824)	548.27295 (95100824)
-10000.0	1141.46497 (95121624)	2180.11597 (95032924)	1418.33508 (95021224)	1019.70264 (95080824)	647.12677 (95071524)
-15000.0	844.27222 (95060524)	1405.77393 (95101424)	1353.78760 (95083124)	946.62384 (95070224)	726.58221 (95071924)
-20000.0	691.41766 (95060524)	1526.97375 (95101424)	1132.56848 (95030524)	865.94336 (95083124)	714.64008 (95070224)
-25000.0	577.35895 (95060524)	1131.26538 (95050824)	986.35376 (95051324)	836.88281 (95083124)	674.68433 (95122724)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	709.36279 (95043024)
20000.0	1214.87415 (95061424)
15000.0	580.89008 (95102824)
10000.0	702.16083 (95040724)
5000.0	693.23175 (95083024)
0.0	862.26752 (95112824)
-5000.0	578.96729 (95090224)
-10000.0	718.11060 (95072024)
-15000.0	662.64252c (95080124)
-20000.0	705.71307 (95080524)
-25000.0	594.24310 (95050624)

APPENDIX-B

100 Highest 1-hr CO Concentrations in μg/m³ for 1200 MW Generation Capacity Estimated by ISCST3.

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	μg/m³	YYMMDDHH	X	Y		μg/m³	YYMMDDHH	X	Y
1	84.4	95011310	0	5000	41	58.4	95070721	-25000	-5000
2	78.7	95073011	0	-5000	42	58.4	95053101	-25000	5000
3	72.2	95121018	-5000	-5000	43	58.3	95091722	-5000	20000
4	71.8	95102408	0	5000	44	58.2	95091723	-5000	20000
5	71.5	95021104	5000	0	45	58.1	95022807	5000	0
6	70.7	95080321	-10000	-10000	46	58.1	95051617	0	-5000
7	69.9	95021409	5000	0	47	58.0	95100404	5000	20000
8	69.9	95013110	5000	0	48	57.9	95081623	-15000	-15000
9	67.9	95042904	-5000	15000	49	57.8	95112801	5000	0
10	67.4	95052021	-15000	5000	50	57.8	95111923	-25000	-5000
11	67.3	95121020	15000	5000	51	57.5	95010509	5000	0
12	67.2	95042301	-5000	-15000	52	57.5	95043022	15000	15000
13	67.1	95110722	-15000	-10000	53	57.2	95050923	5000	-5000
14	66.2	95120301	-5000	10000	54	57.1	95031905	15000	10000
15	65.8	95092424	-5000	-10000	55	57.1	95070807	5000	0
16	65.6	95091721	-5000	20000	56	56.9	95022706	15000	15000
17	65.6	95101122	5000	20000	57	56.5	95080408	5000	0
18	65.2	95042203	5000	-20000	58	56.4	95112802	5000	0
19	65.2	95102303	10000	15000	59	56.2	95011508	5000	0
20	65.0	95080321	-15000	-15000	60	56.0	95120821	5000	-20000
21	65.0	95120921	-15000	10000	61	56.0	95020117	-5000	0
22	64.3	95080322	-5000	10000	62	55.9	95121403	5000	0
23	64.0	95120918	-5000	5000	63	55.8	95053024	10000	15000
24	63.7	95081207	-5000	0	64	55.7	95053103	-5000	-25000
25	63.5	95081623	-10000	-10000	65	55.7	95060422	15000	-10000
26	63.2	95111408	5000	0	66	55.6	95080321	-20000	-20000
27	62.9	95043022	10000	10000	67	55.4	95062605	10000	-10000
28	62.8	95030508	5000	0	68	55.4	95111821	-5000	25000
29	61.9	95022706	10000	10000	69	55.4	95120622	5000	0
30	61.6	95120301	-10000	20000	70	55.2	95042903	0	-15000
31	61.4	95052508	0	5000	71	55.2	95030806	-15000	-5000
32	60.9	95092424	-10000	-20000	72	55.1	95102110	-5000	5000
33	59.3	95091823	-5000	20000	73	55.0	95021604	-20000	-5000
34	59.2	95031010	-5000	-5000	74	55.0	95010208	5000	0
35	59.1	95032524	-20000	-5000	75	54.9	95032103	15000	0
36	58.9	95122607	5000	0	76	54.8	95060517	0	-5000
37	58.8	95040209	5000	5000	77	54.7	95080503	-25000	10000
38	58.8	95080322	-10000	20000	78	54.6	95091822	10000	25000
39	58.8	95032111	0	-5000	79	54.5	95060303	10000	5000
40	58.6	95062124	-5000	10000	80	54.3	95051208	-5000	0

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	μg/m³	YYMMDDHH	X	Y		μg/m³	YYMMDDHH	X	Y
81	54.3	95052106	15000	20000	91	53.6	95032103	10000	0
82	54.2	95052104	25000	-15000	92	53.3	95102812	0	-5000
83	54.2	95050524	5000	-15000	93	53.2	95041303	15000	5000
84	54.1	95052612	-5000	0	94	53.1	95091819	-5000	0
85	54.0	95042903	0	-10000	95	53.1	95032101	-5000	-25000
86	53.9	95080922	-5000	25000	96	52.9	95081124	-20000	15000
87	53.8	95040218	-5000	0	97	52.2	95041421	-15000	20000
88	53.8	95081921	5000	25000	98	52.2	95051118	0	-5000
89	53.7	95013024	-25000	-15000	99	52.1	95032423	-10000	-5000
90	53.6	95022202	15000	20000	100	52.1	95052608	-5000	5000

100 Highest 8-hr CO Concentrations in μg/m³ for 1200 MW Generation Capacity Estimated by ISCST3.

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	μg/m³	YYMMDDHH	X	Y		μg/m³	YYMMDDHH	X	Y
1	24.0	95091724	-5000	20000	41	12.1	95011216	0	5000
2	22.4	95022808	5000	0	42	12.1	95050524	10000	-25000
3	21.6	95121408	5000	0	43	11.9	95112808	10000	0
4	20.5	95112708	5000	0	44	11.8	95111408	5000	0
5	19.9	95021108	5000	0	45	11.8	95022808	15000	0
6	19.6	95061708	5000	0	46	11.7	95021216	5000	-5000
7	19.1	95111308	5000	0	47	11.7	95042908	0	-20000
8	19.1	95112808	5000	0	48	11.6	95101808	10000	5000
9	19.0	95091724	-5000	25000	49	11.6	95122216	5000	-15000
10	16.7	95072416	-5000	5000	50	11.5	95032916	5000	-10000
11	16.6	95011124	-5000	5000	51	11.4	95111624	5000	-5000
12	15.9	95110316	0	5000	52	11.4	95112708	10000	0
13	15.9	95061216	5000	5000	53	11.4	95111308	10000	0
14	15.9	95022808	10000	0	54	11.3	95021108	10000	0
15	15.1	95101916	-5000	0	55	11.2	95061224	5000	5000
16	15.0	95120624	5000	0	56	11.2	95121224	5000	-5000
17	14.5	95061124	10000	-15000	57	11.2	95061408	5000	5000
18	14.4	95041308	10000	0	58	11.1	95071116	5000	-5000
19	14.4	95121624	0	-5000	59	11.0	95030516	5000	-10000
20	13.9	95041308	15000	0	60	11.0	95052608	-5000	5000
21	13.8	95122824	5000	-5000	61	10.9	95081716	0	-5000
22	13.8	95011316	0	5000	62	10.8	95030508	5000	0
23	13.6	95120924	-5000	5000	63	10.6	95081208	-5000	0
24	13.4	95092308	5000	0	64	10.6	95102808	15000	10000
25	13.1	95071924	5000	-5000	65	10.6	95110824	-15000	10000
26	13.1	95121408	10000	0	66	10.6	95011508	5000	0
27	12.9	95061316	5000	5000	67	10.6	95041308	25000	0
28	12.9	95102124	-5000	5000	68	10.5	95051124	0	-5000
29	12.7	95061708	10000	0	69	10.5	95092308	10000	0
30	12.7	95042908	0	-15000	70	10.4	95062724	-5000	5000
31	12.7	95012708	5000	0	71	10.4	95010708	5000	0
32	12.5	95060724	0	-5000	72	10.4	95080808	5000	-5000
33	12.3	95042908	0	-10000	73	10.3	95061308	5000	5000
34	12.3	95061208	5000	5000	74	10.3	95042908	0	-25000
35	12.3	95061324	5000	5000	75	10.3	95011208	-5000	10000
36	12.3	95121116	-5000	5000	76	10.1	95031908	15000	10000
37	12.3	95041308	20000	0	77	10.1	95111424	5000	-10000
38	12.2	95061916	5000	-5000	78	10.0	95070516	5000	-10000
39	12.2	95031224	-5000	0	79	9.9	95010708	10000	0
40	12.2	95052016	-5000	0	80	9.9	95102324	-5000	-10000

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	μg/m³	YYMMDDHH	X	Y		μg/m³	YYMMDDHH	X	Y
81	9.8	95073016	0	-5000	91	9.6	95080908	5000	-5000
82	9.8	95062724	-10000	10000	92	9.6	95072524	-25000	5000
83	9.8	95011516	5000	-5000	93	9.6	95122924	5000	-5000
84	9.8	95073116	5000	-5000	94	9.5	95122716	5000	0
85	9.8	95062308	5000	-5000	95	9.3	95012508	10000	0
86	9.8	95121108	-15000	10000	96	9.3	95051224	-5000	-5000
87	9.7	95083124	5000	-5000	97	9.3	95022808	20000	0
88	9.7	95011016	-5000	5000	98	9.3	95122608	5000	0
89	9.6	95060524	0	-5000	99	9.3	95071208	5000	-5000
90	9.6	95020216	-5000	-5000	100	9.2	95021408	15000	5000

100 Highest 1-hr CO Concentrations in $\mu g/m^3$ for 3600 MW Generation Capacity Estimated by ISCST3.

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	$\mu g/m^3$	YYMMDDHH	X	Y		$\mu g/m^3$	YYMMDDHH	X	Y
1	253.3	95011310	0	5000	41	175.1	95070721	-25000	-5000
2	236.0	95073011	0	-5000	42	175.1	95053101	-25000	5000
3	216.5	95121018	-5000	-5000	43	174.8	95091722	-5000	20000
4	215.3	95102408	0	5000	44	174.7	95091723	-5000	20000
5	214.5	95021104	5000	0	45	174.3	95022807	5000	0
6	212.2	95080321	-10000	-10000	46	174.2	95051617	0	-5000
7	209.8	95021409	5000	0	47	173.9	95100404	5000	20000
8	209.6	95013110	5000	0	48	173.8	95081623	-15000	-15000
9	203.7	95042904	-5000	15000	49	173.5	95112801	5000	0
10	202.2	95052021	-15000	5000	50	173.5	95111923	-25000	-5000
11	201.8	95121020	15000	5000	51	172.6	95010509	5000	0
12	201.6	95042301	-5000	-15000	52	172.6	95043022	15000	15000
13	201.4	95110722	-15000	-10000	53	171.5	95050923	5000	-5000
14	198.6	95120301	-5000	10000	54	171.4	95031905	15000	10000
15	197.3	95092424	-5000	-10000	55	171.2	95070807	5000	0
16	196.9	95091721	-5000	20000	56	170.6	95022706	15000	15000
17	196.8	95101122	5000	20000	57	169.5	95080408	5000	0
18	195.6	95042203	5000	-20000	58	169.1	95112802	5000	0
19	195.6	95102303	10000	15000	59	168.5	95011508	5000	0
20	195.0	95080321	-15000	-15000	60	168.1	95120821	5000	-20000
21	194.9	95120921	-15000	10000	61	167.9	95020117	-5000	0
22	192.9	95080322	-5000	10000	62	167.7	95121403	5000	0
23	191.9	95120918	-5000	5000	63	167.4	95053024	10000	15000
24	191.1	95081207	-5000	0	64	167.1	95053103	-5000	-25000
25	190.5	95081623	-10000	-10000	65	167.1	95060422	15000	-10000
26	189.6	95111408	5000	0	66	166.9	95080321	-20000	-20000
27	188.7	95043022	10000	10000	67	166.3	95062605	10000	-10000
28	188.3	95030508	5000	0	68	166.3	95111821	-5000	25000
29	185.7	95022706	10000	10000	69	166.2	95120622	5000	0
30	184.8	95120301	-10000	20000	70	165.7	95042903	0	-15000
31	184.2	95052508	0	5000	71	165.7	95030806	-15000	-5000
32	182.6	95092424	-10000	-20000	72	165.2	95102110	-5000	5000
33	178.0	95091823	-5000	20000	73	165.1	95021604	-20000	-5000
34	177.6	95031010	-5000	-5000	74	165.0	95010208	5000	0
35	177.4	95032524	-20000	-5000	75	164.8	95032103	15000	0
36	176.8	95122607	5000	0	76	164.4	95060517	0	-5000
37	176.4	95040209	5000	5000	77	164.2	95080503	-25000	10000
38	176.3	95080322	-10000	20000	78	163.9	95091822	10000	25000
39	176.3	95032111	0	-5000	79	163.4	95060303	10000	5000
40	175.7	95062124	-5000	10000	80	163.0	95051208	-5000	0

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	µg/m³	YYMMDDHH	X	Y		µg/m³	YYMMDDHH	X	Y
81	162.8	95052106	15000	20000	91	160.8	95032103	10000	0
82	162.7	95052104	25000	-15000	92	160.0	95102812	0	-5000
83	162.5	95050524	5000	-15000	93	159.6	95041303	15000	5000
84	162.3	95052612	-5000	0	94	159.4	95091819	-5000	0
85	162.1	95042903	0	-10000	95	159.2	95032101	-5000	-25000
86	161.6	95080922	-5000	25000	96	158.7	95081124	-20000	15000
87	161.5	95040218	-5000	0	97	156.6	95041421	-15000	20000
88	161.3	95081921	5000	25000	98	156.6	95051118	0	-5000
89	161.0	95013024	-25000	-15000	99	156.3	95032423	-10000	-5000
90	160.9	95022202	15000	20000	100	156.3	95052608	-5000	5000

100 Highest 8-hr CO Concentrations in μg/m^3 for 3600 MW Generation Capacity Estimated by ISCST3.

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	μg/m^3	YYMMDDHH	X	Y		μg/m^3	YYMMDDHH	X	Y
1	71.9	95091724	-5000	20000	41	36.2	95011216	0	5000
2	67.1	95022808	5000	0	42	36.2	95050524	10000	-25000
3	64.8	95121408	5000	0	43	35.7	95112808	10000	0
4	61.5	95112708	5000	0	44	35.4	95111408	5000	0
5	59.8	95021108	5000	0	45	35.4	95022808	15000	0
6	58.8	95061708	5000	0	46	35.2	95021216	5000	-5000
7	57.4	95111308	5000	0	47	35.1	95042908	0	-20000
8	57.3	95112808	5000	0	48	34.9	95101808	10000	5000
9	56.9	95091724	-5000	25000	49	34.7	95122216	5000	-15000
10	50.1	95072416	-5000	5000	50	34.5	95032916	5000	-10000
11	49.8	95011124	-5000	5000	51	34.3	95111624	5000	-5000
12	47.7	95110316	0	5000	52	34.3	95112708	10000	0
13	47.6	95061216	5000	5000	53	34.1	95111308	10000	0
14	47.6	95022808	10000	0	54	33.8	95021108	10000	0
15	45.2	95101916	-5000	0	55	33.7	95061224	5000	5000
16	45.1	95120624	5000	0	56	33.6	95121224	5000	-5000
17	43.6	95061124	10000	-15000	57	33.5	95061408	5000	5000
18	43.3	95041308	10000	0	58	33.4	95071116	5000	-5000
19	43.2	95121624	0	-5000	59	33.1	95030516	5000	-10000
20	41.6	95041308	15000	0	60	33.0	95052608	-5000	5000
21	41.3	95122824	5000	-5000	61	32.7	95081716	0	-5000
22	41.3	95011316	0	5000	62	32.4	95030508	5000	0
23	40.9	95120924	-5000	5000	63	31.8	95081208	-5000	0
24	40.2	95092308	5000	0	64	31.8	95102808	15000	10000
25	39.4	95071924	5000	-5000	65	31.8	95110824	-15000	10000
26	39.3	95121408	10000	0	66	31.8	95011508	5000	0
27	38.8	95061316	5000	5000	67	31.7	95041308	25000	0
28	38.8	95102124	-5000	5000	68	31.6	95051124	0	-5000
29	38.2	95061708	10000	0	69	31.4	95092308	10000	0
30	38.2	95042908	0	-15000	70	31.2	95062724	-5000	5000
31	38.0	95012708	5000	0	71	31.2	95010708	5000	0
32	37.6	95060724	0	-5000	72	31.1	95080808	5000	-5000
33	37.0	95042908	0	-10000	73	30.9	95061308	5000	5000
34	37.0	95061208	5000	5000	74	30.8	95042908	0	-25000
35	36.9	95061324	5000	5000	75	30.8	95011208	-5000	10000
36	36.9	95121116	-5000	5000	76	30.4	95031908	15000	10000
37	36.8	95041308	20000	0	77	30.3	95111424	5000	-10000
38	36.6	95061916	5000	-5000	78	30.0	95070516	5000	-10000
39	36.5	95031224	-5000	0	79	29.8	95010708	10000	0
40	36.5	95052016	-5000	0	80	29.6	95102324	-5000	-10000

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	$\mu g/m^3$	YYMMDDHH	X	Y		$\mu g/m^3$	YYMMDDHH	X	Y
81	29.5	95073016	0	-5000	91	28.7	95080908	5000	-5000
82	29.4	95062724	-10000	10000	92	28.7	95072524	-25000	5000
83	29.4	95011516	5000	-5000	93	28.7	95122924	5000	-5000
84	29.4	95073116	5000	-5000	94	28.4	95122716	5000	0
85	29.3	95062308	5000	-5000	95	28.0	95012508	10000	0
86	29.3	95121108	-15000	10000	96	27.9	95051224	-5000	-5000
87	29.0	95083124	5000	-5000	97	27.8	95022808	20000	0
88	29.0	95011016	-5000	5000	98	27.8	95122608	5000	0
89	28.9	95060524	0	-5000	99	27.8	95071208	5000	-5000
90	28.8	95020216	-5000	-5000	100	27.6	95021408	15000	5000

The Annual Estimated CO concentrations for 1200 MW Generation Capacity.

*** THE ANNUAL (1 YRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00	0.00	5000.00	10000.00	15000.00
25000.00	0.11245	0.11357	0.09287	0.12032	0.12288	0.11424	0.09901	0.10365	0.12513
20000.00	0.14649	0.14067	0.12969	0.12587	0.15372	0.13934	0.14706	0.14799	0.10479
15000.00	0.14730	0.18615	0.18503	0.16664	0.19765	0.17214	0.17382	0.17809	0.20071
10000.00	0.14014	0.15556	0.24268	0.25833	0.20070	0.21340	0.22708	0.27044	0.20555
5000.00	0.17139	0.18147	0.22090	0.25705	0.37967	0.23487	0.35187	0.25545	0.28617
0.00	0.10757	0.13287	0.17090	0.23585	0.38994	0.00000	0.66867	0.57285	0.44896
-5000.00	0.08788	0.11026	0.11946	0.19665	0.31882	0.31054	0.96154	0.36302	0.22790
-10000.00	0.07005	0.11180	0.18051	0.19188	0.20514	0.19526	0.80172	0.50593	0.31549
-15000.00	0.09961	0.13198	0.13639	0.13552	0.16168	0.14215	0.49718	0.52161	0.33814
-20000.00	0.10044	0.10440	0.10384	0.11517	0.13067	0.11067	0.35546	0.40556	0.34367
-25000.00	0.08417	0.07907	0.08088	0.09435	0.11219	0.08961	0.24915	0.30341	0.32340

Y-COORD (METERS)	X-COORD (METERS) 20000.00	25000.00
25000.00	0.08007	0.12477
20000.00	0.15485	0.16063
15000.00	0.17824	0.13781
10000.00	0.15873	0.16052
5000.00	0.22494	0.18763
0.00	0.35918	0.29414
-5000.00	0.17200	0.16002
-10000.00	0.19164	0.15271
-15000.00	0.24770	0.19467
-20000.00	0.25257	0.20597
-25000.00	0.24910	0.20129

The Highest Three CO Concentrations at all Receptors for 1200 MW Generation Capacity.

