

APPENDIX I

HAZARDOUS AIR POLLUTANT DISCUSSION

I.1 INTRODUCTION

In recent years, public and agency interest has increased regarding the contribution of airports to hazardous air pollutants (HAPs).¹ HAPs are gaseous organic and inorganic chemicals and particulate matter that are either known or suspected to cause cancer (to be carcinogenic) or known or suspected to cause other serious health effects (non-carcinogenic). In response to Scoping comments from the Illinois Environmental Protection Agency (IEPA), the U.S. Environmental Protection Agency (USEPA) and the public, the Federal Aviation Administration (FAA) undertook an evaluation related to HAPs. This Appendix provides a discussion of potential increases/decreases in HAP emissions that would result from construction and operation of the proposed O'Hare International Airport Build Alternatives (Alternatives C, D, and G) when compared to Alternative A (No Action Alternative).

While the effects on human health from HAPs were raised in Scoping, the FAA, USEPA, and IEPA concur that at this time it is not appropriate to conduct a human health risk assessment for the HAPs discussed in this Appendix, and that the influence of the proposed airport development on the health of those living in the vicinity of O'Hare cannot currently be quantified in a meaningful way. Collectively, the agencies believe that, given the absence of HAP emissions data and the limitations of HAP speciation profiles for commercial jet aircraft engines, an accurate emissions inventory (the first step in a sound human health risk assessment) cannot be accomplished.²

The FAA consulted with the USEPA and IEPA while developing the methodology for this HAPs evaluation with the knowledge that the data available for such an evaluation is incomplete and in some cases scientifically inadequate. The evaluation was performed using procedures described in the HAP Protocol³ (dated February 25, 2003) for the purpose of disclosing the potential for increases in HAP emissions based on available data, despite limitations of the data.

The FAA acknowledges that because the FAA and City of Los Angeles jointly conducted the NEPA analysis and CEQA analysis for proposed improvements at Los Angeles International Airport (LAX) in a single document, a Human Health Risk Assessment (HHRA) regarding human exposure to toxic air pollutants (TAPs) was included in the Draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR)(January 2001) and Supplement to the Draft EIS/EIR (July 2003), with a clear explanation that the information was included only for

¹ HAPs are also referred to as toxic air contaminants and, more generally, as air toxics.

² King, Suzanne, USEPA Region 5 facsimile to Mike MacMullen, FAA, December 17, 2004.

³ Analysis Protocol for Hazardous Air Pollutants, February 25, 2003.

purposes of CEQA compliance. Based on case law, an HHRA is required under CEQA, but not NEPA. Furthermore, the Environmental Justice section of the Final EIS (January 2005) for proposed master plan improvements at Los Angeles World Airports included a reproduction and summary of this same HHRA. The EJ section clearly states that the reproduction and summary of the TAPs analysis was included for informational purposes only. In addition, it states that there are no federal standards for exposure to TAPs and that data necessary to make conclusive statements was lacking. Finally, the LAX ROD reiterates and clarifies "As indicated in Volume A of the Final EIS, there are no federal standards regarding exposure to TAPs. Furthermore, there is an absence of TAPs emissions data and limitations on TAPs speciation profiles for commercial jet aircraft engines. As a result, the data that would be necessary to make scientifically supportable conclusions is lacking. As is clearly indicated in Volume A of Part 1 of the Final EIS, Section A.2.2.4, page A.2-88, the HHRA is not being relied upon by the FAA in evaluating the choice among alternatives presented in the Final EIS. Therefore, the information, analyses, and conclusions reached in the CEQA HHRA analysis and presented in Volume A of the Final EIS are not relied upon in this Record of Decision, and do not constitute a part of the Final EIS for purposes of NEPA compliance."⁴

The evaluation of the proposed build alternatives on levels of HAPs was performed using the following approach (simplified for the purpose of this introduction):

- Because no source exists from which to obtain emission rates of HAPs, the emissions of volatile organic compounds and particulate matter developed in support of the criteria air pollutant assessment and HAP source-specific speciation factors were used to develop source-specific HAP emissions.
- The source-specific HAP emissions were evaluated using estimated emission levels and toxicity values⁵. By considering toxicity values, the evaluation accounts for the fact that a small emission level of a highly toxic HAP is more detrimental than an equivalent emission level of a HAP with a lower toxicity.