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*** THE   1ST HIGHEST  1-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL     ***
    INCLUDING SOURCE(S):      01      , 02      ,

*** NETWORK ID: 001      ;  NETWORK TYPE: GRIDCART ***

** CONC OF CO      IN MICROGRAMS/M**3                 **
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Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	18.76149 (95052606)	26.49919 (95120919)	23.07397 (95030903)	47.35525 (95020302)	55.42188 (95111821)
20000.0	50.52716 (95060401)	22.57837 (95052606)	52.19685 (95041421)	61.59359 (95120301)	65.63116 (95091721)
15000.0	46.99912 (95070322)	52.91153 (95081124)	27.92439 (95052606)	44.26526 (95081522)	67.90714 (95042904)
10000.0	54.72447 (95080503)	41.65441 (95011704)	64.98087 (95120921)	34.28890 (95120918)	66.19035 (95120301)
5000.0	58.36902 (95053101)	35.71268 (95112221)	67.40512 (95052021)	49.81616 (95011704)	63.96006 (95120918)
0.0	36.91877 (95042824)	42.32616 (95042824)	47.04839 (95042824)	47.56997 (95042824)	63.69714 (95081207)
-5000.0	58.37106 (95070721)	59.11684 (95032524)	55.23191 (95030806)	52.09282 (95032423)	72.17764 (95121018)
-10000.0	32.71140 (95110723)	47.21429 (95032423)	67.14748 (95110722)	70.72806 (95080321)	65.75079 (95092424)
-15000.0	53.65063 (95013024)	33.95025 (95042706)	64.99904 (95080321)	28.72936 (95052920)	67.20229 (95042301)
-20000.0	33.57658 (95111921)	55.64407 (95080321)	27.12034 (95040122)	60.87525 (95092424)	41.94138 (95053103)
-25000.0	48.08854 (95080321)	26.24117 (95042202)	14.89756 (95102913)	26.12669 (95091221)	55.71516 (95053103)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	33.83890 (95030904)	53.75410 (95081921)	54.62113 (95091822)	36.51698 (95091003)	48.66908 (95070722)
20000.0	38.91168 (95030904)	65.60446 (95101122)	40.76526 (95091622)	54.28227 (95052106)	48.98709 (95043022)
15000.0	43.49932 (95030904)	49.03415 (95053023)	65.19523 (95102303)	57.53735 (95043022)	29.35846 (95091903)
10000.0	44.89222 (95011310)	47.87466 (95091622)	62.90084 (95043022)	57.11852 (95031905)	46.39553 (95060303)
5000.0	84.44743 (95011310)	58.79906 (95040209)	54.46809 (95060303)	67.27331 (95121020)	40.89013 (95121102)
0.0	0.00000 (00000000)	71.51303 (95021104)	53.60326 (95032103)	54.94693 (95032103)	50.44400 (95032103)
-5000.0	78.66899 (95073011)	57.18055 (95050923)	43.14731 (95032105)	40.67169 (95073121)	45.16832 (95042605)
-10000.0	54.03888 (95042903)	45.49160 (95120822)	55.42278 (95062605)	55.68793 (95060422)	35.96868 (95032105)
-15000.0	55.24780 (95042903)	54.15475 (95050524)	33.11501 (95101904)	49.17847 (95062605)	34.80824 (95020206)
-20000.0	50.65099 (95042903)	65.21521 (95042203)	37.90173 (95120822)	34.09058 (95081920)	41.27644 (95062605)
-25000.0	44.62659 (95042903)	47.96973 (95040123)	48.13914 (95050523)	29.21898 (95101904)	48.57516 (95081920)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	42.11816 (95043022)
20000.0	41.63683 (95040905)
15000.0	40.72103 (95041304)
10000.0	39.21076 (95041303)
5000.0	24.42982 (95082323)
0.0	44.47232 (95032103)
-5000.0	30.82553 (95121101)
-10000.0	44.01984 (95032323)
-15000.0	54.21786 (95052104)
-20000.0	42.34278 (95080504)
-25000.0	35.15324 (95062605)

*** THE 2ND HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD	X-COORD (METERS)				
(METERS)	-25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	17.73452 (95091322)	25.93250 (95112223)	22.00721 (95032206)	39.79074 (95072803)	53.86163 (95080922)
20000.0	39.46626 (95091024)	21.30129 (95091322)	32.20908 (95120919)	58.77258 (95080322)	59.32847 (95091823)
15000.0	34.83639 (95060402)	37.38556 (95091821)	26.32862 (95091322)	42.07144 (95102503)	40.86703 (95073006)
10000.0	42.54172 (95070321)	32.38651 (95060402)	50.76822 (95062620)	34.07048 (95052606)	64.31014 (95080322)
5000.0	48.93447 (95072521)	34.80145 (95052823)	51.77757 (95043001)	40.31485 (95101119)	55.05736 (95102110)
0.0	20.33478 (95073003)	23.93757 (95073003)	26.96522 (95073003)	34.81910 (95081207)	55.97742 (95020117)
-5000.0	57.82880 (95111923)	55.01884 (95021604)	37.38020 (95091223)	51.50245 (95050610)	59.21657 (95031010)
-10000.0	27.98167 (95072520)	38.93782 (95051224)	48.10871 (95081622)	63.50845 (95081623)	47.43621 (95042901)
-15000.0	20.58591 (95090821)	31.54696 (95092521)	57.92537 (95081623)	27.75861 (95091621)	32.87754 (95042902)
-20000.0	27.68037 (95081205)	49.25743 (95081623)	23.27729 (95120224)	38.79036 (95042901)	39.99815 (95032101)
-25000.0	42.31698 (95081623)	24.93241 (95040122)	14.17731 (95120912)	23.05973 (95042301)	53.07517 (95032101)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	31.53702 (95030805)	42.41098 (95100404)	27.80482 (95062706)	35.41642 (95020204)	29.42064 (95060101)
20000.0	36.36348 (95030805)	57.97829 (95100404)	38.73145 (95042604)	53.64283 (95022202)	48.51917 (95022706)
15000.0	40.18103 (95030805)	42.14683 (95052901)	55.79911 (95053024)	56.87277 (95022706)	29.34878 (95081904)
10000.0	44.41962 (95030904)	47.26288 (95042604)	61.91213 (95022706)	45.59315 (95030706)	30.94302 (95080424)
5000.0	71.77667 (95102408)	44.61362 (95112209)	45.07401 (95113019)	53.19412 (95041303)	34.75320 (95080124)
0.0	0.00000 (00000000)	69.92967 (95021409)	50.31198 (95041223)	50.60600 (95041223)	45.96157 (95041223)
-5000.0	58.77057 (95032111)	50.33160 (95122714)	38.58366 (95040210)	32.40209 (95112201)	28.78505 (95081704)
-10000.0	44.56026 (95042906)	39.19405 (95033111)	41.78554 (95050601)	31.35367 (95052104)	27.90050 (95040404)
-15000.0	46.57967 (95042906)	42.01191 (95022122)	32.07636 (95090721)	35.18734 (95050601)	30.35739 (95080504)
-20000.0	42.92913 (95042906)	56.04998 (95120821)	28.03753 (95051323)	31.44891 (95052902)	28.91161 (95050601)
-25000.0	37.59790 (95042906)	40.63237 (95120821)	39.28895 (95050524)	21.77447 (95061122)	17.43554 (95021412)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	41.77220 (95022706)
20000.0	37.18542 (95043005)
15000.0	30.46905 (95051123)
10000.0	29.86821 (95053124)
5000.0	24.14750 (95070723)
0.0	40.29085 (95041223)
-5000.0	27.59339 (95051121)
-10000.0	24.15631 (95031102)
-15000.0	28.52307 (95040404)
-20000.0	31.99959 (95020206)
-25000.0	24.31583 (95050601)

*** THE 3RD HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	15.98221 (95102504)	24.92495 (95102824)	20.47299 (95102503)	29.99736 (95072801)	43.73474 (95060103)
20000.0	22.86683 (95070324)	19.46096 (95043021)	31.34507 (95081422)	51.60291 (95062124)	58.25737 (95091722)
15000.0	33.00384 (95120921)	35.28694 (95060401)	24.42416 (95043021)	40.71676 (95080122)	38.78646 (95030122)
10000.0	37.81758 (95043001)	29.14450 (95072723)	43.65012 (95040406)	32.32498 (95091322)	58.55561 (95062124)
5000.0	31.47236 (95021606)	24.64843 (95021606)	42.62330 (95052403)	37.99551 (95060402)	52.09171 (95052608)
0.0	17.42045 (95102024)	20.64315 (95102024)	24.53482 (95081207)	30.12312 (95020117)	54.32075 (95051208)
-5000.0	40.66107 (95021604)	43.33667 (95042703)	37.23225 (95042703)	47.72633 (95051224)	50.05425 (95020209)
-10000.0	23.15544 (95112220)	29.82273 (95110723)	44.21146 (95090520)	37.31246 (95121018)	42.07986 (95041402)
-15000.0	18.44119 (95110722)	26.49161 (95031008)	26.30476 (95092520)	26.30420 (95041401)	29.42779 (95032302)
-20000.0	23.02506 (95121018)	21.15701 (95092520)	23.03226 (95011613)	33.24789 (95041402)	32.37568 (95110423)
-25000.0	17.43894 (95092520)	17.12061 (95011613)	13.83938 (95022701)	19.22578 (95032302)	25.36296 (95042905)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	24.69407 (95070404)	38.02320 (95073004)	27.74462 (95041123)	33.29293 (95081702)	22.58461 (95102906)
20000.0	28.85545 (95070404)	43.31030 (95072904)	26.22211 (95072902)	51.82474 (95070722)	25.79324 (95040422)
15000.0	33.11997 (95070404)	38.02061 (95072904)	39.21040 (95052106)	31.66032 (95040422)	29.31610 (95040905)
10000.0	39.74267 (95102408)	35.64371 (95010912)	38.00071 (95040422)	38.27381 (95081710)	27.46737 (95101802)
5000.0	61.40777 (95052508)	43.42077 (95121609)	40.08442 (95080424)	41.32625 (95020305)	31.95893 (95031902)
0.0	0.00000 (00000000)	69.87283 (95013110)	46.93509 (95031903)	46.59174 (95031903)	42.00227 (95031903)
-5000.0	58.07868 (95051617)	48.84991 (95010714)	34.87251 (95123012)	31.18138 (95032323)	22.22084 (95030406)
-10000.0	42.96404 (95073011)	36.36909 (95051323)	33.79667 (95081721)	30.30302 (95042606)	21.48518 (95082520)
-15000.0	31.35211 (95032320)	27.28308 (95050609)	31.90916 (95061123)	27.75195 (95081721)	29.47038 (95041501)
-20000.0	27.18857 (95032320)	30.35864 (95081823)	26.11847 (95050521)	25.97510 (95051301)	22.46626 (95081721)
-25000.0	23.26646 (95032320)	36.58063 (95081822)	27.34445 (95081104)	19.41412 (95030907)	17.31854 (95082222)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	21.53946 (95040422)
20000.0	27.92078 (95020705)
15000.0	30.35358 (95020306)
10000.0	29.64569 (95040721)
5000.0	19.74198 (95092406)
0.0	36.67618 (95031903)
-5000.0	23.12365 (95090223)
-10000.0	17.92373 (95071021)
-15000.0	28.21439 (95060422)
-20000.0	24.95587 (95052221)
-25000.0	18.68277 (95081721)

*** THE 1ST HIGHEST 8-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD	X-COORD (METERS)				
(METERS)	-25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	4.74105 (95062724)	5.44790 (95120924)	3.69782c(95032208)	8.72351 (95072808)	18.97768 (95091724)
20000.0	6.31597 (95060408)	5.86491 (95062724)	6.52461 (95041424)	7.69920 (95120308)	23.95044 (95091724)
15000.0	6.16007 (95072724)	8.38837 (95110324)	7.53104 (95062724)	6.32361c(95081524)	8.65988 (95011208)
10000.0	6.84056 (95080508)	5.85064 (95072724)	10.59150 (95110824)	9.81557 (95062724)	10.27299 (95011208)
5000.0	9.56261 (95072524)	6.94608 (95052824)	8.42565 (95052024)	8.47318 (95041024)	16.68469 (95072416)
0.0	4.69445 (95042824)	5.39648 (95042824)	6.03189 (95042824)	7.56836 (95101916)	15.05202 (95101916)
-5000.0	8.26126c(95111924)	8.99128 (95042708)	6.90399 (95030808)	7.76581 (95050616)	9.58946 (95020216)
-10000.0	4.08893 (95110724)	5.90179 (95032424)	8.39380 (95110724)	9.07267c(95081624)	9.85507 (95102324)
-15000.0	6.70633 (95013024)	6.46751 (95092524)	8.27506c(95081624)	6.31665 (95041324)	8.40029 (95042308)
-20000.0	4.80868c(95111924)	7.03678c(95081624)	7.28637 (95041324)	7.61185 (95092424)	5.24267 (95053108)
-25000.0	6.04528c(95081624)	5.05437 (95041324)	3.24866 (95091624)	3.99431 (95091224)	6.96439 (95053108)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	6.09630 (95030808)	7.00499 (95081924)	7.80302c(95091824)	7.86051 (95091008)	6.25357 (95070724)
20000.0	7.09321 (95030808)	8.28263c(95100408)	6.25953 (95072908)	7.01398 (95052108)	6.12339 (95043024)
15000.0	8.01573 (95030808)	8.52370 (95030208)	8.68421 (95081724)	7.19217 (95043024)	6.91815 (95040908)
10000.0	8.28612 (95030808)	8.46467 (95072908)	8.59927 (95102908)	10.59585 (95102808)	8.02479 (95101808)
5000.0	15.91234 (95110316)	15.88023 (95061216)	11.62868 (95101808)	9.18768 (95021408)	5.11442 (95121108)
0.0	0.00000 (00000000)	22.36492 (95022808)	15.86083 (95022808)	13.86619 (95041308)	12.26559 (95041308)
-5000.0	14.39196 (95121624)	13.76174 (95122824)	7.95447 (95022408)	7.13091 (95072024)	6.45262c(95042608)
-10000.0	12.32495 (95042908)	11.51434 (95032916)	8.02160 (95050608)	8.99134 (95080108)	4.49609 (95032108)
-15000.0	12.72845 (95042908)	11.55735 (95122216)	14.51832 (95061124)	6.61110 (95050608)	4.35103 (95020208)
-20000.0	11.69752 (95042908)	8.28311 (95121716)	5.84244 (95030516)	5.92231 (95012424)	5.35691 (95050608)
-25000.0	10.27806 (95042908)	8.69212 (95040124)	12.07100 (95050524)	7.34325 (95061124)	6.07189 (95081924)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	5.26477 (95043024)
20000.0	9.11156 (95061408)
15000.0	5.09013 (95041308)
10000.0	5.26522 (95040724)
5000.0	5.48992 (95121824)
0.0	10.58112 (95041308)
-5000.0	5.03451 (95100808)
-10000.0	5.50248 (95032324)
-15000.0	6.77723 (95052108)
-20000.0	5.29285 (95080508)
-25000.0	4.45660 (95050608)

*** THE 2ND HIGHEST 8-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	4.04795 (95052608)	3.94361 (95031608)	3.21589 (95020724)	6.76504c(95020308)	6.92804 (95111824)
20000.0	4.93328 (95091024)	4.92027 (95052608)	5.37882 (95031608)	7.34714 (95080324)	8.47550c(95091824)
15000.0	5.87547 (95070324)	6.76260 (95091924)	6.23107 (95052608)	5.81668c(95080124)	8.48839 (95042908)
10000.0	5.32029 (95070324)	5.20814 (95011708)	9.76064 (95121108)	8.77451 (95072416)	8.27379 (95120308)
5000.0	7.29613 (95053108)	6.32118 (95031708)	8.13058 (95040224)	7.99385 (95072724)	16.60609 (95011124)
0.0	3.52617 (95031924)	4.35213 (95031924)	5.44554 (95031924)	7.27364 (95031224)	12.17947 (95031224)
-5000.0	7.29638 (95070724)	7.38961 (95032524)	5.96666 (95042708)	7.52574 (95020524)	9.31566 (95051224)
-10000.0	3.80651 (95062824)	5.77364 (95051224)	7.28449 (95030924)	8.84101 (95080324)	8.40379 (95041408)
-15000.0	4.44809 (95030924)	5.32148 (95030924)	8.12488 (95080324)	5.33517 (95102916)	7.13222 (95032308)
-20000.0	4.61340c(95081208)	6.95551 (95080324)	4.28334 (95041508)	5.75028 (95041408)	4.99977 (95032108)
-25000.0	6.01107 (95080324)	3.28015 (95042208)	2.89074 (95102916)	3.53198 (95102324)	6.63440 (95032108)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	4.22986 (95030908)	6.06162c(95100408)	4.51440 (95091708)	5.54882c(95081708)	3.86856 (95060108)
20000.0	4.86396 (95030908)	8.20056 (95101124)	5.53306c(95042608)	6.72073 (95022208)	6.06490 (95022708)
15000.0	5.51410 (95101208)	7.21943 (95072908)	8.14940 (95102308)	7.10910 (95022708)	6.81788 (95061408)
10000.0	7.17967 (95110316)	7.45395 (95022208)	7.86261 (95043024)	10.13923 (95031908)	5.79944 (95060308)
5000.0	13.75501 (95011316)	12.93079 (95061316)	7.34536 (95040208)	8.84228 (95121024)	4.96474c(95080124)
0.0	0.00000 (00000000)	21.58736 (95121408)	14.41850 (95041308)	11.79357 (95022808)	9.26656 (95022808)
-5000.0	12.53539 (95060724)	13.12923 (95071924)	7.31790 (95111608)	5.08396 (95073124)	4.79751c(95081708)
-10000.0	8.56099 (95121624)	11.03899 (95030516)	7.43729 (95122824)	6.96099 (95060424)	3.80229 (95111608)
-15000.0	6.33204 (95060524)	7.96956 (95112508)	8.84567 (95012424)	6.14731 (95062608)	4.30497 (95111616)
-20000.0	5.18563 (95060524)	8.15190 (95042208)	5.83397 (95032916)	5.84563 (95061124)	5.15956 (95062608)
-25000.0	4.33019 (95060524)	6.27561 (95122124)	6.10096 (95112824)	4.84528 (95111424)	3.55494 (95012424)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	5.22153 (95022708)
20000.0	8.24705 (95061208)
15000.0	4.35668 (95102808)
10000.0	5.03929 (95121024)
5000.0	3.36185 (95051408)
0.0	7.58123 (95022808)
-5000.0	4.72233 (95013008)
-10000.0	4.17501 (95071524)
-15000.0	5.71765 (95071624)
-20000.0	3.99995 (95020208)
-25000.0	4.39415 (95062608)

*** THE 3RD HIGHEST 8-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	3.74649 (95072416)	3.78201 (95102824)	2.98535 (95011116)	6.41328 (95011208)	6.73270 (95080924)
20000.0	4.76111 (95091924)	4.61008 (95072416)	4.80242 (95120924)	6.45036 (95062124)	5.21748 (95111824)
15000.0	5.39453 (95041024)	6.61394 (95081124)	6.02241 (95072416)	5.68527 (95020108)	6.33885 (95030124)
10000.0	4.92154 (95052008)	5.02866 (95041024)	8.51300 (95120924)	8.21639 (95052608)	8.04147 (95080324)
5000.0	6.05378 (95020408)	6.29278 (95052424)	6.47220 (95043008)	7.09763 (95052008)	13.62847 (95120924)
0.0	3.13274c (95091824)	3.82810 (95101916)	5.08664 (95101916)	6.69396 (95031924)	12.15061 (95052016)
-5000.0	5.08263 (95021608)	6.87735 (95021608)	4.67252 (95091224)	7.48123 (95051224)	9.02224 (95121024)
-10000.0	3.49771 (95072524)	4.54812 (95060324)	6.87280c (95081624)	5.59203 (95051224)	8.22844 (95092424)
-15000.0	2.86649 (95062516)	4.75333 (95042816)	3.93051 (95051224)	4.60130 (95091624)	5.40392 (95102224)
-20000.0	4.15853 (95042816)	2.99879 (95051224)	3.39004 (95040124)	5.65850 (95102324)	4.92536 (95060424)
-25000.0	2.41333 (95051224)	3.11655 (95040124)	2.62847 (95041324)	3.34340 (95080516)	3.96478 (95042424)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	3.67616 (95101208)	5.21902 (95073008)	3.97091 (95010908)	4.66750 (95062708)	3.82898 (95112208)
20000.0	4.47772 (95101208)	5.47029 (95072908)	5.20776 (95091624)	6.50627 (95070724)	5.42451 (95102908)
15000.0	5.43742 (95030908)	7.13242 (95103108)	8.02039 (95052108)	6.82530 (95102908)	6.60625 (95061208)
10000.0	7.14499 (95011316)	7.35881 (95060108)	7.81244 (95061216)	5.69914 (95030708)	5.25690 (95040208)
5000.0	12.07408 (95011216)	12.31761 (95061208)	6.80851 (95060308)	7.03114 (95120524)	4.14253 (95123108)
0.0	0.00000 (00000000)	20.48422 (95112708)	13.09820 (95121408)	9.17403 (95061708)	7.11122 (95061708)
-5000.0	10.90200 (95081716)	12.20548 (95061916)	7.25441 (95071708)	5.05848 (95071908)	4.01386 (95013008)
-10000.0	7.88874 (95060524)	10.10997 (95111424)	6.92785 (95062608)	5.83916 (95080808)	3.79390 (95071708)
-15000.0	5.68105 (95121624)	7.85600 (95050524)	8.41371 (95012724)	5.00552 (95122824)	3.95617 (95080108)
-20000.0	4.18866 (95121624)	7.00625 (95120824)	5.36121 (95070516)	4.34080 (95052908)	3.78443 (95122824)
-25000.0	3.29388 (95121624)	6.21826 (95101316)	4.11944 (95122216)	4.54589 (95012724)	3.01958 (95080908)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	4.45568 (95102908)
20000.0	8.02715 (95061324)
15000.0	4.33623c (95020308)
10000.0	4.90358 (95041308)
5000.0	3.26630 (95031508)
0.0	5.78221 (95061708)
-5000.0	3.99925 (95082208)
-10000.0	3.70552 (95060408)
-15000.0	4.76274 (95080108)
-20000.0	3.51293 (95123124)
-25000.0	3.05453 (95122824)

The Annual Estimated CO concentrations for 3600 MW Generation Capacity.

*** THE ANNUAL (1 YRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00	0.00	5000.00	10000.00	15000.00
25000.00	0.33734	0.34072	0.27862	0.36095	0.36865	0.34273	0.29704	0.31096	0.37540
20000.00	0.43948	0.42202	0.38908	0.37760	0.46115	0.41801	0.44119	0.44396	0.31436
15000.00	0.44190	0.55845	0.55510	0.49993	0.59297	0.51643	0.52146	0.53427	0.60213
10000.00	0.42042	0.46669	0.72804	0.77498	0.60210	0.64019	0.68124	0.81132	0.61666
5000.00	0.51416	0.54442	0.66271	0.77116	1.13900	0.70460	1.05562	0.76634	0.85852
0.00	0.32272	0.39860	0.51270	0.70755	1.16982	0.00000	2.00602	1.71856	1.34687
-5000.00	0.26363	0.33077	0.35838	0.58994	0.95646	0.93162	2.88463	1.08906	0.68369
-10000.00	0.21015	0.33540	0.54154	0.57565	0.61543	0.58579	2.40515	1.51780	0.94648
-15000.00	0.29883	0.39593	0.40916	0.40655	0.48503	0.42646	1.49153	1.56484	1.01442
-20000.00	0.30132	0.31320	0.31153	0.34552	0.39200	0.33202	1.06639	1.21669	1.03103
-25000.00	0.25250	0.23722	0.24265	0.28304	0.33657	0.26883	0.74744	0.91024	0.97021

Y-COORD (METERS)	X-COORD (METERS) 20000.00	25000.00
25000.00	0.24021	0.37431
20000.00	0.46455	0.48188
15000.00	0.53473	0.41344
10000.00	0.47618	0.48156
5000.00	0.67483	0.56289
0.00	1.07755	0.88243
-5000.00	0.51601	0.48005
-10000.00	0.57492	0.45813
-15000.00	0.74311	0.58401
-20000.00	0.75770	0.61791
-25000.00	0.74730	0.60387

The Highest Three CO Concentrations at all Receptors for 3600 MW Generation Capacity.

*** THE 1ST HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	56.28448 (95052606)	79.49757 (95120919)	69.22191 (95030903)	142.06573 (95020302)	166.26566 (95111821)
20000.0	151.58148 (95060401)	67.73512 (95052606)	156.59056 (95041421)	184.78076 (95120301)	196.89348 (95091721)
15000.0	140.99736 (95070322)	158.73459 (95081124)	83.77317 (95052606)	132.79578 (95081522)	203.72142 (95042904)
10000.0	164.17342 (95080503)	124.96323 (95011704)	194.94260 (95120921)	102.86670 (95120918)	198.57106 (95120301)
5000.0	175.10706 (95053101)	107.13803 (95112221)	202.21536 (95052021)	149.44849 (95011704)	191.88019 (95120918)
0.0	110.75630 (95042824)	126.97847 (95042824)	141.14517 (95042824)	142.70992 (95042824)	191.09142 (95081207)
-5000.0	175.11316 (95070721)	177.35052 (95032524)	165.69572 (95030806)	156.27844 (95032423)	216.53290 (95121018)
-10000.0	98.13421 (95110723)	141.64285 (95032423)	201.44241 (95110722)	212.18419 (95080321)	197.25237 (95092424)
-15000.0	160.95189 (95013024)	101.85075 (95042706)	194.99713 (95080321)	86.18810 (95052920)	201.60687 (95042301)
-20000.0	100.72976 (95111921)	166.93222 (95080321)	81.36102 (95040122)	182.62573 (95092424)	125.82413 (95053103)
-25000.0	144.26563 (95080321)	78.72351 (95042202)	44.69269 (95102913)	78.38007 (95091221)	167.14546 (95053103)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	101.51669 (95030904)	161.26230 (95081921)	163.86340 (95091822)	109.55095 (95091003)	146.00723 (95070722)
20000.0	116.73504 (95030904)	196.81339 (95101122)	122.29578 (95091622)	162.84683 (95052106)	146.96126 (95043022)
15000.0	130.49797 (95030904)	147.10245 (95053023)	195.58569 (95102303)	172.61206 (95043022)	88.07539 (95091903)
10000.0	134.67667 (95011310)	143.62399 (95091622)	188.70251 (95043022)	171.35555 (95031905)	139.18660 (95060303)
5000.0	253.34232 (95011310)	176.39716 (95040209)	163.40427 (95060303)	201.81993 (95121020)	122.67038 (95121102)
0.0	0.00000 (00000000)	214.53912 (95021104)	160.80980 (95032103)	164.84081 (95032103)	151.33200 (95032103)
-5000.0	236.00696 (95073011)	171.54166 (95050923)	129.44193 (95032105)	122.01508 (95073121)	135.50494 (95042605)
-10000.0	162.11664 (95042903)	136.47479 (95120822)	166.26833 (95062605)	167.06381 (95060422)	107.90605 (95032105)
-15000.0	165.74338 (95042903)	162.46425 (95050524)	99.34504 (95101904)	147.53540 (95062605)	104.42473 (95020206)
-20000.0	151.95300 (95042903)	195.64565 (95042203)	113.70518 (95120822)	102.27176 (95081920)	123.82932 (95062605)
-25000.0	133.87976 (95042903)	143.90918 (95040123)	144.41742 (95050523)	87.65694 (95101904)	145.72546 (95081920)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	126.35448 (95043022)
20000.0	124.91050 (95040905)
15000.0	122.16309 (95041304)
10000.0	117.63228 (95041303)
5000.0	73.28947 (95082323)
0.0	133.41696 (95032103)
-5000.0	92.47659 (95121101)
-10000.0	132.05951 (95032323)
-15000.0	162.65359 (95052104)
-20000.0	127.02834 (95080504)
-25000.0	105.45972 (95062605)

*** THE 2ND HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	53.20358 (95091322)	77.79749 (95112223)	66.02161 (95032206)	119.37222 (95072803)	161.58490 (95080922)
20000.0	118.39877 (95091024)	63.90387 (95091322)	96.62726 (95120919)	176.31772 (95080322)	177.98541 (95091823)
15000.0	104.50916 (95060402)	112.15668 (95091821)	78.98586 (95091322)	126.21432 (95102503)	122.60109 (95073006)
10000.0	127.62517 (95070321)	97.15954 (95060402)	152.30466 (95062620)	102.21144 (95052606)	192.93042 (95080322)
5000.0	146.80342 (95072521)	104.40433 (95052823)	155.33269 (95043001)	120.94456 (95101119)	165.17206 (95102110)
0.0	61.00434 (95073003)	71.81270 (95073003)	80.89565 (95073003)	104.45731 (95081207)	167.93225 (95020117)
-5000.0	173.48639 (95111923)	165.05652 (95021604)	112.14059 (95091223)	154.50732 (95050610)	177.64972 (95031010)
-10000.0	83.94501 (95072520)	116.81346 (95051224)	144.32614 (95081622)	190.52534 (95081623)	142.30864 (95042901)
-15000.0	61.75774 (95090821)	94.64088 (95092521)	173.77611 (95081623)	83.27584 (95091621)	98.63263 (95042902)
-20000.0	83.04111 (95081205)	147.77228 (95081623)	69.83185 (95120224)	116.37106 (95042901)	119.99445 (95032101)
-25000.0	126.95094 (95081623)	74.79723 (95040122)	42.53191 (95120912)	69.17918 (95042301)	159.22552 (95032101)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	94.61105 (95030805)	127.23294 (95100404)	83.41446 (95062706)	106.24925 (95020204)	88.26192 (95060101)
20000.0	109.09042 (95030805)	173.93488 (95100404)	116.19434 (95042604)	160.92850 (95022202)	145.55753 (95022706)
15000.0	120.54308 (95030805)	126.44049 (95052901)	167.39734 (95053024)	170.61832 (95022706)	88.04634 (95081904)
10000.0	133.25888 (95030904)	141.78864 (95042604)	185.73639 (95022706)	136.77945 (95030706)	92.82907 (95080424)
5000.0	215.33000 (95102408)	133.84088 (95112209)	135.22205 (95113019)	159.58237 (95041303)	104.25960 (95080124)
0.0	0.00000 (00000000)	209.78900 (95021409)	150.93593 (95041223)	151.81798 (95041223)	137.88470 (95041223)
-5000.0	176.31172 (95032111)	150.99481 (95122714)	115.75099 (95040210)	97.20627 (95112201)	86.35516 (95081704)
-10000.0	133.68077 (95042906)	117.58217 (95033111)	125.35661 (95050601)	94.06101 (95052104)	83.70148 (95040404)
-15000.0	139.73901 (95042906)	126.03574 (95022122)	96.22910 (95090721)	105.56203 (95050601)	91.07217 (95080504)
-20000.0	128.78738 (95042906)	168.14993 (95120821)	84.11260 (95051323)	94.34671 (95052902)	86.73483 (95050601)
-25000.0	112.79369 (95042906)	121.89711 (95120821)	117.86685 (95050524)	65.32340 (95061122)	52.30664 (95021412)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	125.31660 (95022706)
20000.0	111.55626 (95043005)
15000.0	91.40714 (95051123)
10000.0	89.60463 (95053124)
5000.0	72.44250 (95070723)
0.0	120.87254 (95041223)
-5000.0	82.78017 (95051121)
-10000.0	72.46893 (95031102)
-15000.0	85.56923 (95040404)
-20000.0	95.99876 (95020206)
-25000.0	72.94748 (95050601)

*** THE 3RD HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	47.94663 (95102504)	74.77484 (95102824)	61.41897 (95102503)	89.99210 (95072801)	131.20422 (95060103)
20000.0	68.60050 (95070324)	58.38287 (95043021)	94.03522 (95081422)	154.80875 (95062124)	174.77213 (95091722)
15000.0	99.01152 (95120921)	105.86083 (95060401)	73.27249 (95043021)	122.15028 (95080122)	116.35939 (95030122)
10000.0	113.45274 (95043001)	87.43350 (95072723)	130.95038 (95040406)	96.97495 (95091322)	175.66684 (95062124)
5000.0	94.41708 (95021606)	73.94528 (95021606)	127.86989 (95052403)	113.98653 (95060402)	156.27512 (95052608)
0.0	52.26136 (95102024)	61.92944 (95102024)	73.60446 (95081207)	90.36937 (95020117)	162.96225 (95051208)
-5000.0	121.98322 (95021604)	130.01003 (95042703)	111.69675 (95042703)	143.17899 (95051224)	150.16275 (95020209)
-10000.0	69.46631 (95112220)	89.46820 (95110723)	132.63437 (95090520)	111.93739 (95121018)	126.23960 (95041402)
-15000.0	55.32356 (95110722)	79.47482 (95031008)	78.91426 (95092520)	78.91258 (95041401)	88.28337 (95032302)
-20000.0	69.07519 (95121018)	63.47103 (95092520)	69.09679 (95011613)	99.74365 (95041402)	97.12704 (95110423)
-25000.0	52.31682 (95092520)	51.36183 (95011613)	41.51814 (95022701)	57.67735 (95032302)	76.08890 (95042905)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	74.08220 (95070404)	114.06961 (95073004)	83.23386 (95041123)	99.87878 (95081702)	67.75383 (95102906)
20000.0	86.56636 (95070404)	129.93089 (95072904)	78.66634 (95072902)	155.47421 (95070722)	77.37971 (95040422)
15000.0	99.35992 (95070404)	114.06184 (95072904)	117.63120 (95052106)	94.98095 (95040422)	87.94829 (95040905)
10000.0	119.22800 (95102408)	106.93114 (95010912)	114.00212 (95040422)	114.82143 (95081710)	82.40211 (95101802)
5000.0	184.22333 (95052508)	130.26231 (95121609)	120.25327 (95080424)	123.97874 (95020305)	95.87681 (95031902)
0.0	0.00000 (00000000)	209.61850 (95013110)	140.80527 (95031903)	139.77521 (95031903)	126.00679 (95031903)
-5000.0	174.23604 (95051617)	146.54973 (95010714)	104.61751 (95123012)	93.54414 (95032323)	66.66251 (95030406)
-10000.0	128.89212 (95073011)	109.10726 (95051323)	101.39001 (95081721)	90.90907 (95042606)	64.45554 (95082520)
-15000.0	94.05634 (95032320)	81.84924 (95050609)	95.72749 (95061123)	83.25584 (95081721)	88.41114 (95041501)
-20000.0	81.56570 (95032320)	91.07593 (95081823)	78.35539 (95050521)	77.92529 (95051301)	67.39879 (95081721)
-25000.0	69.79937 (95032320)	109.74190 (95081822)	82.03334 (95081104)	58.24235 (95030907)	51.95564 (95082222)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	64.61839 (95040422)
20000.0	83.76234 (95020705)
15000.0	91.06075 (95020306)
10000.0	88.93707 (95040721)
5000.0	59.22595 (95092406)
0.0	110.02855 (95031903)
-5000.0	69.37094 (95090223)
-10000.0	53.77117 (95071021)
-15000.0	84.64316 (95060422)
-20000.0	74.86761 (95052221)
-25000.0	56.04832 (95081721)

*** THE 1ST HIGHEST 8-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	14.22314 (95062724)	16.34370 (95120924)	11.09345c(95032208)	26.17054 (95072808)	56.93305 (95091724)
20000.0	18.94790 (95060408)	17.59473 (95062724)	19.57382 (95041424)	23.09760 (95120308)	71.85130 (95091724)
15000.0	18.48021 (95072724)	25.16512 (95110324)	22.59311 (95062724)	18.97083c(95081524)	25.97963 (95011208)
10000.0	20.52168 (95080508)	17.55193 (95072724)	31.77451 (95110824)	29.44673 (95062724)	30.81897 (95011208)
5000.0	28.68784 (95072524)	20.83825 (95052824)	25.27695 (95052024)	25.41953 (95041024)	50.05407 (95072416)
0.0	14.08334 (95042824)	16.18945 (95042824)	18.09566 (95042824)	22.70509 (95101916)	45.15607 (95101916)
-5000.0	24.78377c(95111924)	26.97384 (95042708)	20.71197 (95030808)	23.29743 (95050616)	28.76837 (95020216)
-10000.0	12.26678 (95110724)	17.70536 (95032424)	25.18139 (95110724)	27.21800c(95081624)	29.56522 (95102324)
-15000.0	20.11899 (95013024)	19.40252 (95092524)	24.82518c(95081624)	18.94995 (95041324)	25.20086 (95042308)
-20000.0	14.42604c(95111924)	21.11033c(95081624)	21.85911 (95041324)	22.83554 (95092424)	15.72802 (95053108)
-25000.0	18.13585c(95081624)	15.16311 (95041324)	9.74598 (95091624)	11.98293 (95091224)	20.89318 (95053108)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	18.28891 (95030808)	21.01497 (95081924)	23.40906c(95091824)	23.58154 (95091008)	18.76072 (95070724)
20000.0	21.27962 (95030808)	24.84788c(95100408)	18.77859 (95072908)	21.04196 (95052108)	18.37016 (95043024)
15000.0	24.04720 (95030808)	25.57111 (95030208)	26.05264 (95081724)	21.57651 (95043024)	20.75444 (95040908)
10000.0	24.85837 (95030808)	25.39400 (95072908)	25.79782 (95102908)	31.78755 (95102808)	24.07438 (95101808)
5000.0	47.73703 (95110316)	47.64069 (95061216)	34.88602 (95101808)	27.56303 (95021408)	15.34327 (95121108)
0.0	0.00000 (00000000)	67.09476 (95022808)	47.58250 (95022808)	41.59857 (95041308)	36.79678 (95041308)
-5000.0	43.17588 (95121624)	41.28521 (95122824)	23.86342 (95022408)	21.39272 (95072024)	19.35785c(95042608)
-10000.0	36.97484 (95042908)	34.54303 (95032916)	24.06480 (95050608)	26.97401 (95080108)	13.48826 (95032108)
-15000.0	38.18535 (95042908)	34.67204 (95122216)	43.55495 (95061124)	19.83329 (95050608)	13.05309 (95020208)
-20000.0	35.09257 (95042908)	24.84932 (95121716)	17.52732 (95030516)	17.76693 (95012424)	16.07073 (95050608)
-25000.0	30.83419 (95042908)	26.07636 (95040124)	36.21300 (95050524)	22.02975 (95061124)	18.21568 (95081924)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	15.79431 (95043024)
20000.0	27.33467 (95061408)
15000.0	15.27040 (95041308)
10000.0	15.79566 (95040724)
5000.0	16.46975 (95121824)
0.0	31.74334 (95041308)
-5000.0	15.10353 (95100808)
-10000.0	16.50744 (95032324)
-15000.0	20.33170 (95052108)
-20000.0	15.87854 (95080508)
-25000.0	13.36979 (95050608)

*** THE 2ND HIGHEST 8-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	12.14385 (95052608)	11.83082 (95031608)	9.64766 (95020724)	20.29510c(95020308)	20.78413 (95111824)
20000.0	14.79985 (95091024)	14.76081 (95052608)	16.13647 (95031608)	22.04143 (95080324)	25.42649c(95091824)
15000.0	17.62640 (95070324)	20.28780 (95091924)	18.69321 (95052608)	17.45004c(95080124)	25.46518 (95042908)
10000.0	15.96088 (95070324)	15.62442 (95011708)	29.28191 (95121108)	26.32353 (95072416)	24.82138 (95120308)
5000.0	21.88838 (95053108)	18.96354 (95031708)	24.39174 (95040224)	23.98156 (95072724)	49.81828 (95011124)
0.0	10.57850 (95031924)	13.05638 (95031924)	16.33663 (95031924)	21.82090 (95031224)	36.53841 (95031224)
-5000.0	21.88914 (95070724)	22.16882 (95032524)	17.89997 (95042708)	22.57720 (95020524)	27.94698 (95051224)
-10000.0	11.41952 (95062824)	17.32092 (95051224)	21.85346 (95030924)	26.52302 (95080324)	25.21137 (95041408)
-15000.0	13.34428 (95030924)	15.96443 (95030924)	24.37464 (95080324)	16.00550 (95102916)	21.39665 (95032308)
-20000.0	13.84018c(95081208)	20.86653 (95080324)	12.85002 (95041508)	17.25083 (95041408)	14.99931 (95032108)
-25000.0	18.03320 (95080324)	9.84044 (95042208)	8.67221 (95102916)	10.59594 (95102324)	19.90319 (95032108)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	12.68959 (95030908)	18.18486c(95100408)	13.54321 (95091708)	16.64646c(95081708)	11.60568 (95060108)
20000.0	14.59188 (95030908)	24.60167 (95101124)	16.59919c(95042608)	20.16219 (95022208)	18.19169 (95022708)
15000.0	16.54230 (95101208)	21.65829 (95072908)	24.44821 (95102308)	21.32729 (95022708)	20.45363 (95061408)
10000.0	21.53900 (95110316)	22.36185 (95022208)	23.58781 (95043024)	30.41770 (95031908)	17.39832 (95060308)
5000.0	41.26502 (95011316)	38.79238 (95061316)	22.03608 (95040208)	26.52682 (95121024)	14.89423c(95080124)
0.0	0.00000 (00000000)	64.76208 (95121408)	43.25549 (95041308)	35.38070 (95022808)	27.79967 (95022808)
-5000.0	37.60618 (95060724)	39.38770 (95071924)	21.95370 (95111608)	15.25188 (95073124)	14.39253c(95081708)
-10000.0	25.68296 (95121624)	33.11698 (95030516)	22.31187 (95122824)	20.88298 (95060424)	11.40687 (95111608)
-15000.0	18.99612 (95060524)	23.90868 (95112508)	26.53702 (95012424)	18.44193 (95062608)	12.91491 (95111616)
-20000.0	15.55690 (95060524)	24.45571 (95042208)	17.50190 (95032916)	17.53689 (95061124)	15.47866 (95062608)
-25000.0	12.99058 (95060524)	18.82683 (95122124)	18.30288 (95112824)	14.53585 (95111424)	10.66483 (95012424)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	15.66458 (95022708)
20000.0	24.74116 (95061208)
15000.0	13.07003 (95102808)
10000.0	15.11788 (95121024)
5000.0	10.08555 (95051408)
0.0	22.74368 (95022808)
-5000.0	14.16700 (95013008)
-10000.0	12.52502 (95071524)
-15000.0	17.15295 (95071624)
-20000.0	11.99984 (95020208)
-25000.0	13.18246 (95062608)