Notably, a review of available regional emission estimates and the results of the evaluation indicate that, on a regional basis, the sources within the O'Hare study area emit from 1 to 3 percent of the regional emissions of the HAPs determined to be of most interest (discussed in **Section I.2.2, Description of Select HAPs**). Further, because the sources included in the O'Hare evaluation include both motor vehicle traffic related to the Airport and background traffic, these estimates should be considered conservative.

⁴ FAA, Record of Decision, Proposed LAX Master Plan Improvements, May 20, 2005, p. 23 (<http://www.laxmasterplan.org/publications.cfm>)

⁵ Toxicity is defined by USEPA as "Deleterious or adverse biological effects elicited by a chemical, physical, or biological agent." <http://www.epa.gov/iris/gloss8.htm#t>. Toxicity values are used by USEPA to characterize the risks associated with HAPs. <http://www.epa.gov/oppt/rsei/docs/toxwght97.pdf>

I.1.1 Purpose and Scope

The purpose of this evaluation is to estimate potential HAP emission levels with and without the proposed build alternatives at O'Hare. It should be noted that before developing the methodology used to consider HAP emissions associated with O'Hare, a thorough review was undertaken of the state-of-the-science related to the evaluation of aircraft-related HAPs.⁶ Based on the review, it was determined that limitations to this type of evaluation include, but are not limited to, a limited number of aircraft engine-related HAP speciation profiles (emission factors); the fact that the profiles are based on a small amount of outdated testing and; the lack of profiles to represent future aircraft fleets.

It should also be noted that some of the assumptions made in the evaluation should produce conservative results, especially those for future years. The results for future years can be considered conservative because the results were not adjusted to reflect any future reduction in HAP emissions that would occur by replacing conventionally-fueled vehicles with alternatively-fueled vehicles or by the replacement of older aircraft with a newer future aircraft fleet mix.

To understand the issues associated with the O'Hare-related HAP emissions, the following four questions were posed:

1. *How do levels of HAPs near O'Hare compare to HAP levels in other non-airport urban regions in Illinois?* To address this question, available ambient monitoring data were evaluated. The data were reviewed to determine if measured concentrations of HAPs near O'Hare are higher/lower than in other urban areas. If concentrations of HAPs are similar to those measured at other urban monitoring stations in the region this would indicate that the ambient air in the vicinity of the Airport could be considered "typical urban air."
2. *How do HAP emissions and levels in the air at O'Hare compare to HAP levels at other airports that are comparable in size and types of aviation activity as well as other sources operating within the region?* The first part of this question was addressed using current measured ambient concentration data for O'Hare and for comparable airports, as well as regional emission estimates. The issue evaluated on this basis is whether O'Hare-related emissions and/or HAP concentrations differ from "typical airport air." The second part of this question was addressed by comparing HAP emission data from other sources operating in the region to emissions data for O'Hare.

⁶ Vanderbilt, Pamela, 2003, *Health Risk Assessment of Air Toxics from Airports; The State of the Science, May 2002*, CH2M Hill with John Lowe, presented to the Air & Waste Management Association; Hayes, Stanley, 2003, *Characterizing Air Toxics Composition of Jet Exhaust for Airport Health Risk Assessments*, presented at an Air & Waste Management Association conference; Pehrson, John, 2003, *Toxic Air Contaminant Emissions from Aircraft – A Literature Review of Aircraft Engine Measurements*, (other contributors include Wei Guo, Teresa Raine, Vincent Tino, and Roger Johnson – Los Angeles World Airports), presented at an Air & Waste Management Association conference; and CDM, 2003, *A Preliminary Study and Analysis of Hazardous Air Pollutant Emissions from a Commercial Airport using Modeled and source Speciation Profiles*, by Wei Guo, John Pehrson, Teresa Raine, James LaVelle, and Vincent Tino, presented at an Air & Waste Management conference.