*** THE 3RD HIGHEST 8-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF CO IN MICROGRAMS/M**3 **

Y-COORD	X-COORD (METERS)				
(METERS)	-25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	11.23947 (95072416)	11.34603 (95102824)	8.95606 (95011116)	19.23985 (95011208)	20.19811 (95080924)
20000.0	14.28334 (95091924)	13.83023 (95072416)	14.40726 (95120924)	19.35109 (95062124)	15.65245 (95111824)
15000.0	16.18360 (95041024)	19.84182 (95081124)	18.06722 (95072416)	17.05580 (95020108)	19.01655 (95030124)
10000.0	14.76462 (95052008)	15.08599 (95041024)	25.53901 (95120924)	24.64916 (95052608)	24.12440 (95080324)
5000.0	18.16134 (95020408)	18.87835 (95052424)	19.41659 (95043008)	21.29289 (95052008)	40.88540 (95120924)
0.0	9.39821c(95091824)	11.48431 (95101916)	15.25991 (95101916)	20.08189 (95031924)	36.45183 (95052016)
-5000.0	15.24790 (95021608)	20.63206 (95021608)	14.01757 (95091224)	22.44369 (95051224)	27.06673 (95121024)
-10000.0	10.49313 (95072524)	13.64436 (95060324)	20.61839c(95081624)	16.77609 (95051224)	24.68533 (95092424)
-15000.0	8.59947 (95062516)	14.25999 (95042816)	11.79154 (95051224)	13.80389 (95091624)	16.21176 (95102224)
-20000.0	12.47560 (95042816)	8.99637 (95051224)	10.17013 (95040124)	16.97549 (95102324)	14.77608 (95060424)
-25000.0	7.23998 (95051224)	9.34965 (95040124)	7.88540 (95041324)	10.03020 (95080516)	11.89433 (95042424)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	11.02849 (95101208)	15.65705 (95073008)	11.91272 (95010908)	14.00249 (95062708)	11.48693 (95112208)
20000.0	13.43317 (95101208)	16.41088 (95072908)	15.62328 (95091624)	19.51882 (95070724)	16.27353 (95102908)
15000.0	16.31225 (95030908)	21.39727 (95103108)	24.06116 (95052108)	20.47589 (95102908)	19.81874 (95061208)
10000.0	21.43497 (95011316)	22.07643 (95060108)	23.43732 (95061216)	17.09743 (95030708)	15.77070 (95040208)
5000.0	36.22223 (95011216)	36.95282 (95061208)	20.42553 (95060308)	21.09343 (95120524)	12.42759 (95123108)
0.0	0.00000 (00000000)	61.45265 (95112708)	39.29460 (95121408)	27.52210 (95061708)	21.33366 (95061708)
-5000.0	32.70600 (95081716)	36.61644 (95061916)	21.76323 (95071708)	15.17544 (95071908)	12.04157 (95013008)
-10000.0	23.66623 (95060524)	30.32990 (95111424)	20.78354 (95062608)	17.51747 (95080808)	11.38170 (95071708)
-15000.0	17.04316 (95121624)	23.56800 (95050524)	25.24113 (95012724)	15.01656 (95122824)	11.86850 (95080108)
-20000.0	12.56597 (95121624)	21.01874 (95120824)	16.08363 (95070516)	13.02239 (95052908)	11.35330 (95122824)
-25000.0	9.88164 (95121624)	18.65479 (95101316)	12.35833 (95122216)	13.63767 (95012724)	9.05874 (95080908)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	13.36704 (95102908)
20000.0	24.08146 (95061324)
15000.0	13.00968c (95020308)
10000.0	14.71075 (95041308)
5000.0	9.79889 (95031508)
0.0	17.34664 (95061708)
-5000.0	11.99776 (95082208)
-10000.0	11.11657 (95060408)
-15000.0	14.28823 (95080108)
-20000.0	10.53880 (95123124)
-25000.0	9.16360 (95122824)

APPENDIX-C

100 Highest 1-hr NO_x Concentrations in μg/m^3 for 1200 MW Generation Capacity Estimated by ISCST3.

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	μg/m^3	YYMMDDHH	X	Y		μg/m^3	YYMMDDHH	X	Y
1	794.4	95011310	0	5000	41	549.1	95070721	-25000	-5000
2	740.1	95073011	0	-5000	42	549.1	95053101	-25000	5000
3	679.0	95121018	-5000	-5000	43	548.1	95091722	-5000	20000
4	675.2	95102408	0	5000	44	548.0	95091723	-5000	20000
5	672.8	95021104	5000	0	45	546.6	95022807	5000	0
6	665.4	95080321	-10000	-10000	46	546.4	95051617	0	-5000
7	657.9	95021409	5000	0	47	545.4	95100404	5000	20000
8	657.3	95013110	5000	0	48	544.9	95081623	-15000	-15000
9	638.8	95042904	-5000	15000	49	544.0	95112801	5000	0
10	634.1	95052021	-15000	5000	50	544.0	95111923	-25000	-5000
11	632.9	95121020	15000	5000	51	541.4	95010509	5000	0
12	632.2	95042301	-5000	-15000	52	541.3	95043022	15000	15000
13	631.7	95110722	-15000	-10000	53	537.9	95050923	5000	-5000
14	622.7	95120301	-5000	10000	54	537.3	95031905	15000	10000
15	618.5	95092424	-5000	-10000	55	536.8	95070807	5000	0
16	617.4	95091721	-5000	20000	56	535.0	95022706	15000	15000
17	617.2	95101122	5000	20000	57	531.6	95080408	5000	0
18	613.5	95042203	5000	-20000	58	530.2	95112802	5000	0
19	613.3	95102303	10000	15000	59	528.5	95011508	5000	0
20	611.5	95080321	-15000	-15000	60	527.3	95120821	5000	-20000
21	611.3	95120921	-15000	10000	61	526.6	95020117	-5000	0
22	605.0	95080322	-5000	10000	62	525.9	95121403	5000	0
23	601.7	95120918	-5000	5000	63	524.9	95053024	10000	15000
24	599.2	95081207	-5000	0	64	524.1	95053103	-5000	-25000
25	597.4	95081623	-10000	-10000	65	523.9	95060422	15000	-10000
26	594.4	95111408	5000	0	66	523.5	95080321	-20000	-20000
27	591.7	95043022	10000	10000	67	521.4	95062605	10000	-10000
28	590.5	95030508	5000	0	68	521.4	95111821	-5000	25000
29	582.4	95022706	10000	10000	69	521.1	95120622	5000	0
30	579.4	95120301	-10000	20000	70	519.7	95042903	0	-15000
31	577.7	95052508	0	5000	71	519.6	95030806	-15000	-5000
32	572.7	95092424	-10000	-20000	72	517.9	95102110	-5000	5000
33	558.1	95091823	-5000	20000	73	517.6	95021604	-20000	-5000
34	557.1	95031010	-5000	-5000	74	517.4	95010208	5000	0
35	556.1	95032524	-20000	-5000	75	516.9	95032103	15000	0
36	554.5	95122607	5000	0	76	515.6	95060517	0	-5000
37	553.1	95040209	5000	5000	77	514.8	95080503	-25000	10000
38	552.9	95080322	-10000	20000	78	513.8	95091822	10000	25000
39	552.9	95032111	0	-5000	79	512.4	95060303	10000	5000
40	550.9	95062124	-5000	10000	80	511.0	95051208	-5000	0

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	µg/m³	YYMMDDHH	X	Y		µg/m³	YYMMDDHH	X	Y
81	510.7	95052106	15000	20000	91	504.3	95032103	10000	0
82	510.0	95052104	25000	-15000	92	501.6	95102812	0	-5000
83	509.5	95050524	5000	-15000	93	500.4	95041303	15000	5000
84	508.9	95052612	-5000	0	94	499.8	95091819	-5000	0
85	508.4	95042903	0	-10000	95	499.3	95032101	-5000	-25000
86	506.7	95080922	-5000	25000	96	497.8	95081124	-20000	15000
87	506.5	95040218	-5000	0	97	491.0	95041421	-15000	20000
88	505.7	95081921	5000	25000	98	491.0	95051118	0	-5000
89	504.7	95013024	-25000	-15000	99	490.1	95032423	-10000	-5000
90	504.6	95022202	15000	20000	100	490.0	95052608	-5000	5000

100 Highest 1-hr NO_x Concentrations in $\mu g/m^3$ for 3600 MW Generation Capacity Estimated by ISCST3.

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	$\mu g/m^3$	YYMMDDHH	X	Y		$\mu g/m^3$	YYMMDDHH	X	Y
1	2377.0	95011310	0	5000	41	1643.0	95070721	-25000	-5000
2	2214.4	95073011	0	-5000	42	1643.0	95053101	-25000	5000
3	2031.7	95121018	-5000	-5000	43	1639.8	95091722	-5000	20000
4	2020.4	95102408	0	5000	44	1639.6	95091723	-5000	20000
5	2013.0	95021104	5000	0	45	1635.3	95022807	5000	0
6	1990.9	95080321	-10000	-10000	46	1634.8	95051617	0	-5000
7	1968.4	95021409	5000	0	47	1632.0	95100404	5000	20000
8	1966.8	95013110	5000	0	48	1630.5	95081623	-15000	-15000
9	1911.5	95042904	-5000	15000	49	1627.8	95112801	5000	0
10	1897.3	95052021	-15000	5000	50	1627.8	95111923	-25000	-5000
11	1893.6	95121020	15000	5000	51	1619.8	95010509	5000	0
12	1891.6	95042301	-5000	-15000	52	1619.6	95043022	15000	15000
13	1890.1	95110722	-15000	-10000	53	1609.5	95050923	5000	-5000
14	1863.1	95120301	-5000	10000	54	1607.8	95031905	15000	10000
15	1850.8	95092424	-5000	-10000	55	1606.2	95070807	5000	0
16	1847.4	95091721	-5000	20000	56	1600.9	95022706	15000	15000
17	1846.6	95101122	5000	20000	57	1590.6	95080408	5000	0
18	1835.7	95042203	5000	-20000	58	1586.3	95112802	5000	0
19	1835.1	95102303	10000	15000	59	1581.4	95011508	5000	0
20	1829.6	95080321	-15000	-15000	60	1577.7	95120821	5000	-20000
21	1829.1	95120921	-15000	10000	61	1575.7	95020117	-5000	0
22	1810.2	95080322	-5000	10000	62	1573.7	95121403	5000	0
23	1800.4	95120918	-5000	5000	63	1570.6	95053024	10000	15000
24	1793.0	95081207	-5000	0	64	1568.3	95053103	-5000	-25000
25	1787.6	95081623	-10000	-10000	65	1567.5	95060422	15000	-10000
26	1778.5	95111408	5000	0	66	1566.3	95080321	-20000	-20000
27	1770.5	95043022	10000	10000	67	1560.0	95062605	10000	-10000
28	1766.7	95030508	5000	0	68	1560.0	95111821	-5000	25000
29	1742.7	95022706	10000	10000	69	1559.1	95120622	5000	0
30	1733.7	95120301	-10000	20000	70	1555.1	95042903	0	-15000
31	1728.5	95052508	0	5000	71	1554.7	95030806	-15000	-5000
32	1713.5	95092424	-10000	-20000	72	1549.8	95102110	-5000	5000
33	1670.0	95091823	-5000	20000	73	1548.7	95021604	-20000	-5000
34	1666.8	95031010	-5000	-5000	74	1548.1	95010208	5000	0
35	1664.0	95032524	-20000	-5000	75	1546.7	95032103	15000	0
36	1659.2	95122607	5000	0	76	1542.7	95060517	0	-5000
37	1655.1	95040209	5000	5000	77	1540.4	95080503	-25000	10000
38	1654.3	95080322	-10000	20000	78	1537.5	95091822	10000	25000
39	1654.3	95032111	0	-5000	79	1533.2	95060303	10000	5000
40	1648.2	95062124	-5000	10000	80	1529.0	95051208	-5000	0

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	µg/m³	YYMMDDHH	X	Y		µg/m³	YYMMDDHH	X	Y
81	1527.9	95052106	15000	20000	91	1508.8	95032103	10000	0
82	1526.1	95052104	25000	-15000	92	1500.9	95102812	0	-5000
83	1524.4	95050524	5000	-15000	93	1497.3	95041303	15000	5000
84	1522.7	95052612	-5000	0	94	1495.5	95091819	-5000	0
85	1521.1	95042903	0	-10000	95	1494.0	95032101	-5000	-25000
86	1516.1	95080922	-5000	25000	96	1489.4	95081124	-20000	15000
87	1515.6	95040218	-5000	0	97	1469.2	95041421	-15000	20000
88	1513.1	95081921	5000	25000	98	1469.2	95051118	0	-5000
89	1510.2	95013024	-25000	-15000	99	1466.3	95032423	-10000	-5000
90	1509.9	95022202	15000	20000	100	1466.3	95052608	-5000	5000

The Annual Estimated NO_x concentrations for 1200 MW Generation Capacity.

*** THE ANNUAL (1 YRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF NOX IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00	0.00	5000.00	10000.00	15000.00
25000.00	1.05782	1.06842	0.87370	1.13187	1.15601	1.07474	0.93145	0.97511	1.17717
20000.00	1.37812	1.32338	1.22006	1.18407	1.44608	1.31081	1.38348	1.39216	0.98576
15000.00	1.38570	1.75119	1.74069	1.56767	1.85942	1.61941	1.63520	1.67535	1.88816
10000.00	1.31835	1.46343	2.28298	2.43018	1.88806	2.00750	2.13624	2.54415	1.93374
5000.00	1.61229	1.70718	2.07812	2.41821	3.57168	2.20949	3.31022	2.40309	2.69215
0.00	1.01199	1.24994	1.60774	2.21875	3.66833	0.00000	6.29049	5.38906	4.22353
-5000.00	0.82669	1.03722	1.12380	1.84995	2.99926	2.92137	9.04562	3.41509	2.14392
-10000.00	0.65898	1.05174	1.69816	1.80513	1.92987	1.83694	7.54208	4.75952	2.96796
-15000.00	0.93706	1.24156	1.28303	1.27487	1.52097	1.33730	4.67715	4.90703	3.18101
-20000.00	0.94488	0.98214	0.97689	1.08349	1.22923	1.04113	3.34398	3.81530	3.23309
-25000.00	0.79178	0.74387	0.76089	0.88756	1.05541	0.84301	2.34382	2.85434	3.04239

Y-COORD (METERS)	X-COORD (METERS) 20000.00	25000.00
25000.00	0.75326	1.17376
20000.00	1.45674	1.51109
15000.00	1.67680	1.29648
10000.00	1.49320	1.51007
5000.00	2.11614	1.76512
0.00	3.37899	2.76713
-5000.00	1.61810	1.50536
-10000.00	1.80283	1.43661
-15000.00	2.33025	1.83134
-20000.00	2.37600	1.93764
-25000.00	2.34340	1.89362

The Highest Three NOx Concentrations at all Receptors for 1200 MW Generation Capacity.

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*** THE   1ST HIGHEST  1-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL      ***
    INCLUDING SOURCE(S):       01      , 02       ,

     *** NETWORK ID: 001      ;  NETWORK TYPE: GRIDCART ***

         ** CONC OF NOX       IN MICROGRAMS/M**3                 **
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Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	176.49701 (95052606)	249.28867 (95120919)	217.06622 (95030903)	445.49008 (95020302)	521.37622 (95111821)
20000.0	475.32956 (95060401)	212.40393 (95052606)	491.03705 (95041421)	579.43597 (95120301)	617.41907 (95091721)
15000.0	442.13989 (95070322)	497.76035 (95081124)	262.69611 (95052606)	416.42133 (95081522)	638.83014 (95042904)
10000.0	514.81543 (95080503)	391.85999 (95011704)	611.30145 (95120921)	322.56964 (95120918)	622.67963 (95120301)
5000.0	549.10114 (95053101)	335.96368 (95112221)	634.10742 (95052021)	468.64093 (95011704)	601.69836 (95120918)
0.0	347.30988 (95042824)	398.17938 (95042824)	442.60339 (95042824)	447.51010 (95042824)	599.22491 (95081207)
-5000.0	549.12024 (95070721)	556.13623 (95032524)	519.58911 (95030806)	490.05835 (95032423)	679.00439 (95121018)
-10000.0	307.72949 (95110723)	444.16406 (95032423)	631.68365 (95110722)	665.36768 (95080321)	618.54443 (95092424)
-15000.0	504.71332 (95013024)	319.38379 (95042706)	611.47253 (95080321)	270.26883 (95052920)	632.19934 (95042301)
-20000.0	315.86862 (95111921)	523.46649 (95080321)	255.13208 (95040122)	572.67828 (95092424)	394.55960 (95053103)
-25000.0	452.38852 (95080321)	246.86137 (95042202)	140.14745 (95102913)	245.78439 (95091221)	524.13513 (95053103)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	318.33630 (95030904)	505.68674 (95081921)	513.84326 (95091822)	343.53015 (95091003)	457.84985 (95070722)
20000.0	366.05804 (95030904)	617.16785 (95101122)	383.49539 (95091622)	510.65546 (95052106)	460.84149 (95043022)
15000.0	409.21588 (95030904)	461.28424 (95053023)	613.31812 (95102303)	541.27734 (95043022)	276.18701 (95091903)
10000.0	422.31946 (95011310)	450.37646 (95091622)	591.73383 (95043022)	537.33716 (95031905)	436.46167 (95060303)
5000.0	794.43140 (95011310)	553.14667 (95040209)	512.40356 (95060303)	632.86743 (95121020)	384.67010 (95121102)
0.0	0.00000 (00000000)	672.75226 (95021104)	504.26776 (95032103)	516.90820 (95032103)	474.54730 (95032103)
-5000.0	740.07117 (95073011)	537.92072 (95050923)	405.90430 (95032105)	382.61517 (95073121)	424.91675 (95042605)
-10000.0	508.36572 (95042903)	427.95801 (95120822)	521.38464 (95062605)	523.87909 (95060422)	338.37207 (95032105)
-15000.0	519.73853 (95042903)	509.45578 (95050524)	311.52643 (95101904)	462.64188 (95062605)	327.45532 (95020206)
-20000.0	476.49457 (95042903)	613.50610 (95042203)	356.55698 (95120822)	320.70404 (95081920)	388.30429 (95062605)
-25000.0	419.82050 (95042903)	451.27075 (95040123)	452.86447 (95050523)	274.87482 (95101904)	456.96625 (95081920)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	396.22269 (95043022)
20000.0	391.69464 (95040905)
15000.0	383.07928 (95041304)
10000.0	368.87158 (95041303)
5000.0	229.82130 (95082323)
0.0	418.36926 (95032103)
-5000.0	289.98831 (95121101)
-10000.0	414.11258 (95032323)
-15000.0	510.04956 (95052104)
-20000.0	398.33582 (95080504)
-25000.0	330.70084 (95062605)

*** THE 2ND HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF NOX IN MICROGRAMS/M**3 **

Y-COORD	X-COORD (METERS)				
(METERS)	-25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	166.83589 (95091322)	243.95753 (95112223)	207.03073 (95032206)	374.32773 (95072803)	506.69833 (95080922)
20000.0	371.27515 (95091024)	200.38989 (95091322)	303.00400 (95120919)	552.89758 (95080322)	558.12708 (95091823)
15000.0	327.72006 (95060402)	351.70120 (95091821)	247.68405 (95091322)	395.78317 (95102503)	384.45279 (95073006)
10000.0	400.20731 (95070321)	304.67313 (95060402)	477.59732 (95062620)	320.51486 (95052606)	604.99170 (95080322)
5000.0	460.34656 (95072521)	327.39136 (95052823)	487.09265 (95043001)	379.25824 (95101119)	517.94702 (95102110)
0.0	191.29758 (95073003)	225.19044 (95073003)	253.67279 (95073003)	327.55750 (95081207)	526.60236 (95020117)
-5000.0	544.01904 (95111923)	517.58466 (95021604)	351.65076 (95091223)	484.50446 (95050610)	557.07440 (95031010)
-10000.0	263.23499 (95072520)	366.30396 (95051224)	452.57825 (95081622)	597.44983 (95081623)	446.25177 (95042901)
-15000.0	193.66006 (95090821)	296.77512 (95092521)	544.92755 (95081623)	261.13660 (95091621)	309.29248 (95042902)
-20000.0	260.40051 (95081205)	463.38470 (95081623)	218.97891 (95120224)	364.91669 (95042901)	376.27887 (95032101)
-25000.0	398.09308 (95081623)	234.54933 (95040122)	133.37169 (95120912)	216.93225 (95042301)	499.29977 (95032101)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	296.68158 (95030805)	398.97736 (95100404)	261.57129 (95062706)	333.17667 (95020204)	276.77191 (95060101)
20000.0	342.08603 (95030805)	545.42542 (95100404)	364.36249 (95042604)	504.63995 (95022202)	456.43964 (95022706)
15000.0	377.99927 (95030805)	396.49237 (95052901)	524.92493 (95053024)	535.02539 (95022706)	276.09595 (95081904)
10000.0	417.87354 (95030904)	444.62115 (95042604)	582.43262 (95022706)	428.91333 (95030706)	291.09363 (95080424)
5000.0	675.23236 (95102408)	419.69855 (95112209)	424.02963 (95113019)	500.41876 (95041303)	326.93750 (95080124)
0.0	0.00000 (00000000)	657.85687 (95021409)	473.30527 (95041223)	476.07120 (95041223)	432.37918 (95041223)
-5000.0	552.87866 (95032111)	473.48993 (95122714)	362.97223 (95040210)	304.81964 (95112201)	270.79272 (95081704)
-10000.0	419.19647 (95042906)	368.71442 (95033111)	393.09357 (95050601)	294.95673 (95052104)	262.47131 (95040404)
-15000.0	438.19391 (95042906)	395.22318 (95022122)	301.75543 (95090721)	331.02167 (95050601)	285.58435 (95080504)
-20000.0	403.85181 (95042906)	527.28503 (95120821)	263.76050 (95051323)	295.85266 (95052902)	271.98331 (95050601)
-25000.0	353.69873 (95042906)	382.24524 (95120821)	369.60718 (95050524)	204.84129 (95061122)	164.02328 (95021412)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	392.96811 (95022706)
20000.0	349.81839 (95043005)
15000.0	286.63470 (95051123)
10000.0	280.98242 (95053124)
5000.0	227.16537 (95070723)
0.0	379.03241 (95041223)
-5000.0	259.58228 (95051121)
-10000.0	227.24825 (95031102)
-15000.0	268.32819 (95040404)
-20000.0	301.03314 (95020206)
-25000.0	228.74890 (95050601)

*** THE 3RD HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF NOX IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	150.35117 (95102504)	234.47913 (95102824)	192.59775 (95102503)	282.19745 (95072801)	411.43054 (95060103)
20000.0	215.11763 (95070324)	183.07715 (95043021)	294.87585 (95081422)	485.44965 (95062124)	548.05084 (95091722)
15000.0	310.48056 (95120921)	331.95865 (95060401)	229.76807 (95043021)	383.03918 (95080122)	364.88007 (95030122)
10000.0	355.76538 (95043001)	274.17419 (95072723)	410.63452 (95040406)	304.09430 (95091322)	550.85645 (95062124)
5000.0	296.07330 (95021606)	231.87781 (95021606)	400.97473 (95052403)	357.43927 (95060402)	490.04788 (95052608)
0.0	163.88129 (95102024)	194.19849 (95102024)	230.80905 (95081207)	283.38049 (95020117)	511.01743 (95051208)
-5000.0	382.51526 (95021604)	407.68576 (95042703)	350.25891 (95042703)	448.98105 (95051224)	470.88068 (95020209)
-10000.0	217.83264 (95112220)	280.55463 (95110723)	415.91516 (95090520)	351.01355 (95121018)	395.86243 (95041402)
-15000.0	173.48376 (95110722)	249.21735 (95031008)	247.45953 (95092520)	247.45428 (95041401)	276.83920 (95032302)
-20000.0	216.60614 (95121018)	199.03262 (95092520)	216.67386 (95011613)	312.77643 (95041402)	304.57123 (95110423)
-25000.0	164.05522 (95092520)	161.06056 (95011613)	130.19267 (95022701)	180.86479 (95032302)	238.59973 (95042905)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	232.30713 (95070404)	357.69977 (95073004)	261.00491 (95041123)	313.20013 (95081702)	212.46265 (95102906)
20000.0	271.45499 (95070404)	407.43762 (95072904)	246.68207 (95072902)	487.53644 (95070722)	242.64751 (95040422)
15000.0	311.57309 (95070404)	357.67542 (95072904)	368.86816 (95052106)	297.84149 (95040422)	275.78845 (95040905)
10000.0	373.87543 (95102408)	335.31494 (95010912)	357.48813 (95040422)	360.05731 (95081710)	258.39673 (95101802)
5000.0	577.68793 (95052508)	408.47687 (95121609)	377.09048 (95080424)	388.77286 (95020305)	300.65070 (95031902)
0.0	0.00000 (00000000)	657.32220 (95013110)	441.53754 (95031903)	438.30743 (95031903)	395.13242 (95031903)
-5000.0	546.36981 (95051617)	459.55103 (95010714)	328.05984 (95123012)	293.33594 (95032323)	209.04047 (95030406)
-10000.0	404.18027 (95073011)	342.13882 (95051323)	317.93909 (95081721)	285.07291 (95042606)	202.11983 (95082520)
-15000.0	294.94208 (95032320)	256.66306 (95050609)	300.18250 (95061123)	261.07388 (95081721)	277.23987 (95041501)
-20000.0	255.77393 (95032320)	285.59613 (95081823)	245.70705 (95050521)	244.35832 (95051301)	211.34927 (95081721)
-25000.0	218.87704 (95032320)	344.12891 (95081822)	257.24036 (95081104)	182.63651 (95030907)	162.92261 (95082222)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	202.63049 (95040422)
20000.0	262.66217 (95020705)
15000.0	285.54849 (95020306)
10000.0	278.88907 (95040721)
5000.0	185.72089 (95092406)
0.0	345.02777 (95031903)
-5000.0	217.53355 (95090223)
-10000.0	168.61578 (95071021)
-15000.0	265.42422 (95060422)
-20000.0	234.77002 (95052221)
-25000.0	175.75645 (95081721)

The Annual Estimated NO_x concentrations for 3600 MW Generation Capacity.

*** THE ANNUAL (1 YRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF NOX IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00	0.00	5000.00	10000.00	15000.00
25000.00	3.16514	3.19685	2.61421	3.38671	3.45892	3.21575	2.78703	2.91765	3.52223
20000.00	4.12352	3.95971	3.65058	3.54288	4.32684	3.92209	4.13956	4.16552	2.94951
15000.00	4.14618	5.23977	5.20837	4.69067	5.56362	4.84549	4.89271	5.01287	5.64962
10000.00	3.94467	4.37878	6.83098	7.27141	5.64932	6.00671	6.39189	7.61242	5.78599
5000.00	4.82419	5.10809	6.21799	7.23560	10.68691	6.61108	9.90460	7.19034	8.05525
0.00	3.02802	3.73997	4.81056	6.63877	10.97611	0.00000	18.82191	16.12474	12.63730
-5000.00	2.47357	3.10350	3.36254	5.53529	8.97417	8.74112	27.06566	10.21837	6.41488
-10000.00	1.97174	3.14695	5.08110	5.40117	5.77440	5.49635	22.56684	14.24110	8.88051
-15000.00	2.80381	3.71489	3.83899	3.81457	4.55094	4.00136	13.99459	14.68244	9.51799
-20000.00	2.82719	2.93870	2.92297	3.24194	3.67800	3.11521	10.00562	11.41581	9.67382
-25000.00	2.36911	2.22575	2.27668	2.65569	3.15791	2.52238	7.01300	8.54053	9.10319

Y-COORD (METERS)	X-COORD (METERS) 20000.00	25000.00
25000.00	2.25385	3.51205
20000.00	4.35874	4.52136
15000.00	5.01720	3.87923
10000.00	4.46783	4.51832
5000.00	6.33175	5.28147
0.00	10.11034	8.27960
-5000.00	4.84157	4.50422
-10000.00	5.39430	4.29852
-15000.00	6.97239	5.47959
-20000.00	7.10929	5.79766
-25000.00	7.01175	5.66594

The Highest Three NOx Concentrations at all Receptors for 3600 MW Generation Capacity.

*** THE 1ST HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF NOX IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	528.10126 (95052606)	745.90314 (95120919)	649.48950 (95030903)	1332.96240 (95020302)	1560.02332 (95111821)
20000.0	1422.24597 (95060401)	635.53931 (95052606)	1469.24475 (95041421)	1733.74536 (95120301)	1847.39563 (95091721)
15000.0	1322.93823 (95070322)	1489.36157 (95081124)	786.01990 (95052606)	1245.98511 (95081522)	1911.46021 (95042904)
10000.0	1540.39258 (95080503)	1172.49438 (95011704)	1829.09106 (95120921)	965.16901 (95120918)	1863.13574 (95120301)
5000.0	1642.97974 (95053101)	1005.24573 (95112221)	1897.32935 (95052021)	1402.23267 (95011704)	1800.35730 (95120918)
0.0	1039.19507 (95042824)	1191.40295 (95042824)	1324.32520 (95042824)	1339.00659 (95042824)	1792.95654 (95081207)
-5000.0	1643.03699 (95070721)	1664.02954 (95032524)	1554.67603 (95030806)	1466.31628 (95032423)	2031.66675 (95121018)
-10000.0	920.76538 (95110723)	1328.99475 (95032423)	1890.07703 (95110722)	1990.86401 (95080321)	1850.76294 (95092424)
-15000.0	1510.16589 (95013024)	955.63660 (95042706)	1829.60278 (95080321)	808.67841 (95052920)	1891.62012 (95042301)
-20000.0	945.11871 (95111921)	1566.27759 (95080321)	763.38733 (95040122)	1713.52539 (95092424)	1180.57202 (95053103)
-25000.0	1353.60339 (95080321)	738.64032 (95042202)	419.33881 (95102913)	735.41785 (95091221)	1568.27832 (95053103)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	952.50232 (95030904)	1513.07837 (95081921)	1537.48364 (95091822)	1027.88550 (95091003)	1363.94434 (95070722)
20000.0	1095.29175 (95030904)	1846.64404 (95101122)	1147.46655 (95091622)	1527.94556 (95052106)	1373.89575 (95043022)
15000.0	1224.42542 (95030904)	1380.22070 (95053023)	1835.12500 (95102303)	1619.57007 (95043022)	826.38635 (95091903)
10000.0	1263.63306 (95011310)	1347.58301 (95091622)	1770.54211 (95043022)	1607.78040 (95031905)	1305.94836 (95060303)
5000.0	2377.03906 (95011310)	1655.08447 (95040209)	1533.17578 (95060303)	1893.61914 (95121020)	1150.98145 (95121102)
0.0	0.00000 (00000000)	2012.95947 (95021104)	1508.83276 (95032103)	1546.65442 (95032103)	1419.90527 (95032103)
-5000.0	2214.38623 (95073011)	1609.52661 (95050923)	1214.51685 (95032105)	1144.83276 (95073121)	1271.40454 (95042605)
-10000.0	1521.09424 (95042903)	1280.50415 (95120822)	1560.04858 (95062605)	1567.51221 (95060422)	1012.45178 (95032105)
-15000.0	1555.12305 (95042903)	1524.35596 (95050524)	932.12634 (95101904)	1384.28271 (95062605)	979.78760 (95020206)
-20000.0	1425.73169 (95042903)	1835.68750 (95042203)	1066.86340 (95120822)	959.58685 (95081920)	1161.85547 (95062605)
-25000.0	1256.15576 (95042903)	1350.25903 (95040123)	1355.02759 (95050523)	822.46008 (95101904)	1367.30066 (95081920)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	1185.54810 (95043022)
20000.0	1171.99976 (95040905)
15000.0	1146.22144 (95041304)
10000.0	1103.71021 (95041303)
5000.0	687.65430 (95082323)
0.0	1251.81348 (95032103)
-5000.0	867.68158 (95121101)
-10000.0	1239.07690 (95032323)
-15000.0	1526.13257 (95052104)
-20000.0	1191.87085 (95080504)
-25000.0	989.49854 (95062605)

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*** THE   2ND HIGHEST  1-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL      ***
          INCLUDING SOURCE(S):       01      , 02      ,

                  *** NETWORK ID: 001      ;  NETWORK TYPE: GRIDCART ***

                      ** CONC OF NOX      IN MICROGRAMS/M**3                  **
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Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	499.19403 (95091322)	729.95166 (95112223)	619.46204 (95032206)	1120.03564 (95072803)	1516.10522 (95080922)
20000.0	1110.90210 (95091024)	599.59180 (95091322)	906.62610 (95120919)	1654.33911 (95080322)	1669.98657 (95091823)
15000.0	980.57971 (95060402)	1052.33435 (95091821)	741.10193 (95091322)	1184.23315 (95102503)	1150.33118 (95073006)
10000.0	1197.47070 (95070321)	911.62036 (95060402)	1429.03137 (95062620)	959.02087 (95052606)	1810.21143 (95080322)
5000.0	1377.41479 (95072521)	979.59619 (95052823)	1457.44250 (95043001)	1134.78845 (95101119)	1549.76270 (95102110)
0.0	572.38641 (95073003)	673.79822 (95073003)	759.02094 (95073003)	980.09326 (95081207)	1575.66064 (95020117)
-5000.0	1627.77356 (95111923)	1548.67847 (95021604)	1052.18335 (95091223)	1449.69849 (95050610)	1666.83679 (95031010)
-10000.0	787.63220 (95072520)	1096.02759 (95051224)	1354.17114 (95081622)	1787.64526 (95081623)	1335.24158 (95042901)
-15000.0	579.45532 (95090821)	887.98853 (95092521)	1630.49182 (95081623)	781.35358 (95091621)	925.44202 (95042902)
-20000.0	779.15112 (95081205)	1386.50537 (95081623)	655.21246 (95120224)	1091.87671 (95042901)	1125.87378 (95032101)
-25000.0	1191.14465 (95081623)	701.80115 (95040122)	399.06488 (95120912)	649.08862 (95042301)	1493.96777 (95032101)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	887.70868 (95030805)	1193.79053 (95100404)	782.65417 (95062706)	996.90662 (95020204)	828.13647 (95060101)
20000.0	1023.56451 (95030805)	1631.98157 (95100404)	1090.21851 (95042604)	1509.94629 (95022202)	1365.72485 (95022706)
15000.0	1131.02148 (95030805)	1186.35522 (95052901)	1570.64160 (95053024)	1600.86328 (95022706)	826.11383 (95081904)
10000.0	1250.33020 (95030904)	1330.36255 (95042604)	1742.71191 (95022706)	1283.36279 (95030706)	870.98877 (95080424)
5000.0	2020.38025 (95102408)	1255.79102 (95112209)	1268.75000 (95113019)	1497.31604 (95041303)	978.23816 (95080124)
0.0	0.00000 (00000000)	1968.39063 (95021409)	1416.18896 (95041223)	1424.46509 (95041223)	1293.73291 (95041223)
-5000.0	1654.28271 (95032111)	1416.74146 (95122714)	1086.05859 (95040210)	912.05884 (95112201)	810.24585 (95081704)
-10000.0	1254.28857 (95042906)	1103.23999 (95033111)	1176.18555 (95050601)	882.54773 (95052104)	785.34729 (95040404)
-15000.0	1311.13135 (95042906)	1182.55762 (95022122)	902.89026 (95090721)	990.45850 (95050601)	854.50433 (95080504)
-20000.0	1208.37549 (95042906)	1577.70313 (95120821)	789.20465 (95051323)	885.22839 (95052902)	813.80835 (95050601)
-25000.0	1058.31128 (95042906)	1143.72595 (95120821)	1105.91138 (95050524)	612.91095 (95061122)	490.77829 (95021412)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	1175.81006 (95022706)
20000.0	1046.70068 (95043005)
15000.0	857.64722 (95051123)
10000.0	840.73486 (95053124)
5000.0	679.70740 (95070723)
0.0	1134.11279 (95041223)
-5000.0	776.70288 (95051121)
-10000.0	679.95538 (95031102)
-15000.0	802.87170 (95040404)
-20000.0	900.72913 (95020206)
-25000.0	684.44543 (95050601)

*** THE 3RD HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF NOX IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	449.86963 (95102504)	701.59106 (95102824)	576.27673 (95102503)	844.37024 (95072801)	1231.05200 (95060103)
20000.0	643.65906 (95070324)	547.78986 (95043021)	882.30566 (95081422)	1452.52649 (95062124)	1639.83716 (95091722)
15000.0	928.99695 (95120921)	993.26208 (95060401)	687.49500 (95043021)	1146.10144 (95080122)	1091.76709 (95030122)
10000.0	1064.49475 (95043001)	820.36377 (95072723)	1228.67017 (95040406)	909.88843 (95091322)	1648.23193 (95062124)
5000.0	885.88867 (95021606)	693.80762 (95021606)	1199.76685 (95052403)	1069.50317 (95060402)	1466.28491 (95052608)
0.0	490.35349 (95102024)	581.06635 (95102024)	690.60974 (95081207)	847.91016 (95020117)	1529.02856 (95051208)
-5000.0	1144.53381 (95021604)	1219.84717 (95042703)	1048.01880 (95042703)	1343.40784 (95051224)	1408.93433 (95020209)
-10000.0	651.78271 (95112220)	839.45477 (95110723)	1244.47070 (95090520)	1050.27673 (95121018)	1184.47034 (95041402)
-15000.0	519.08527 (95110722)	745.68970 (95031008)	740.43011 (95092520)	740.41437 (95041401)	828.33777 (95032302)
-20000.0	648.11292 (95121018)	595.53064 (95092520)	648.31555 (95011613)	935.86646 (95041402)	911.31543 (95110423)
-25000.0	490.87390 (95092520)	481.91348 (95011613)	389.55289 (95022701)	541.17029 (95032302)	713.92053 (95042905)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	695.09216 (95070404)	1070.28271 (95073004)	780.95959 (95041123)	937.13428 (95081702)	635.71497 (95102906)
20000.0	812.22754 (95070404)	1219.10474 (95072904)	738.10388 (95072902)	1458.77051 (95070722)	726.03192 (95040422)
15000.0	932.26593 (95070404)	1070.20996 (95072904)	1103.70007 (95052106)	891.17926 (95040422)	825.19379 (95040905)
10000.0	1118.68237 (95102408)	1003.30457 (95010912)	1069.64954 (95040422)	1077.33679 (95081710)	773.15564 (95101802)
5000.0	1728.51514 (95052508)	1222.21423 (95121609)	1128.30225 (95080424)	1163.25732 (95020305)	899.58484 (95031902)
0.0	0.00000 (00000000)	1966.79077 (95013110)	1321.13599 (95031903)	1311.47095 (95031903)	1182.28589 (95031903)
-5000.0	1634.80725 (95051617)	1375.03455 (95010714)	981.59644 (95123012)	877.69812 (95032323)	625.47546 (95030406)
-10000.0	1209.35828 (95073011)	1023.72241 (95051323)	951.31372 (95081721)	852.97406 (95042606)	604.76794 (95082520)
-15000.0	882.50391 (95032320)	767.96814 (95050609)	898.18390 (95061123)	781.16589 (95081721)	829.53662 (95041501)
-20000.0	765.30786 (95032320)	854.53955 (95081823)	735.18640 (95050521)	731.15088 (95051301)	632.38367 (95081721)
-25000.0	654.90771 (95032320)	1029.67700 (95081822)	769.69550 (95081104)	546.47144 (95030907)	487.48495 (95082222)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	606.29596 (95040422)
20000.0	785.91833 (95020705)
15000.0	854.39709 (95020306)
10000.0	834.47119 (95040721)
5000.0	555.70032 (95092406)
0.0	1032.36670 (95031903)
-5000.0	650.88782 (95090223)
-10000.0	504.51965 (95071021)
-15000.0	794.18274 (95060422)
-20000.0	702.46155 (95052221)
-25000.0	525.88544 (95081721)

APPENDIX-D

100 Highest 24-hr PM Concentrations in $\mu g/m^3$ for 1200 MW Generation Capacity Estimated by ISCST3.

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	$\mu g/m^3$	YYMMDDHH	X	Y		$\mu g/m^3$	YYMMDDHH	X	Y
1	111.9	95061224	5000	5000	41	47.6	95052024	-5000	0
2	100.9	95061324	5000	5000	42	47.4	95061324	20000	15000
3	71.4	95080824	5000	-5000	43	46.4	95032924	5000	-10000
4	69.0	95102124	-5000	5000	44	46.3	95030524	5000	-10000
5	68.0	95091724	-5000	20000	45	45.7	95022824	10000	0
6	64.5	95021224	5000	-5000	46	45.7	95050724	5000	-10000
7	64.2	95022824	5000	0	47	45.4	95111624	5000	-5000
8	62.1	95072424	-5000	5000	48	43.8	95111224	5000	-5000
9	61.3	95121424	5000	0	49	43.1	95070524	5000	-10000
10	60.3	95112724	5000	0	50	43.0	95052424	-15000	5000
11	59.7	95061224	25000	20000	51	42.8	95031024	-5000	0
12	59.3	95112824	5000	0	52	42.7	95101924	-5000	0
13	59.1	95122224	5000	-15000	53	42.6	95120624	5000	0
14	59.0	95070224	5000	-5000	54	42.1	95012424	10000	-15000
15	58.1	95031224	-5000	0	55	41.6	95121124	-5000	5000
16	57.4	95111324	5000	0	56	40.9	95041324	10000	0
17	57.4	95011124	-5000	5000	57	40.9	95121724	5000	-25000
18	56.6	95021124	5000	0	58	40.9	95121624	0	-5000
19	56.6	95071124	5000	-5000	59	40.8	95071624	10000	-5000
20	55.7	95061724	5000	0	60	40.4	95112824	10000	0
21	54.8	95061324	25000	20000	61	40.3	95102124	-10000	10000
22	54.1	95021524	-5000	5000	62	40.3	95123024	5000	0
23	53.9	95091724	-5000	25000	63	39.8	95122224	5000	-20000
24	53.2	95061224	10000	10000	64	39.8	95121224	5000	-5000
25	53.2	95012424	5000	-10000	65	39.4	95041324	15000	0
26	53.1	95122924	5000	-5000	66	39.1	95050824	0	-5000
27	53.0	95052024	-15000	5000	67	39.1	95011324	0	5000
28	52.1	95061224	20000	15000	68	39.0	95071324	5000	-5000
29	51.5	95110324	0	5000	69	38.7	95120924	-5000	5000
30	50.6	95083124	5000	-5000	70	38.5	95012324	5000	-5000
31	50.3	95081224	-5000	0	71	38.4	95031224	-10000	0
32	49.8	95122824	5000	-5000	72	38.1	95092324	5000	0
33	49.4	95071924	5000	-5000	73	38.1	95072424	-10000	10000
34	49.3	95111424	5000	-10000	74	37.8	95122724	5000	-5000
35	48.7	95061124	10000	-15000	75	37.6	95012724	5000	0
36	48.7	95122724	5000	0	76	37.5	95051124	0	-5000
37	48.6	95052524	0	5000	77	37.3	95090124	5000	-5000
38	48.2	95122624	5000	0	78	37.2	95121424	10000	0
39	48.1	95121724	5000	-20000	79	37.1	95011024	-5000	5000
40	47.9	95061324	10000	10000	80	37.0	95122624	5000	-5000