3. *Would HAP emissions at O'Hare decrease or increase as a result of implementing the proposed Airport improvements?* Because ambient concentration data cannot be collected for future conditions/scenarios (i.e., only historical and existing conditions can be measured), this comparison relied on emission estimates of HAPs for future years with and without implementation of the proposed Airport development alternatives. To accomplish this goal, Alternative A (No Action Alternative) HAP emissions were compared to emissions with the "build" alternatives (Alternatives C, D, and G) to determine how the proposed airport improvements would affect the quantity of Airport-related HAPs emissions in the future.
4. *How do the predicted future HAP emissions levels at O'Hare, with and without implementation of the proposed Airport improvements, compare to predicted HAP emissions levels in the future at other airports?* The estimated future levels of HAP emissions for O'Hare were compared to estimated levels of emissions prepared by others for other airports. This would indicate whether future emissions at O'Hare are expected to be extraordinary.

This Appendix is organized as follows:

- Section I.2 Background* – Describes airport-related HAPs and discusses why HAPs are of concern.
- Section I.3 Uncertainties and Limitations* – Discusses the uncertainties and limitations associated with the data and methodologies used to perform the HAP evaluation.
- Section I.4 Statutes/Airport-Related Guidance* – Describes the regulations that pertain to airport facilities and specific sources of HAPs.
- Section I.5 Trends* – Provides the results of an evaluation of regional HAP-related trends using measured concentrations and emission inventory data from the databases of agencies whose purpose is the evaluation and/or control of the pollutants.
- Section I.6 Airport-Related HAP Studies* – Provides summaries of historical airport-related HAP studies.
- Section I.7 HAPs Evaluation Methodology* – Describes the methodology used to prepare the O'Hare-specific HAP emission inventories.
- Section I.8 Existing Condition and Alternatives Analysis* – Presents and discusses the results of the evaluation of the proposed O'Hare improvements for Construction Phase I, Construction Phase II, Build Out, and Build Out + 5. Results are also presented for the Original Schedule for the proposed Airport development and two additional schedules (Compressed and Delayed).
- Section I.9 Construction Emissions* – Discusses and summarizes the results of the evaluation of short-term construction-related emissions that would occur with the proposed improvements.

Section I.10 Comparative Evaluation – Provides a comparison of ambient HAP measurements in the vicinity of O'Hare to measurements elsewhere in the region and; O'Hare-related HAP emission levels to regional levels, levels for other airports, and for other sources.

I.2 BACKGROUND

I.2.1 Airport-Related HAPs

This evaluation considers HAP emissions associated with the sources operating at and in the vicinity of O'Hare. The sources include aircraft, ground support equipment, mobile sources (vehicles conveying passengers, employees, and cargo to and from the Airport), non-road equipment (construction equipment), and stationary sources (heating plants, fire training, storage tanks, generating stations, etc.).

In response to Clean Air Act requirements, the USEPA identified 188 air pollutants as HAPs. Based on a review of available data, 65 of the 188 USEPA-identified HAPs have the potential to be emitted by sources operating at and in the vicinity of O'Hare. One additional pollutant, diesel particulate matter, is also considered in this evaluation to be an Airport-related HAP. Although the USEPA has not identified diesel exhaust as a HAP, the agency has concluded that it is likely to be carcinogenic to humans by inhalation.⁷ **Table I-1** lists the 66 HAPs and indicates from which sources the HAPs are emitted. The HAPs can be categorized in to the following three groups--volatile organic compounds,⁸ polycyclic aromatic hydrocarbons,⁹ and particulates/metals.

⁷ <http://www.epa.gov/ttn/atw/nata/natsafaq.html#B7>

⁸ Volatile organic compounds are organic compounds that easily become vapors or gases.

⁹ Polycyclic aromatic hydrocarbons are a group of over 100 different chemicals that are formed during the incomplete combustion of coal, oil and gas, garbage, and other organic substances.