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	μg/m³	YYMMDDHH	X	Y		μg/m³	YYMMDDHH	X	Y
81	36.9	95011124	-5000	10000	91	35.8	95081224	-10000	-5000
82	36.9	95102424	-5000	-5000	92	35.8	95111324	10000	0
83	36.9	95120524	5000	-5000	93	35.6	95060724	0	-5000
84	36.7	95031024	-5000	-5000	94	35.3	95040424	-5000	5000
85	36.5	95061024	5000	-5000	95	35.3	95052624	-5000	5000
86	36.3	95080824	10000	-10000	96	35.0	95042924	0	-10000
87	36.2	95061724	10000	0	97	34.9	95111424	5000	0
88	36.1	95042924	0	-15000	98	34.9	95081724	10000	15000
89	36.1	95111524	5000	-5000	99	34.8	95041324	20000	0
90	35.9	95121024	15000	5000	100	34.8	95112724	10000	0

100 Highest 24-hr PM Concentrations in μg/m^3 for 3600 MW Generation Capacity Estimated by ISCST3

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	μg/m^3	YYMMDDHH	X	Y		μg/m^3	YYMMDDHH	X	Y
1	331.0	95061224	5000	5000	41	140.7	95052024	-5000	0
2	298.4	95061324	5000	5000	42	140.0	95061324	20000	15000
3	211.0	95080824	5000	-5000	43	137.3	95032924	5000	-10000
4	204.0	95102124	-5000	5000	44	136.9	95030524	5000	-10000
5	201.1	95091724	-5000	20000	45	135.1	95022824	10000	0
6	190.7	95021224	5000	-5000	46	135.1	95050724	5000	-10000
7	189.8	95022824	5000	0	47	134.1	95111624	5000	-5000
8	183.5	95072424	-5000	5000	48	129.4	95111224	5000	-5000
9	181.2	95121424	5000	0	49	127.3	95070524	5000	-10000
10	178.3	95112724	5000	0	50	127.3	95052424	-15000	5000
11	176.5	95061224	25000	20000	51	126.4	95031024	-5000	0
12	175.3	95112824	5000	0	52	126.4	95101924	-5000	0
13	174.7	95122224	5000	-15000	53	126.1	95120624	5000	0
14	174.3	95070224	5000	-5000	54	124.3	95012424	10000	-15000
15	171.9	95031224	-5000	0	55	122.9	95121124	-5000	5000
16	169.8	95111324	5000	0	56	121.0	95041324	10000	0
17	169.7	95011124	-5000	5000	57	120.8	95121724	5000	-25000
18	167.3	95021124	5000	0	58	120.8	95121624	0	-5000
19	167.3	95071124	5000	-5000	59	120.7	95071624	10000	-5000
20	164.6	95061724	5000	0	60	119.5	95112824	10000	0
21	161.9	95061324	25000	20000	61	119.2	95102124	-10000	10000
22	160.0	95021524	-5000	5000	62	119.1	95123024	5000	0
23	159.3	95091724	-5000	25000	63	117.8	95122224	5000	-20000
24	157.4	95061224	10000	10000	64	117.7	95121224	5000	-5000
25	157.2	95012424	5000	-10000	65	116.4	95041324	15000	0
26	156.9	95122924	5000	-5000	66	115.7	95050824	0	-5000
27	156.6	95052024	-15000	5000	67	115.5	95011324	0	5000
28	153.9	95061224	20000	15000	68	115.3	95071324	5000	-5000
29	152.1	95110324	0	5000	69	114.4	95120924	-5000	5000
30	149.5	95083124	5000	-5000	70	113.8	95012324	5000	-5000
31	148.8	95081224	-5000	0	71	113.5	95031224	-10000	0
32	147.2	95122824	5000	-5000	72	112.6	95092324	5000	0
33	146.0	95071924	5000	-5000	73	112.6	95072424	-10000	10000
34	145.8	95111424	5000	-10000	74	111.6	95122724	5000	-5000
35	144.0	95061124	10000	-15000	75	111.2	95012724	5000	0
36	143.9	95122724	5000	0	76	110.9	95051124	0	-5000
37	143.6	95052524	0	5000	77	110.1	95090124	5000	-5000
38	142.4	95122624	5000	0	78	110.0	95121424	10000	0
39	142.3	95121724	5000	-20000	79	109.7	95011024	-5000	5000
40	141.5	95061324	10000	10000	80	109.4	95122624	5000	-5000

Rank	Conc.	Occurrence			Rank	Conc.	Occurrence		
		Time	Location (m)				Time	Location (m)	
	$\mu g/m^3$	YYMMDDHH	X	Y		$\mu g/m^3$	YYMMDDHH	X	Y
81	109.2	95011124	-5000	10000	91	106.0	95081224	-10000	-5000
82	109.2	95102424	-5000	-5000	92	105.9	95111324	10000	0
83	109.0	95120524	5000	-5000	93	105.2	95060724	0	-5000
84	108.6	95031024	-5000	-5000	94	104.4	95040424	-5000	5000
85	108.0	95061024	5000	-5000	95	104.3	95052624	-5000	5000
86	107.2	95080824	10000	-10000	96	103.5	95042924	0	-10000
87	106.9	95061724	10000	0	97	103.2	95111424	5000	0
88	106.9	95042924	0	-15000	98	103.2	95081724	10000	15000
89	106.7	95111524	5000	-5000	99	103.0	95041324	20000	0
90	106.3	95121024	15000	5000	100	102.9	95112724	10000	0

The Annual Estimated PM concentrations for 1200 MW Generation Capacity.

*** THE ANNUAL (1 YRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF PM IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00	0.00	5000.00	10000.00	15000.00
25000.00	0.95787	0.96747	0.79114	1.02492	1.04678	0.97319	0.84344	0.88297	1.06594
20000.00	1.24791	1.19834	1.10478	1.07219	1.30944	1.18695	1.25276	1.26062	0.89261
15000.00	1.25477	1.58572	1.57622	1.41954	1.68373	1.46640	1.48069	1.51705	1.70975
10000.00	1.19378	1.32516	2.06727	2.20056	1.70966	1.81782	1.93439	2.30376	1.75102
5000.00	1.45995	1.54587	1.88176	2.18972	3.23420	2.00072	2.99745	2.17603	2.43777
0.00	0.91637	1.13183	1.45583	2.00910	3.32172	0.00000	5.69611	4.87986	3.82445
-5000.00	0.74858	0.93922	1.01761	1.67515	2.71586	2.64534	8.19092	3.09240	1.94135
-10000.00	0.59671	0.95237	1.53770	1.63457	1.74752	1.66337	6.82945	4.30981	2.68752
-15000.00	0.84852	1.12424	1.16180	1.15441	1.37726	1.21094	4.23521	4.44337	2.88044
-20000.00	0.85560	0.88934	0.88458	0.98111	1.11308	0.94276	3.02802	3.45480	2.92761
-25000.00	0.71697	0.67358	0.68899	0.80370	0.95568	0.76335	2.12236	2.58464	2.75492

Y-COORD (METERS)	X-COORD (METERS) 20000.00	25000.00
25000.00	0.68209	1.06286
20000.00	1.31909	1.36831
15000.00	1.51836	1.17398
10000.00	1.35211	1.36739
5000.00	1.91619	1.59834
0.00	3.05971	2.50567
-5000.00	1.46521	1.36312
-10000.00	1.63248	1.30087
-15000.00	2.11007	1.65830
-20000.00	2.15150	1.75455
-25000.00	2.12197	1.71470

The Highest Three PM Concentrations at all Receptors for 1200 MW Generation Capacity.

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	17.53614 (95102124)	15.46935 (95120924)	15.71525 (95011124)	24.84726 (95072824)	53.88759 (95091724)
20000.0	17.93423 (95060424)	21.61015 (95102124)	18.52666 (95041424)	21.86192 (95120324)	68.00740 (95091724)
15000.0	17.49156 (95072724)	29.45477 (95110324)	28.17403 (95102124)	28.37049 (95011124)	32.02359 (95011224)
10000.0	29.96320 (95052024)	18.46823 (95051924)	34.49328 (95121124)	40.30962 (95102124)	36.93646 (95011124)
5000.0	27.15310 (95072524)	26.09735 (95051924)	52.95955 (95052024)	32.24282 (95052024)	68.98866 (95102124)
0.0	17.49983 (95031224)	21.57614 (95031224)	27.78582 (95031224)	38.39098 (95031224)	58.12643 (95031224)
-5000.0	21.41807c(95111924)	25.53080 (95042724)	25.06682 (95030824)	35.84161c(95081224)	36.92994 (95102424)
-10000.0	15.94050c(95081224)	19.66062c(95081224)	23.83423 (95110724)	25.25378c(95081624)	30.10335 (95102324)
-15000.0	19.04266 (95013024)	24.12715 (95042724)	23.07065 (95080324)	21.00766c(95032224)	28.34636 (95042324)
-20000.0	20.70807 (95042724)	19.75021 (95080324)	20.68970 (95041324)	21.61389 (95092424)	16.53401 (95050824)
-25000.0	17.06846 (95080324)	14.35192 (95041324)	10.94538c(95032224)	13.41661 (95102324)	22.41472 (95032124)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	17.31049 (95030824)	21.61248 (95081924)	24.00380c(95091824)	22.31998 (95091024)	17.75706 (95070724)
20000.0	20.14120 (95030824)	23.28553 (95101124)	17.77397 (95072924)	19.91625 (95052124)	24.42948 (95061224)
15000.0	22.76072 (95030824)	26.12255 (95112324)	34.89492c(95081724)	33.81802 (95061224)	52.06149 (95061224)
10000.0	29.43781 (95110324)	24.03547 (95072924)	53.23520 (95061224)	30.08698 (95102824)	22.78645 (95101824)
5000.0	51.45609 (95110324)	111.94971 (95061224)	33.01970 (95101824)	35.94298 (95121024)	21.05886 (95121024)
0.0	0.00000 (00000000)	64.18151 (95022824)	45.70860 (95022824)	39.37313 (95041324)	34.82823 (95041324)
-5000.0	40.86605 (95121624)	71.36492 (95080824)	40.82672 (95071624)	24.41428 (95072024)	16.72901c(95042624)
-10000.0	34.99676 (95042924)	53.15483 (95012424)	36.26754 (95080824)	26.64100c(95080124)	20.45574 (95071624)
-15000.0	36.14251 (95042924)	59.09755 (95122224)	48.70882 (95061124)	23.69260 (95080824)	22.84443 (95121324)
-20000.0	33.21518 (95042924)	48.13788 (95121724)	25.69583 (95012424)	24.32724 (95012424)	17.55057 (95080824)
-25000.0	29.18462 (95042924)	40.87426 (95121724)	34.27568 (95050524)	26.31188 (95061124)	17.24118 (95081924)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	18.94014 (95061224)
20000.0	59.68274 (95061224)
15000.0	14.45346 (95041324)
10000.0	20.30606 (95121024)
5000.0	15.58865 (95121824)
0.0	30.04514 (95041324)
-5000.0	14.91914 (95100824)
-10000.0	17.85264 (95071524)
-15000.0	24.66346 (95071624)
-20000.0	19.77741 (95121324)
-25000.0	13.95478 (95080824)

*** THE 2ND HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF PM IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	16.95514 (95072424)	15.08831 (95102124)	9.58693c(95032224)	19.37651 (95011224)	19.67222 (95111824)
20000.0	15.46527 (95110324)	20.87975 (95072424)	17.84407 (95031624)	20.86226 (95080324)	21.97351c(95091824)
15000.0	16.73157 (95041024)	20.67698c(95091924)	27.09515 (95072424)	17.41784 (95052724)	24.10284 (95042924)
10000.0	19.42386 (95080524)	17.84465 (95052024)	31.87911 (95110824)	38.07866 (95072424)	29.25282 (95011224)
5000.0	20.71740 (95053124)	24.89505 (95052424)	43.04049 (95052424)	30.41310 (95051924)	62.06341 (95072424)
0.0	17.44773 (95042824)	20.26287 (95042824)	23.97038c(95081224)	32.45741c(95081224)	50.32051c(95081224)
-5000.0	20.71812 (95070724)	20.98283 (95032524)	16.94416 (95042724)	31.74475 (95060324)	36.74881 (95031024)
-10000.0	12.31025 (95072524)	18.98786 (95060324)	23.46761 (95030924)	25.10410 (95080324)	24.38236 (95022624)
-15000.0	13.17353 (95030924)	19.13965 (95030924)	22.50421c(95081624)	17.93617 (95041324)	20.25197 (95032324)
-20000.0	14.33059c(95081224)	18.96940c(95081624)	13.77425 (95041524)	17.22205 (95102324)	16.41608 (95042424)
-25000.0	16.21252c(95081624)	11.63387 (95102424)	9.73875 (95022624)	11.34186 (95091224)	19.77544 (95053124)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	14.15508 (95072324)	15.71531c(95100424)	13.31418 (95010924)	21.70543c(95081724)	11.23567 (95112224)
20000.0	17.18012 (95072324)	21.47347c(95100424)	16.76603 (95091624)	19.08355 (95022224)	21.81618 (95061324)
15000.0	21.40431 (95110324)	24.20311 (95030224)	23.14028 (95102324)	30.28768 (95061324)	47.36032 (95061324)
10000.0	27.08779 (95072324)	23.98866 (95010924)	47.87518 (95061324)	28.79041 (95031924)	16.46755 (95060324)
5000.0	48.58466 (95052524)	100.94351 (95061324)	24.93028 (95012924)	26.08851 (95021424)	17.36214 (95090224)
0.0	0.00000 (00000000)	61.29745 (95121424)	40.94141 (95041324)	33.95797 (95022824)	26.64374 (95022824)
-5000.0	39.14918 (95050824)	64.48519 (95021224)	27.71631 (95022424)	20.86777 (95071524)	12.47867 (95090224)
-10000.0	31.60077 (95120224)	49.30907 (95111424)	32.23833 (95071124)	24.56444 (95071624)	14.44143 (95082524)
-15000.0	25.05673 (95120224)	32.94189 (95112524)	42.05276 (95012424)	22.13522 (95071124)	20.59257 (95052224)
-20000.0	20.05317 (95120224)	39.83661 (95122224)	25.30790 (95111424)	21.13933 (95061124)	16.72428 (95071124)
-25000.0	16.39472 (95120224)	29.45857 (95040124)	28.02714 (95112824)	24.11846 (95012424)	15.76112 (95080824)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	16.88102 (95061324)
20000.0	54.77353 (95061324)
15000.0	12.62666 (95051124)
10000.0	17.32978 (95012924)
5000.0	14.94637 (95121024)
0.0	21.76750 (95022824)
-5000.0	13.41407 (95013024)
-10000.0	15.62433 (95032324)
-15000.0	19.24414 (95052124)
-20000.0	17.60871 (95052224)
-25000.0	13.39401 (95071124)

*** THE 3RD HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF PM IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	13.46223 (95062724)	13.47353 (95031624)	9.13153 (95020724)	17.53898c(95020324)	19.11756 (95080924)
20000.0	14.95330c(95091924)	16.65345 (95062724)	15.82739 (95102124)	19.25928 (95011124)	14.81508 (95111824)
15000.0	16.68343 (95070324)	19.56299 (95121124)	21.38443 (95062724)	16.39454c(95081524)	22.11990 (95040424)
10000.0	17.72473 (95043024)	16.61294 (95072724)	24.48046 (95110324)	31.12197 (95021524)	23.49349 (95120324)
5000.0	17.18975 (95020424)	19.72348 (95052824)	31.55454 (95043024)	27.23598 (95041024)	57.39876 (95011124)
0.0	15.61955c(95081224)	18.94362c(95081224)	23.09121 (95042824)	27.81322 (95052024)	47.58007 (95052024)
-5000.0	14.43217 (95021624)	19.52829 (95021624)	15.26852c(95081224)	23.99008 (95042824)	31.37263 (95042724)
-10000.0	11.61053 (95110724)	16.75816 (95032424)	20.51932 (95042824)	21.43731 (95042724)	23.86267 (95041424)
-15000.0	11.14892 (95042824)	18.36453 (95092524)	16.01795 (95042724)	15.69558 (95041524)	18.57757 (95021824)
-20000.0	13.96887 (95030924)	12.43214 (95042724)	12.45225c(95032224)	16.32795 (95041424)	14.97583 (95032124)
-25000.0	10.05931 (95042724)	9.37004 (95022624)	9.48980 (95042024)	10.78343 (95042324)	14.33496 (95042424)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	13.79621 (95110324)	14.81943 (95073024)	12.81868 (95091724)	13.25338 (95062724)	10.98479 (95060124)
20000.0	16.84661 (95110324)	15.53293 (95072924)	14.34498c(95042624)	18.47460 (95070724)	17.62562 (95043024)
15000.0	21.32853 (95072324)	22.90247 (95103124)	22.77394 (95052124)	20.80660 (95043024)	19.64412 (95040924)
10000.0	26.94562 (95052524)	21.32902 (95022224)	24.41769 (95102924)	23.62728 (95061224)	15.13453 (95012924)
5000.0	39.05743 (95011324)	31.66953 (95061424)	22.48421 (95060624)	22.26085 (95113024)	14.63858 (95123124)
0.0	0.00000 (00000000)	60.30482 (95112724)	40.43528 (95112824)	28.99503 (95112824)	22.51163 (95112824)
-5000.0	37.50064 (95051124)	58.95549 (95070224)	27.31470 (95071524)	18.92594 (95112824)	11.67618 (95100824)
-10000.0	24.30898 (95121624)	46.42839 (95032924)	30.20528 (95021224)	21.71589 (95080824)	13.78140 (95071524)
-15000.0	17.97987 (95060524)	29.93777 (95101424)	28.83066 (95083124)	20.15958 (95070224)	15.47351 (95071924)
-20000.0	14.72463 (95060524)	32.51889 (95101424)	24.11951 (95030524)	18.44139 (95083124)	15.21919 (95070224)
-25000.0	12.29561 (95060524)	24.09176 (95050824)	21.00568 (95051324)	17.82251 (95083124)	14.36828 (95122724)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	15.10680 (95043024)
20000.0	25.87232 (95061424)
15000.0	12.37081 (95102824)
10000.0	14.95343 (95040724)
5000.0	14.76327 (95083024)
0.0	18.36310 (95112824)
-5000.0	12.32986 (95090224)
-10000.0	15.29309 (95072024)
-15000.0	14.11183c(95080124)
-20000.0	15.02907 (95080524)
-25000.0	12.65518 (95050624)

The Annual Estimated PM concentrations for 3600 MW Generation Capacity.

*** THE ANNUAL (1 YRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF PM IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00	0.00	5000.00	10000.00	15000.00
25000.00	2.83197	2.86034	2.33904	3.03021	3.09483	2.87725	2.49366	2.61053	3.15147
20000.00	3.68947	3.54290	3.26631	3.16995	3.87139	3.50924	3.70382	3.72704	2.63904
15000.00	3.70974	4.68821	4.66011	4.19692	4.97798	4.33544	4.37769	4.48520	5.05492
10000.00	3.52944	3.91786	6.11192	6.50599	5.05466	5.37442	5.71907	6.81111	5.17694
5000.00	4.31638	4.57040	5.56346	6.47395	9.56198	5.91517	8.86202	6.43346	7.20733
0.00	2.70928	3.34629	4.30418	5.93995	9.82072	0.00000	16.84066	14.42740	11.30707
-5000.00	2.21319	2.77682	3.00859	4.95263	8.02951	7.82099	24.21666	9.14276	5.73963
-10000.00	1.76419	2.81569	4.54625	4.83263	5.16657	4.91778	20.19138	12.74206	7.94572
-15000.00	2.50867	3.32385	3.43489	3.41304	4.07189	3.58016	12.52148	13.13693	8.51609
-20000.00	2.52959	2.62936	2.61529	2.90068	3.29084	2.78729	8.95240	10.21419	8.65553
-25000.00	2.11973	1.99146	2.03703	2.37614	2.82550	2.25687	6.27479	7.64153	8.14498

Y-COORD (METERS)	X-COORD (METERS) 20000.00	25000.00
25000.00	2.01660	3.14236
20000.00	3.89992	4.04543
15000.00	4.48907	3.47089
10000.00	3.99753	4.04271
5000.00	5.66525	4.72553
0.00	9.04609	7.40807
-5000.00	4.33193	4.03009
-10000.00	4.82648	3.84605
-15000.00	6.23846	4.90280
-20000.00	6.36095	5.18738
-25000.00	6.27367	5.06954

The Highest Three PM Concentrations at all Receptors for 3600 MW Generation Capacity.

*** THE 1ST HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF PM IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-25000.00	-20000.00	X-COORD (METERS) -15000.00	-10000.00	-5000.00
25000.0	51.84599 (95102124)	45.73546 (95120924)	46.46249 (95011124)	73.46145 (95072824)	159.31984 (95091724)
20000.0	53.02294 (95060424)	63.89087 (95102124)	54.77448 (95041424)	64.63525 (95120324)	201.06538 (95091724)
15000.0	51.71417 (95072724)	87.08367 (95110324)	83.29711 (95102124)	83.87798 (95011124)	94.67844 (95011224)
10000.0	88.58685 (95052024)	54.60173 (95051924)	101.98011 (95121124)	119.17628 (95102124)	109.20342 (95011124)
5000.0	80.27872 (95072524)	77.15739 (95051924)	156.57603 (95052024)	95.32658 (95052024)	203.96648 (95102124)
0.0	51.73862 (95031224)	63.79033 (95031224)	82.14936 (95031224)	113.50378 (95031224)	171.85207 (95031224)
-5000.0	63.32300c(95111924)	75.48235 (95042724)	74.11059 (95030824)	105.96649c(95081224)	109.18415 (95102424)
-10000.0	47.12843c(95081224)	58.12704c(95081224)	70.46643 (95110724)	74.66335c(95081624)	89.00120 (95102324)
-15000.0	56.30005 (95013024)	71.33245 (95042724)	68.20887 (95080324)	62.10960c(95032224)	83.80663 (95042324)
-20000.0	61.22384 (95042724)	58.39193 (95080324)	61.16954 (95041324)	63.90193 (95092424)	48.88315 (95050824)
-25000.0	50.46329 (95080324)	42.43175 (95041324)	32.36024c(95032224)	39.66651 (95102324)	66.26961 (95032124)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	51.17885 (95030824)	63.89777 (95081924)	70.96777c(95091824)	65.98950 (95091024)	52.49912 (95070724)
20000.0	59.54790 (95030824)	68.84418 (95101124)	52.54914 (95072924)	58.88284 (95052124)	72.22629 (95061224)
15000.0	67.29256 (95030824)	77.23189 (95112324)	103.16760c(95081724)	99.98371 (95061224)	153.92091 (95061224)
10000.0	87.03351 (95110324)	71.06139 (95072924)	157.39104 (95061224)	88.95281 (95102824)	67.36863 (95101824)
5000.0	152.13103 (95110324)	330.98169 (95061224)	97.62344 (95101824)	106.26620 (95121024)	62.26098 (95121024)
0.0	0.00000 (00000000)	189.75401 (95022824)	135.13846 (95022824)	116.40752 (95041324)	102.97042 (95041324)
-5000.0	120.82137 (95121624)	210.99194 (95080824)	120.70508 (95071624)	72.18134 (95072024)	49.45967c(95042624)
-10000.0	103.46869 (95042924)	157.15341 (95012424)	107.22575 (95080824)	78.76469c(95080124)	60.47785 (95071624)
-15000.0	106.85612 (95042924)	174.72321 (95122224)	144.00870 (95061124)	70.04767 (95080824)	67.54005 (95121324)
-20000.0	98.20142 (95042924)	142.32066 (95121724)	75.97027 (95012424)	71.92400 (95012424)	51.88864 (95080824)
-25000.0	86.28498 (95042924)	120.84560 (95121724)	101.33678 (95050524)	77.79166 (95061124)	50.97393 (95081924)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	55.99691 (95061224)
20000.0	176.45337 (95061224)
15000.0	42.73198 (95041324)
10000.0	60.03529 (95121024)
5000.0	46.08820 (95121824)
0.0	88.82912 (95041324)
-5000.0	44.10877 (95100824)
-10000.0	52.78170 (95071524)
-15000.0	72.91805 (95071624)
-20000.0	58.47233 (95121324)
-25000.0	41.25762 (95080824)

*** THE 2ND HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF PM IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	50.12825 (95072424)	44.60892 (95102124)	28.34397c(95032224)	57.28708 (95011224)	58.16134 (95111824)
20000.0	45.72341 (95110324)	61.73144 (95072424)	52.75638 (95031624)	61.67973 (95080324)	64.96516c(95091824)
15000.0	49.46726 (95041024)	61.13194c(95091924)	80.10740 (95072424)	51.49623 (95052724)	71.26058 (95042924)
10000.0	57.42705 (95080524)	52.75809 (95052024)	94.25128 (95110824)	112.58038 (95072424)	86.48660 (95011224)
5000.0	61.25145 (95053124)	73.60275 (95052424)	127.25018 (95052424)	89.91700 (95051924)	183.49182 (95072424)
0.0	51.58459 (95042824)	59.90762 (95042824)	70.86896c(95081224)	95.96103c(95081224)	148.77371c(95081224)
-5000.0	61.25357 (95070724)	62.03619 (95032524)	50.09578 (95042724)	93.85404 (95060324)	108.64867 (95031024)
-10000.0	36.39552 (95072524)	56.13803 (95060324)	69.38251 (95030924)	74.22080 (95080324)	72.08698 (95022624)
-15000.0	38.94783 (95030924)	56.58681 (95030924)	66.53419c(95081624)	53.02868 (95041324)	59.87540 (95032324)
-20000.0	42.36871c(95081224)	56.08344c(95081624)	40.72387 (95041524)	50.91736 (95102324)	48.53448 (95042424)
-25000.0	47.93267c(95081624)	34.39579 (95102424)	28.79282 (95022624)	33.53247 (95091224)	58.46653 (95053124)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	41.84980 (95072324)	46.46267c(95100424)	39.36367 (95010924)	64.17257c(95081724)	33.21851 (95112224)
20000.0	50.79341 (95072324)	63.48679c(95100424)	49.56914 (95091624)	56.42093 (95022224)	64.50001 (95061324)
15000.0	63.28231 (95110324)	71.55701 (95030224)	68.41474 (95102324)	89.54617 (95061324)	140.02180 (95061324)
10000.0	80.08564 (95072324)	70.92300 (95010924)	141.54405 (95061324)	85.11948 (95031924)	48.68667 (95060324)
5000.0	143.64162 (95052524)	298.44171 (95061324)	73.70690 (95012924)	77.13126 (95021424)	51.33153 (95090224)
0.0	0.00000 (00000000)	181.22725 (95121424)	121.04416 (95041324)	100.39749 (95022824)	78.77280 (95022824)
-5000.0	115.74537 (95050824)	190.65190 (95021224)	81.94389 (95022424)	61.69601 (95071524)	36.89345 (95090224)
-10000.0	93.42835 (95120224)	145.78336 (95111424)	95.31330 (95071124)	72.62532 (95071624)	42.69641 (95082524)
-15000.0	74.08077 (95120224)	97.39341 (95112524)	124.32993 (95012424)	65.44325 (95071124)	60.88237 (95052224)
-20000.0	59.28764 (95120224)	117.77780 (95122224)	74.82337 (95111424)	62.49888 (95061124)	49.44569 (95071124)
-25000.0	48.47134 (95120224)	87.09491 (95040124)	82.86283 (95112824)	71.30677 (95012424)	46.59808 (95080824)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	49.90912 (95061324)
20000.0	161.93916 (95061324)
15000.0	37.33099 (95051124)
10000.0	51.23587 (95012924)
5000.0	44.18927 (95121024)
0.0	64.35610 (95022824)
-5000.0	39.65898 (95013024)
-10000.0	46.19366 (95032324)
-15000.0	56.89571 (95052124)
-20000.0	52.06054 (95052224)
-25000.0	39.59967 (95071124)

*** THE 3RD HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 01 , 02 ,

*** NETWORK ID: 001 ; NETWORK TYPE: GRIDCART ***

** CONC OF PM IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) -25000.00	-20000.00	-15000.00	-10000.00	-5000.00
25000.0	39.80138 (95062724)	39.83480 (95031624)	26.99758 (95020724)	51.85437c(95020324)	56.52147 (95080924)
20000.0	44.20975c(95091924)	49.23629 (95062724)	46.79403 (95102124)	56.94046 (95011124)	43.80110 (95111824)
15000.0	49.32492 (95070324)	57.83839 (95121124)	63.22353 (95062724)	48.47081c(95081524)	65.39799 (95040424)
10000.0	52.40356 (95043024)	49.11652 (95072724)	72.37703 (95110324)	92.01279 (95021524)	69.45901 (95120324)
5000.0	50.82186 (95020424)	58.31290 (95052824)	93.29169 (95043024)	80.52377 (95041024)	169.70071 (95011124)
0.0	46.17954c(95081224)	56.00721c(95081224)	68.26965 (95042824)	82.23039 (95052024)	140.67151 (95052024)
-5000.0	42.66903 (95021624)	57.73582 (95021624)	45.14170c(95081224)	70.92719 (95042824)	92.75388 (95042724)
-10000.0	34.32678 (95110724)	49.54586 (95032424)	60.66582 (95042824)	63.37986 (95042724)	70.55051 (95041424)
-15000.0	32.96203 (95042824)	54.29514 (95092524)	47.35742 (95042724)	46.40431 (95041524)	54.92498 (95021824)
-20000.0	41.29927 (95030924)	36.75591 (95042724)	36.81535c(95032224)	48.27393 (95041424)	44.27636 (95032124)
-25000.0	29.74057 (95042724)	27.70272 (95022624)	28.05681 (95042024)	31.88146 (95042324)	42.38163 (95042424)

Y-COORD (METERS)	X-COORD (METERS) 0.00	5000.00	10000.00	15000.00	20000.00
25000.0	40.78880 (95110324)	43.81396 (95073024)	37.89870 (95091724)	39.18392 (95062724)	32.47679 (95060124)
20000.0	49.80737 (95110324)	45.92345 (95072924)	42.41124c(95042624)	54.62056 (95070724)	52.11053 (95043024)
15000.0	63.05825 (95072324)	67.71165 (95103124)	67.33164 (95052124)	61.51517 (95043024)	58.07828 (95040924)
10000.0	79.66531 (95052524)	63.05970 (95022224)	72.19144 (95102924)	69.85455 (95061224)	44.74556 (95012924)
5000.0	115.47414 (95011324)	93.63163 (95061424)	66.47504 (95060624)	65.81470 (95113024)	43.27928 (95123124)
0.0	0.00000 (00000000)	178.29250 (95112724)	119.54779 (95112824)	85.72443 (95112824)	66.55613 (95112824)
-5000.0	110.87145 (95051124)	174.30318 (95070224)	80.75649 (95071524)	55.95494 (95112824)	34.52089 (95100824)
-10000.0	71.87002 (95121624)	137.26656 (95032924)	89.30258 (95021224)	64.20351 (95080824)	40.74502 (95071524)
-15000.0	53.15788 (95060524)	88.51170 (95101424)	85.23849 (95083124)	59.60223 (95070224)	45.74775 (95071924)
-20000.0	43.53370 (95060524)	96.14279 (95101424)	71.30987 (95030524)	54.52237 (95083124)	44.99585 (95070224)
-25000.0	36.35223 (95060524)	71.22782 (95050824)	62.10376 (95051324)	52.69262 (95083124)	42.48012 (95122724)

Y-COORD (METERS)	X-COORD (METERS) 25000.00
25000.0	44.66359 (95043024)
20000.0	76.49209 (95061424)
15000.0	36.57456 (95102824)
10000.0	44.21012 (95040724)
5000.0	43.64792 (95083024)
0.0	54.29091 (95112824)
-5000.0	36.45350 (95090224)
-10000.0	45.21437 (95072024)
-15000.0	41.72194c(95080124)
-20000.0	44.43379 (95080524)
-25000.0	37.41531 (95050624)

APPENDIX-E

Hysplit-4 Particulate Deposition Results.

Latitude deg.	Longitude deg.	Deposition kg/m^2	Latitude deg.	Longitude deg.	Deposition kg/m^2
30.00	36.00	4.88E-06	30.00	52.00	4.05E-06
32.00	36.00	2.12E-06	34.00	52.00	1.80E-06
22.00	38.00	2.80E-05	14.00	54.00	2.01E-06
24.00	38.00	1.97E-04	16.00	54.00	3.84E-06
28.00	38.00	1.82E-05	22.00	54.00	8.56E-06
30.00	38.00	1.45E-05	24.00	54.00	8.68E-06
20.00	40.00	1.17E-04	26.00	54.00	6.99E-06
22.00	40.00	6.78E-05	14.00	56.00	1.29E-06
24.00	40.00	8.14E-05	16.00	56.00	2.69E-06
28.00	40.00	2.52E-05	24.00	56.00	5.51E-06
30.00	40.00	1.35E-05	18.00	36.00	4.61E-06
18.00	42.00	2.64E-05	12.00	38.00	5.93E-07
20.00	42.00	7.52E-05	18.00	38.00	7.10E-06
26.00	42.00	4.56E-05	10.00	40.00	5.95E-07
30.00	42.00	1.80E-05	12.00	40.00	1.25E-06
26.00	44.00	1.43E-04	14.00	40.00	2.47E-06
26.00	46.00	8.72E-05	16.00	40.00	5.19E-06
24.00	48.00	6.31E-05	10.00	42.00	1.13E-06
26.00	48.00	1.62E-03	12.00	42.00	2.60E-06
24.00	50.00	4.36E-05	14.00	42.00	4.67E-06
26.00	50.00	1.36E-04	16.00	42.00	9.64E-06
20.00	36.00	6.24E-06	10.00	44.00	1.63E-06
22.00	36.00	7.59E-06	14.00	44.00	7.99E-06
24.00	36.00	8.68E-06	16.00	44.00	1.42E-05
28.00	36.00	1.17E-05	22.00	44.00	2.71E-05
20.00	38.00	1.48E-05	14.00	46.00	7.81E-06
32.00	38.00	3.56E-06	20.00	46.00	1.51E-05
18.00	40.00	1.47E-05	22.00	46.00	2.80E-05
26.00	40.00	2.52E-05	12.00	48.00	3.95E-06
32.00	40.00	5.25E-06	12.00	50.00	2.54E-06
34.00	40.00	2.52E-06	10.00	52.00	5.93E-07
24.00	42.00	4.26E-05	12.00	52.00	1.53E-06
28.00	42.00	2.97E-05	14.00	52.00	3.14E-06
32.00	42.00	6.87E-06	32.00	52.00	2.57E-06
34.00	42.00	2.87E-06	10.00	54.00	3.15E-07
28.00	44.00	3.63E-05	12.00	54.00	8.33E-07
30.00	44.00	1.69E-05	28.00	54.00	5.00E-06
32.00	44.00	7.12E-06	30.00	54.00	3.52E-06
24.00	46.00	8.23E-05	32.00	54.00	2.69E-06
28.00	46.00	5.03E-05	34.00	54.00	1.89E-06
22.00	48.00	3.19E-05	18.00	56.00	4.27E-06
28.00	48.00	7.99E-05	20.00	56.00	5.25E-06
18.00	50.00	9.38E-06	22.00	56.00	5.45E-06

Latitude deg.	Longitude deg.	Deposition kg/m^2	Latitude deg.	Longitude deg.	Deposition kg/m^2
20.00	50.00	1.38E-05	26.00	56.00	5.13E-06
22.00	50.00	2.32E-05	28.00	56.00	4.28E-06
16.00	52.00	5.26E-06	30.00	56.00	3.71E-06
18.00	52.00	8.02E-06	32.00	56.00	2.88E-06
20.00	52.00	1.09E-05	34.00	56.00	1.93E-06
22.00	52.00	1.41E-05	16.00	58.00	1.88E-06
24.00	52.00	1.89E-05	18.00	58.00	2.95E-06
18.00	54.00	6.06E-06	20.00	58.00	3.60E-06
20.00	54.00	7.65E-06	22.00	58.00	3.70E-06
26.00	36.00	7.26E-06	24.00	58.00	3.83E-06
26.00	38.00	1.45E-05	26.00	58.00	3.77E-06
34.00	38.00	1.68E-06	28.00	58.00	3.61E-06
22.00	42.00	3.21E-05	30.00	58.00	3.53E-06
12.00	44.00	4.60E-06	32.00	58.00	2.91E-06
18.00	44.00	3.18E-05	34.00	58.00	2.00E-06
20.00	44.00	2.01E-05	20.00	60.00	2.40E-06
24.00	44.00	4.52E-05	22.00	60.00	2.50E-06
34.00	44.00	2.79E-06	24.00	60.00	2.69E-06
10.00	46.00	1.68E-06	26.00	60.00	2.88E-06
12.00	46.00	5.10E-06	28.00	60.00	3.17E-06
16.00	46.00	8.86E-06	30.00	60.00	3.19E-06
18.00	46.00	1.06E-05	32.00	60.00	2.68E-06
30.00	46.00	1.89E-05	34.00	60.00	1.90E-06
32.00	46.00	7.11E-06	14.00	36.00	9.99E-07
34.00	46.00	2.56E-06	16.00	36.00	2.54E-06
10.00	48.00	1.34E-06	10.00	38.00	2.52E-07
14.00	48.00	6.12E-06	14.00	38.00	1.40E-06
16.00	48.00	7.64E-06	16.00	38.00	3.20E-06
18.00	48.00	1.01E-05	16.00	60.00	1.20E-06
20.00	48.00	1.57E-05	18.00	60.00	1.89E-06
30.00	48.00	1.65E-05	12.00	36.00	3.57E-07
32.00	48.00	5.55E-06	34.00	36.00	8.71E-07
34.00	48.00	2.07E-06	10.00	56.00	2.52E-07
10.00	50.00	9.75E-07	12.00	56.00	5.52E-07
14.00	50.00	4.56E-06	10.00	58.00	2.16E-07
16.00	50.00	6.62E-06	12.00	58.00	4.49E-07
28.00	50.00	2.03E-05	14.00	58.00	9.23E-07
30.00	50.00	7.47E-06	12.00	60.00	3.61E-07
32.00	50.00	3.42E-06	14.00	60.00	6.70E-07
34.00	50.00	1.81E-06	10.00	60.00	1.80E-07
26.00	52.00	1.34E-05	10.00	36.00	1.22E-07
28.00	52.00	7.34E-06			

Hysplit-4 SO_2 Concentration Results.

Latitude deg.	Longitude deg.	Concentration kg/m^3	Latitude deg.	Longitude deg.	Concentration kg/m^3
30.00	36.00	6.25E-10	18.00	48.00	1.14E-09
30.00	38.00	1.54E-09	20.00	48.00	1.68E-09
26.00	42.00	4.35E-09	22.00	48.00	3.05E-09
26.00	46.00	8.66E-09	14.00	50.00	6.62E-10
20.00	36.00	7.25E-10	32.00	50.00	5.07E-10
32.00	36.00	3.84E-10	12.00	52.00	3.47E-10
20.00	38.00	1.52E-09	14.00	52.00	5.35E-10
22.00	38.00	2.58E-09	16.00	52.00	7.27E-10
24.00	38.00	2.14E-08	18.00	52.00	9.47E-10
20.00	40.00	1.42E-08	24.00	52.00	2.31E-09
22.00	40.00	6.31E-09	26.00	52.00	1.39E-09
24.00	40.00	5.27E-09	28.00	52.00	8.66E-10
28.00	40.00	2.16E-09	30.00	52.00	5.54E-10
30.00	40.00	1.33E-09	32.00	52.00	3.86E-10
32.00	40.00	6.77E-10	34.00	52.00	2.86E-10
18.00	42.00	2.59E-09	12.00	54.00	2.55E-10
30.00	42.00	2.08E-09	14.00	54.00	3.53E-10
32.00	42.00	8.32E-10	16.00	54.00	5.06E-10
26.00	44.00	1.57E-08	24.00	54.00	1.16E-09
28.00	44.00	3.78E-09	26.00	54.00	8.92E-10
28.00	46.00	5.47E-09	28.00	54.00	6.58E-10
26.00	48.00	7.61E-08	30.00	54.00	5.14E-10
16.00	36.00	3.55E-10	32.00	54.00	4.11E-10
18.00	36.00	5.07E-10	34.00	54.00	3.06E-10
22.00	36.00	8.20E-10	16.00	56.00	4.24E-10
24.00	36.00	9.67E-10	18.00	56.00	6.09E-10
26.00	36.00	9.42E-10	24.00	56.00	7.31E-10
18.00	38.00	7.57E-10	26.00	56.00	6.54E-10
26.00	38.00	1.62E-09	28.00	56.00	5.75E-10
28.00	38.00	1.63E-09	30.00	56.00	4.78E-10
26.00	40.00	2.14E-09	32.00	56.00	4.22E-10
20.00	42.00	6.78E-09	34.00	56.00	3.37E-10
22.00	42.00	2.89E-09	26.00	58.00	5.34E-10
24.00	42.00	3.75E-09	28.00	58.00	5.45E-10
28.00	42.00	2.88E-09	30.00	58.00	5.65E-10
34.00	42.00	4.93E-10	32.00	58.00	4.65E-10
30.00	44.00	1.78E-09	34.00	58.00	3.63E-10
32.00	44.00	8.61E-10	28.00	60.00	5.36E-10
34.00	44.00	4.58E-10	30.00	60.00	5.28E-10
24.00	46.00	9.41E-09	32.00	60.00	4.29E-10
30.00	46.00	2.36E-09	34.00	60.00	3.48E-10
32.00	46.00	9.32E-10	12.00	38.00	1.61E-10
34.00	46.00	3.74E-10	14.00	38.00	2.51E-10

Latitude deg.	Longitude deg.	Concentration kg/m^3	Latitude deg.	Longitude deg.	Concentration kg/m^3
16.00	48.00	9.04E-10	16.00	38.00	4.08E-10
24.00	48.00	5.78E-09	32.00	38.00	5.50E-10
28.00	48.00	8.37E-09	16.00	40.00	6.23E-10
30.00	48.00	2.28E-09	34.00	40.00	4.84E-10
32.00	48.00	8.03E-10	16.00	42.00	1.08E-09
34.00	48.00	3.18E-10	16.00	44.00	1.61E-09
16.00	50.00	8.68E-10	14.00	46.00	9.40E-10
18.00	50.00	1.15E-09	16.00	46.00	9.11E-10
20.00	50.00	1.61E-09	10.00	50.00	2.39E-10
22.00	50.00	2.52E-09	12.00	50.00	4.56E-10
24.00	50.00	3.60E-09	18.00	54.00	7.79E-10
26.00	50.00	1.36E-08	20.00	56.00	6.53E-10
28.00	50.00	2.20E-09	22.00	56.00	7.23E-10
30.00	50.00	9.74E-10	16.00	58.00	3.48E-10
34.00	50.00	2.58E-10	18.00	58.00	4.22E-10
20.00	52.00	1.15E-09	20.00	58.00	4.82E-10
22.00	52.00	1.81E-09	22.00	58.00	5.48E-10
20.00	54.00	9.20E-10	24.00	58.00	5.36E-10
22.00	54.00	1.12E-09	18.00	60.00	3.26E-10
28.00	36.00	1.49E-09	20.00	60.00	3.41E-10
10.00	40.00	1.79E-10	22.00	60.00	3.71E-10
12.00	40.00	2.56E-10	24.00	60.00	3.95E-10
14.00	40.00	4.03E-10	26.00	60.00	4.41E-10
18.00	40.00	1.64E-09	34.00	36.00	2.27E-10
10.00	42.00	2.62E-10	34.00	38.00	3.29E-10
12.00	42.00	4.13E-10	16.00	60.00	2.85E-10
14.00	42.00	6.84E-10	14.00	56.00	2.94E-10
10.00	44.00	3.32E-10	12.00	58.00	2.48E-10
12.00	44.00	7.33E-10	14.00	58.00	2.93E-10
14.00	44.00	1.05E-09	12.00	60.00	3.06E-10
18.00	44.00	2.78E-09	14.00	60.00	2.84E-10
20.00	44.00	1.78E-09	10.00	52.00	2.12E-10
22.00	44.00	2.68E-09	10.00	54.00	1.96E-10
24.00	44.00	5.12E-09	10.00	56.00	1.99E-10
10.00	46.00	3.04E-10	12.00	56.00	2.09E-10
12.00	46.00	7.69E-10	10.00	58.00	2.11E-10
18.00	46.00	1.10E-09	10.00	60.00	2.22E-10
20.00	46.00	1.65E-09	14.00	36.00	2.04E-10
22.00	46.00	2.79E-09	10.00	36.00	6.89E-11
10.00	48.00	2.74E-10	12.00	36.00	1.08E-10
12.00	48.00	5.94E-10	10.00	38.00	8.63E-11
14.00	48.00	8.24E-10			

Hysplit-4 NOx Concentration Results.