**TABLE I-1
HAPS BY EMISSION SOURCE**

Category	Pollutant	Aircraft		Ground support Equipment			Auxiliary Power Units		On-Road Vehicles		Non-Road Equipment			Heating Plants			Tanks	
		Turbine	Piston	Equipment (Diesel)	Power Units	Vehicles	Diesel	Gasoline(a)	Oil	Gas	Jet A	Gasoline	Gasoline	Gas	Jet A	Gasoline		
																	Diesel	Gasoline(a)
Volatile Organic Compounds and Aldehydes	Acetaldehyde	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Acrolein	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Benzene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	1,3-Butadiene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Butane																	
	Dichlorobenzene																	
	7,12-Dimethylchloranthrene																	
	Ethane																	
	Ethylbenzene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Formaldehyde	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Isobutyraldehyde	✓																
	n-Hexane																	
	2-Methylnaphthalene																	
	3-Methylchloranthrene																	
	Naphthalene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Octachlorodioxin																	
	Pentane																	
	Propionaldehyde	✓																
	Propane																	
	1,1,1-Trichloroethane																	
	Toluene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Styrene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Xylenes	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Individual Polycyclic Aromatic Hydrocarbons	Acenaphthene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Acenaphthylene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Anthracene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Benzo(a)anthracene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Benzo(b,k)fluoranthene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Benzo(g,h,i)perylene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Benzo(a)pyrene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

**TABLE I-1
HAPS BY EMISSION SOURCE**

Category	Pollutant	Aircraft		Ground support Equipment		Auxiliary Power Units		On-Road Vehicles		Non-Road Equipment			Heating Plants			Tanks	
		Turbine	Piston	(Diesel)	(Diesel)	Power Units	Vehicles	Diesel	Gasoline(a)	Oil	Gas	Gas	Jet A	Gasoline			
	Chrysene	✓		✓			✓	✓	✓					✓			
	Dibenzo(a,h)anthracene	✓		✓			✓	✓	✓					✓			
	Fluoranthene	✓		✓			✓	✓	✓					✓			
	Fluorene	✓		✓			✓	✓	✓					✓			
	Indeno(1,2,3-c,d)pyrene	✓		✓			✓	✓	✓					✓			
	Phenanthrene	✓		✓			✓	✓	✓					✓			
	Pyrene	✓		✓			✓	✓	✓					✓			
	2,2,4-Trimethylpentane			✓				✓	✓					✓			✓
Particulate and Metal	Antimony													✓			
	Arsenic			✓				✓	✓					✓			
	Barium		✓				✓							✓			
	Beryllium													✓			
	Cadmium													✓			
	Calcium	✓															
	Chloride														✓		
Chromium III	✓			✓				✓	✓					✓			
Chromium VI				✓				✓	✓								
Cobalt														✓			
Copper	✓													✓			
Fluoride														✓			
Iron	✓													✓			
Lead	✓													✓			
Manganese	✓													✓			
Mercury														✓			
Molybdenum														✓			
Nickel														✓			
Phosphorous														✓			
Scandium																	
Selenium	✓																✓
Strontium	✓																✓
Tin	✓																✓

**TABLE I-1
HAPS BY EMISSION SOURCE**

Category	Pollutant	Aircraft		Ground support Equipment (Diesel)	Auxiliary Power Units	On-Road Vehicles	Non-Road Equipment		Heating Plants		Tanks	
		Turbine	Piston				Diesel	Gasoline(a)	Oil	Gas	Jet A	Gasoline
	Titanium	√			√							
	Vanadium								√			√
	Zinc								√			√
	Zirconium	√			√							
	Diesel Particulate			√		√		√				

Notes: (a) Includes Ground support equipment (gasoline).

Fire training facilities, also an airport source, emit formaldehyde.

Source: Environmental Science Associates, Inc. [IPC] analysis, 2004

I.2.1.1 Aircraft

The level of HAP emissions from aircraft varies depending on the age and model of an engine, the number of engines, and the type of fuel. The level of emissions also depends on the aircraft operating mode (approach, climbout, takeoff, and taxi/idle) and the time spent in each mode. Excessive delay (or idle) can result in as much as 90 percent of the total aircraft-related HAP emissions because aircraft emit more HAPs during this operational mode than the other operating modes. Piston engine aircraft also emit HAPs, although such aircraft account for only a small percentage of total operations at O'Hare. Thirty-seven individual HAPs were identified as having the potential to be emitted from the turbine engine aircraft and 11 HAPs were identified as having the potential to be emitted from the piston engine aircraft that operate at O'Hare.