Latitude deg.	Longitude deg.	Concentration kg/m3	Latitude deg.	Longitude deg.	Concentration kg/m3
30.00	36.00	4.08E-11	24.00	52.00	1.46E-10
30.00	38.00	1.04E-10	26.00	52.00	1.16E-10
26.00	42.00	3.01E-10	28.00	52.00	6.76E-11
26.00	46.00	7.14E-10	30.00	52.00	3.05E-11
20.00	36.00	5.19E-11	32.00	52.00	1.90E-11
32.00	36.00	2.95E-11	34.00	52.00	1.68E-11
20.00	38.00	1.05E-10	14.00	54.00	2.51E-11
22.00	38.00	1.88E-10	16.00	54.00	3.81E-11
24.00	38.00	6.92E-10	18.00	54.00	5.35E-11
20.00	40.00	7.33E-10	22.00	54.00	7.18E-11
22.00	40.00	5.27E-10	24.00	54.00	7.60E-11
24.00	40.00	5.57E-10	26.00	54.00	6.50E-11
28.00	40.00	1.64E-10	28.00	54.00	4.16E-11
30.00	40.00	1.04E-10	30.00	54.00	2.74E-11
32.00	40.00	4.91E-11	32.00	54.00	2.20E-11
18.00	42.00	1.88E-10	34.00	54.00	1.97E-11
30.00	42.00	1.24E-10	22.00	56.00	4.85E-11
32.00	42.00	6.26E-11	24.00	56.00	4.97E-11
26.00	44.00	6.07E-10	26.00	56.00	4.44E-11
28.00	44.00	2.51E-10	28.00	56.00	3.85E-11
28.00	46.00	4.17E-10	30.00	56.00	3.34E-11
26.00	48.00	1.03E-08	32.00	56.00	2.81E-11
22.00	36.00	6.57E-11	34.00	56.00	2.02E-11
24.00	36.00	6.59E-11	24.00	58.00	3.51E-11
26.00	36.00	5.36E-11	26.00	58.00	3.35E-11
26.00	38.00	1.01E-10	28.00	58.00	3.53E-11
28.00	38.00	1.03E-10	30.00	58.00	3.60E-11
26.00	40.00	1.54E-10	32.00	58.00	3.30E-11
20.00	42.00	5.42E-10	34.00	58.00	2.68E-11
22.00	42.00	2.13E-10	24.00	60.00	2.43E-11
24.00	42.00	2.86E-10	26.00	60.00	2.76E-11
28.00	42.00	1.78E-10	28.00	60.00	3.48E-11
34.00	42.00	3.60E-11	30.00	60.00	3.76E-11
30.00	44.00	1.37E-10	32.00	60.00	3.27E-11
32.00	44.00	6.55E-11	34.00	60.00	2.52E-11
24.00	46.00	5.26E-10	16.00	36.00	2.30E-11
30.00	46.00	1.56E-10	18.00	36.00	3.82E-11
32.00	46.00	6.88E-11	18.00	38.00	5.52E-11
24.00	48.00	4.40E-10	32.00	38.00	4.08E-11
28.00	48.00	4.91E-10	18.00	40.00	9.88E-11
30.00	48.00	1.24E-10	34.00	40.00	3.20E-11
22.00	50.00	1.74E-10	12.00	44.00	4.95E-11
24.00	50.00	3.03E-10	16.00	44.00	1.10E-10

Latitude deg.	Longitude deg.	Concentration kg/m3	Latitude deg.	Longitude deg.	Concentration kg/m3
28.00	50.00	1.47E-10	12.00	46.00	5.34E-11
30.00	50.00	6.50E-11	22.00	46.00	1.72E-10
20.00	52.00	9.33E-11	10.00	48.00	2.25E-11
22.00	52.00	1.23E-10	12.00	48.00	4.11E-11
20.00	54.00	6.91E-11	12.00	50.00	3.54E-11
28.00	36.00	9.57E-11	14.00	50.00	4.54E-11
14.00	38.00	1.53E-11	16.00	50.00	5.52E-11
16.00	38.00	2.62E-11	18.00	56.00	4.06E-11
12.00	40.00	1.59E-11	20.00	56.00	4.58E-11
14.00	40.00	2.34E-11	16.00	58.00	2.22E-11
16.00	40.00	4.17E-11	18.00	58.00	2.77E-11
12.00	42.00	2.86E-11	20.00	58.00	3.29E-11
14.00	42.00	4.50E-11	22.00	58.00	3.19E-11
16.00	42.00	7.02E-11	16.00	60.00	2.08E-11
10.00	44.00	2.62E-11	18.00	60.00	2.12E-11
14.00	44.00	7.52E-11	20.00	60.00	2.28E-11
18.00	44.00	1.87E-10	22.00	60.00	2.27E-11
20.00	44.00	1.28E-10	14.00	36.00	1.25E-11
22.00	44.00	1.83E-10	12.00	38.00	1.03E-11
24.00	44.00	3.30E-10	10.00	40.00	1.53E-11
34.00	44.00	3.03E-11	10.00	42.00	1.98E-11
10.00	46.00	2.53E-11	34.00	38.00	2.38E-11
14.00	46.00	6.62E-11	16.00	56.00	2.86E-11
16.00	46.00	6.28E-11	10.00	50.00	1.88E-11
18.00	46.00	7.43E-11	10.00	52.00	1.44E-11
20.00	46.00	1.03E-10	12.00	52.00	2.25E-11
34.00	46.00	2.38E-11	10.00	54.00	1.43E-11
14.00	48.00	5.27E-11	12.00	54.00	1.41E-11
16.00	48.00	5.65E-11	14.00	56.00	2.27E-11
18.00	48.00	7.70E-11	12.00	58.00	1.78E-11
20.00	48.00	1.26E-10	14.00	58.00	2.28E-11
22.00	48.00	2.34E-10	14.00	60.00	1.91E-11
32.00	48.00	5.08E-11	12.00	60.00	2.11E-11
34.00	48.00	1.97E-11	34.00	36.00	1.44E-11
18.00	50.00	7.66E-11	12.00	36.00	7.04E-12
20.00	50.00	1.26E-10	10.00	36.00	4.46E-12
26.00	50.00	1.21E-09	10.00	38.00	7.11E-12
32.00	50.00	2.56E-11	12.00	56.00	1.56E-11
34.00	50.00	1.65E-11	10.00	56.00	1.35E-11
14.00	52.00	3.50E-11	10.00	58.00	1.63E-11
16.00	52.00	4.48E-11	10.00	60.00	1.97E-11
18.00	52.00	6.62E-11			

APPENDIX-F

A Sample Input File for Hysplit-4 Run.

99 10 01 00	Starting time (YY MM DD HH)
4	Number of Sources
27.5 48.0 85.0 2190.0 0.0	Source location and Emission
27.0 47.0 85.0 2190.0 0.0	Latitude Longitude Height Pollutant
26.7 50.0 85.0 2190.0 0.0	Emission kg/hr)
26.0 48.0 85.0 2190.0 0.0	
48	Total run time (hours)
0	Vertical motion calculation method (Default)
5000.0	Top of the model domain (m)
2	Number of input data grids
d:/	Grid directory
metoct011.bin	Filename
d:/	
metoct021.bin	
1	Number of pollutants
nox	Pollutant identification
48.0	Hours of emission
00 00 00 00 00	Release start time (0-values for simulation start time)
1	Number of concentration grids
22.0 48.0	Center of concentration grid (Latitude Longitude)
2.0 2.0	Grid spacing (deg. Latitude Longitude)
24.0 24.0	Grid span (deg. Latitude Longitude)
./	Output directory
out-nox-3	Output filename
1	Number of vertical concentration levels
2	Height of level (m agl)
00 00 00 00 00	Sampling start time (simulation start time)
99 12 31 18 00	Sampling stop time (YY MM DD HH MM)
00 24 00	Sampling interval (24 hr)
0	Number of pollutants depositing
0.0 0.0 0.0	Particle: dia. ((m), density (g/cc), and shape
0.0 0.0 0.0 0.0 0.0	Deposition: vel. (m/s), molecular wt. (g/mole), surface reactivity ratio, diffusivity ratio, effective Henry's constant
0.0 0.0 0.0	Wet removal: Henry's (Molar/atm), in cloud (L/L), below cloud (1/s)
0.0	Radio active decay half-life (days)
0.0	Pollutant resuspension

Sample ISCST3 runstream file

```
** ISC SHORT TERM MODEL. ISCST3 RUN TO ESTIMATE AMBIENT CONCENTRATIONS OF
** SO2 AS A RESULT OF A THERMAL POWER PLANT EMISSIONS.
** THE THERMAL POWER PLANT IS LOCATED IN GHAZLAN, IN EASTERN PROVINCE OF
** THE KINGDOM OF SAUDI ARABIA.

CO STARTING
  TITLEONE  TEST RUN TO ESTIMATE SO2 CONCENTRATIONS
**  TITLETWO
  MODELOPT  DFAULT  CONC  RURAL
** DEFAULT MODELING OPTIONS SELECTED FOR CONCENTRATION CALCULATION USING
** RURAL COEFFICIENTS
  AVERTIME 1 24 ANNUAL
** CALCULATIONS WILL BE DONE FOR 1 HR, 24 HR AVERAGE PERIODS AND ANNUAL
** AVERAGE FOR THE YEAR 1995
  TERRHGTS  FLAT
** FLAT TERRAIN IS SELECTED
  POLLUTID  SO2
** POLLUTANT IDENTIFICATION IS SO2
  RUNORNOT  RUN
** THE MODEL WILL MAKE THE RUN
  ERRORFIL TRLERR.LST
** ERROR MESSAGE FILENAME TRLERR.LST
CO FINISHED

SO STARTING
** THE PLANT CAPACITY IS 1200 MW
** THE STACK HEIGHT IS 85 M
** THE STACK DIAMETER IS 150 CM
** NUMBER OF STACKS = 02
** TYPE OF FUEL = CRUDE OIL
** STACK ONE IS LOCATED AT (0,0) AND THE STACK TWO IS LOCATED AT (00,20)
SO LOCATION 01  POINT  0.00 0.00 0.00
SO LOCATION 02  POINT  0.00 20.00 0.00
SO SRCPARAM 01 3500.0 85.00 440.00  12.00 1.50
** FOR STACK01,  SOURCE PARAMETERS ARE: POLLUTANT EMISSION = 3500 G/SEC; STACK
** HEIGHT = 85 M; EXIT TEMP = 440 DEG. K,  EXIT VEL = 12 M/S
SO SRCPARAM 02 3500.0 85.00 440.00  12.00 1.50
SO SRCGROUP ALL
** BOTH THE SOURCES WILL BE GROUPED FOR CONCENTRATION ESTIMATION
SO FINISHED


RE STARTING
RE GRIDCART 001 STA
** CARTESIAN GRID RECEPTOR NETWORK IS SELECTED
RE GRIDCART XYINC -25000.00 11.00 5000.00 -25000.00 11.00 5000.00
** UNIFORM CARTESIAN GRID IS SELECTED WITH STARTING BOTH X AND Y AXIS AT
** -25000 M, TOTAL 11 GRIDS IN EACH DIRECTION WITH A UNIFORM GRID SPACING
** OF 5000 M
RE GRIDCART END
RE FINISHED


ME STARTING
```

```
   INPUTFIL  FINALMET.DAT
** METEOROLOGICAL FILE NAME IS FINALMET.DAT
   ANEMHGHT  10.
** ANEMOMETER HEIGHT IS 10 M
   SURFDATA  00024  1995
   UAIRDATA  00024  1995
** SURFACE AND UPPER AIR STATION NUMBERS AND YEAR OF DATA
ME FINISHED

OU STARTING

   RECTABLE ALLAVE FIRST-THIRD
** MAXIMUM THREE VALUES BY RECEPTOR FOR EACH AVERAGING PERIOD WILL BE
** ESTIMATED
     MAXTABLE  ALLAVE 100
** OVERALL 100 MAXIMUM VALUES WILL BE ESTIMATED FOR ALL AVERAGING PERIODS
   MAXIFILE 24 ALL 365.0 MAX-SO2.PLT
** 24-HR CONCENTRATIONS EXCEEDING 365 MICRO GRAM/CUBIC M WILL BE STORED IN
** FILE MAX-SO2.PLT
   MAXIFILE 1 ALL 730.0 MAX-SO21.PLT
** 1-HR CONCENTRATIONS EXCEEDING 730 MICRO GRAM/CUBIC M WILL BE STORED IN
** FILE MAX-SO21.PLT
   PLOTFILE ANNUAL ALL  PLOT-SO2.PLT
** PLOTTING FILE WILL BE GENERATED FOR ANNUAL AVERAGE VALUES

OU FINISHED
```

Table F-1. HYsplit4 meteorological data file parameters, their units and identification codes.

Field Description	Units	ID Code
Pressure at surface	hPa	PRSS
Pressure reduced to mean sea level	hPa	MSLP
Temperature at surface	K	TMPS
Total precipitation (6 h accumulation)	m	TPP6
Momentum flux, u-component at surface	N/m^2	UMOF
Momentum flux, v-component at surface	N/m^2	VMOF
Sensible heat net flux at surface	W/m^2	SHTF
Latent heat net flux at surface	W/m^2	LHTF
Downward short wave radiation flux	W/m^2	DSWF
Temperature at 2 m AGL	K	T02M
Relative humidity at 2 m AGL	%	RH2M
U-component of wind at 10 m AGL	m/s	U10M
V-component of wind at 10 m AGL	m/s	V10M
Volumetric soil moisture content	fraction	SOLW
Total cloud cover, entire atmosphere	%	TCLD
U-component of wind with respect to grid	m/s	UWND
V-component of wind with respect to grid	m/s	VWND
Geopotential height	gpm*	HGTS
Temperature	K	TEMP
Pressure vertical velocity	HPa/s	WWND
Relative humidity	%	RELH

***geopotential meters**
In standard meteorological notation, u-component is parallel to mean wind, v-component is the horizontal crosswind component, and w-component is the vertical.

Planetary Boundary Layer (PBL):

Lower part of the atmosphere, also called as friction layer and is defined as "the region in which the atmosphere experiences surface effects through vertical exchanges of momentum, heat, and moisture" (Panofsky and Dutton, 1984). The PBL is further divided into (a) the laminar sublayer and its height is usually represented by z_o (b) the surface layer (SL) from z_o to h_s and (c) the transition layer from h_s to z_i.

Various boundary layer parameters can be estimated using semiempirical equations. These parameters include; the PBL height 'z_i'; the mixing height 'h'; the roughness length 'z_o'; the friction velocity 'u*'; the surface stress '$\tau(0)$'; eddy viscosity in neutral conditions 'k_m'; the Monin-Obukhov length 'L'; the surface heat flux 'H'; the velocity scale in the mixed layer 'w*'; the temperature scale in mixed layer 'θ*'; and the Richardson number 'Ri'. For the description and equations for these parameters, the readers are refferred to Zannetti, 1990.

Atmospheric Stability:

It is atmosphere's ability to resist or enhance the atmospheric movement. The stability of atmosphere is greatly affected by wind speed and the lapse rate of the atmosphere.

The atmosphere has neutral stability when its lapse rate is equal to adiabatic lapse rate, which is -0.98^0 C/100m height. The atmosphere is stable when its lapse rate is greater than dry adiabatic rate. When atmosphere's lapse rate is less than adiabatic lapse rate it is unstable.

Atmospheric stability can be categorized by several methods or parameters. Empirical methods as suggested by Pasquill and Turner are very commonly used to estimate the stability of atmosphere. These methods are presented in Tables F-2 and F-3 respectively.

Table F-2. Pasquill Stability Classes (Dobbins, 1979; adopted from Pasquill, 1974)

Insolation/Cloud Cover		Surface Wind Speed (m/s) <2.0	2 to <3	3 to <5	5 to <6	≥6
Day	Strong Ins.	A	A-B	B	C	C
	Moderate Ins.	A-B	B	B-C	C-D	D
	Slight Ins.	B	C	C	D	D
Day or Night	Overcast	D	D	D	D	D
Night	Thin o/c ≥0.5 c/c	-	E	D	D	D
	≤0.5 c/c	-	F	E	D	D

A = Very unstable; B = Unstable; C = Slightly Unstable; D = Neutral; E = Slightly stable; F = Stable.
Ins = Insolation; o/c = Overcast; c/c = Cloud Cover

Table F-3. Turner Stability Classes (Panofsky and Dutton, 1984)

Wind Speed (knots)	Net Radiation Index 4	3	2	1	0	-1	-2
0-1	1	1	2	3	4	6	7
2-3	1	2	2	3	4	6	7
4-5	1	2	3	4	4	5	5
6	2	2	3	4	4	5	6
7	2	2	3	4	4	4	5
8-9	2	3	3	4	4	4	5
10	3	3	4	4	4	4	5
11	3	3	4	4	4	4	4
≥12	3	4	4	4	4	4	4

Solar Altitude (a)	Insolation	Insolation Class Number
$60^\circ < a$	Strong	4
$35^\circ < a < 60^\circ$	Moderate	3
$15^\circ < a < 35^\circ$	Weak	2
$a \leq 15^\circ$	Very Weak	1

1 = Very unstable; 2 = Unstable; 3 = Slightly Unstable; 4 = Neutral; 5 = Slightly stable; 6 = Stable; 7 = Very Stable.

The Gaussian Plume Model:

The Gaussian plume model is the most widely used and simple air pollution model. This model assumes that as the plume travels downwind from a stack by prevailing wind, the pollutant concentration in the plume follows the Gaussian distribution in both horizontal and vertical directions.

$$\chi(x, y) = \frac{K.Q}{2\pi.u(h)\sigma y.\sigma z} \exp\left\{-\frac{1}{2}\left(\frac{y}{\sigma y}\right)^2\right\} V.D$$

Where,

Q = pollutant emission rate (mass per unit time)

K = conversion factor to calculate concentration in desired units

σy = standard deviation of lateral concentration distribution (m)

σz = standard deviation of vertical concentration distribution (m)

u(h) = mean wind speed (m/sec) at stack height, h

V = vertical term, which includes the effects of source elevation, receptor elevation, plume rise, limited mixing in vertical, and the gravitational settling and dry deposition of particulates with diameter greater than 0.1μ

D = decay term

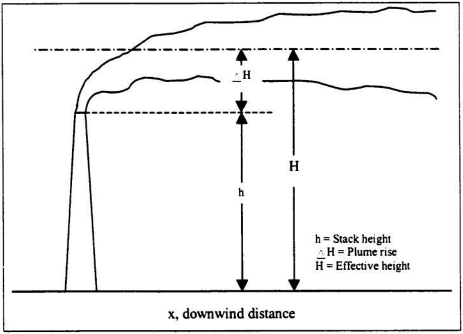

Figure F-1. Plume rise, Stack height, and the Effective height.

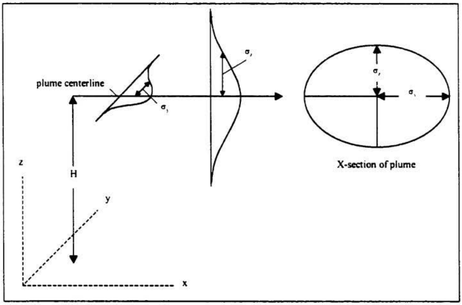

Figure F-2. Schematic of a Plume Showing Gaussian Distribution, and its X-sectional view.