Of all of the airport-related sources, the HAP emission data for aircraft engines is considered the most "unknown". The data is considered as such because limited testing has been performed to identify and quantify HAP emission levels from aircraft engines. Therefore, although the evaluation of aircraft engine-related HAPs was based on the best information and techniques available, it should be noted that the results discussed for aircraft engines are subject to a high degree of imprecision and uncertainty.

I.2.1.2 Ground Support Equipment and Auxiliary Power Units

Ground support equipment include baggage tugs, belt loaders, and fuel carts used to service aircraft and support various Airport-related functions. Auxiliary power units are small turbine engines used on large aircraft to generate both electricity and compressed air. Electricity and compressed air operate an aircraft's instruments, lights, ventilation and other equipment when the main engines are not running. An auxiliary power unit also provides power to restart the aircraft's main engines after shutdown. Thirty individual HAPs were identified as having the potential to be emitted from diesel fueled ground support equipment. Thirty-two HAPs were identified as having the potential to be emitted from gasoline fueled ground support equipment and 35 were identified as having the potential to be emitted from auxiliary power units.

I.2.1.3 On-Road Mobile Sources

The vehicles traveling to and from the Airport also emit HAPs. These vehicles include privately owned vehicles and commercial vehicles such as rental cars, shuttles, buses, taxicabs, and delivery trucks. The HAP contribution from these types of vehicles both on- and off-Airport property was considered as well as vehicles within parking facilities located on the Airport property. Thirty-four HAPs were identified as having the potential to be emitted by these types of motor vehicles.

I.2.1.4 Non-Road Equipment

The non-road equipment category includes construction equipment (e.g., backhoes, bulldozers, asphalt pavers, etc.). This source also includes industrial equipment (e.g., forklifts, sweepers, etc.), and commercial equipment (e.g., portable generators, air compressors, etc.). Equipment

categorized as “non-road” use both diesel and gasoline fuel. Thirty-four HAPs were identified as having the potential to be emitted by the diesel-fueled types of non-road equipment and 32 HAPs were identified as having the potential to be emitted by the gasoline-fueled types of this equipment.

I.2.1.5 Stationary Sources

During the operation of heating plants, small amounts of organic compounds are emitted due to combustion. The rate at which organic compounds are emitted depends, to some extent, on the combustion efficiency of the boiler. For the purpose of this evaluation, the Airport Rescue and Firefighting Facilities at O'Hare, a facility used to train personnel for fuel fire suppression, was also considered a stationary source. The types of fires simulated include engine fires; exterior pool fires involving the aircraft fuselage and the wings; interior fires on the flight deck, cargo, or passenger areas; and other miscellaneous fires. Storage tanks for aviation gasoline and Jet A are included in this evaluation. Fifty HAPs were identified as having the potential to be emitted by the heating/cooling plant at O'Hare, one HAP from fire fighting activities, and seven HAPs were identified from the storage tanks located on Airport property.

I.2.2 Description of Select HAPs

Based on the results of the evaluation (discussed in **Section I.8, Existing Condition and Alternatives Analysis**), 11 of the 66 HAPs emitted from sources operating at and in the vicinity of O'Hare were determined to be of the most interest. After considering the estimated emission levels and toxicity factors of the remaining 55 HAPs, it was determined that the 55 HAPs would not contribute in a measureable way to the overall HAP exposure in the vicinity of the Airport. The 11 HAPs determined to be of most interest were 1,3-butadiene, acetaldehyde, acrolein, arsenic, benzene, chromium VI, diesel particulate matter, formaldehyde, naphthalene, toluene, and nickel. Each of these pollutants has carcinogenic effects. **Attachment I-1** of this Appendix provides detailed descriptions of each of the 11 HAPs. A brief description of each pollutant's characteristics, potential for human exposure, and USEPA's classifications with respect to the pollutant's carcinogenic properties¹⁰ is provided below.

I.2.2.1 1,3-butadiene¹¹

1,3-butadiene is a colorless gas. At room temperature, the gas has a gasoline-like odor. This pollutant is a byproduct of petroleum processing and is used in the production of synthetic

¹⁰ The USEPA uses the classification “known” with respect to carcinogens when there is sufficient evidence from epidemiologic studies to support a causal association between exposure to the agents and cancer. The classification “probable” is used when the weight of evidence of human carcinogenicity based on epidemiologic studies is limited or when the weight of evidence of carcinogenicity based on animal studies is “sufficient”. HAPs are classified as “possible” carcinogens when there is limited evidence of carcinogenicity in animals in the absence of human data. Finally, the USEPA uses the classification “not classifiable” when there is inadequate human and animal evidence of carcinogenicity or for which no data are available.
(<http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=55445>)

¹¹ Summary based on the Agency for Toxic Substance and Disease Registry *ToxFAQ for 1,3-butadiene*, <http://www.atsdr.cdc.gov/tfacts28.html>, September 1995.

rubber and plastics. It is also found in automobile exhaust, gasoline vapor, fossil fuel incineration products, and cigarette smoke. The majority of 1,3-butadiene is released into the air and humans are typically exposed to the pollutant via inhalation. Breathing very high levels of 1,3-butadiene for a short time may cause central nervous system damage, blurred vision, nausea, fatigue, headache, decreased blood pressure and pulse rate, and unconsciousness. Breathing lower levels of this pollutant may cause irritation of the eyes, nose, and throat. The USEPA has classified 1,3-butadiene as a "known" human carcinogen.

I.2.2.2 Acetaldehyde¹²

Acetaldehyde is a colorless, volatile liquid with a characteristic pungent, fruity odor. Acetaldehyde is used primarily as a chemical intermediate in the production of acetic acid, as well as a synthetic flavoring agent. Acetaldehyde is released to the environment in vehicle exhaust and as a product of open burning of gas, fuel oil, and coal. Acute exposure to acetaldehyde can cause eye, nose, and throat irritation and subsequent inflammation of the eyes and coughing. This pollutant can also cause central nervous system depression, delayed pulmonary edema, and moderate unconsciousness. Chronic dermal exposure can lead to skin burns and dermatitis. Carcinogenicity studies in rats have shown that acetaldehyde causes respiratory tract tumors. The USEPA has classified acetaldehyde as a "probable" human carcinogen.

I.2.2.3 Acrolein¹³

Acrolein is a clear or yellow liquid with a disagreeable odor. Acrolein is used as an intermediate in the production of acrylic acid, as well as a pesticide to control algae, weeds, bacteria, and mollusks. Small amounts of acrolein can be formed and emitted into the air when trees, tobacco, other plants, gasoline, and oil are burned. Acrolein may also be released in to the environment in emissions and effluents from its manufacturing and use facilities and in emissions from combustion processes. Exposure to high concentrations of acrolein may damage the lungs and could cause death. Breathing lower amounts may cause eye watering and burning of the nose and throat and a decreased breathing rate. The USEPA has classified acrolein as "not classifiable" as to human carcinogenicity.

I.2.2.4 Arsenic¹⁴

Arsenic is a naturally occurring element that is widely distributed in the earth's crust. Elemental arsenic is used as an alloying agent for heavy metals and in special solders. Inorganic arsenic compounds are mainly used to preserve wood, whereas organic arsenic compounds are used as pesticides. Sources of arsenic include forest fires, volcanic eruptions,

¹² Summary based on the Hazardous Substances Database – Acetaldehyde, <http://toxnet.nlm.nih.gov>, August 2003.

¹³ Summary based on the Agency for Toxic Substance and Disease Registry *ToxFAQ for Acrolein*, <http://www.atsdr.cdc.gov/tfacts124.html>, July 1999.

¹⁴ Summary based on the Agency for Toxic Substance and Disease Registry *ToxFAQ for Arsenic*, <http://www.atsdr.cdc.gov/tfacts2.html>, December 2003.

metal smelting, chemical production and use, coal combustion, motor vehicle exhaust, and waste disposal. Breathing high levels of inorganic arsenic produces a sore throat or irritated lungs. Lower levels of arsenic can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, and damage to blood vessels. The USEPA has classified arsenic as a "known" human carcinogen.

I.2.2.5 Benzene¹⁵

Benzene is a volatile, colorless, flammable liquid that has a sweet odor. It is a chemical intermediate in the synthesis of compounds such as plastics, resins, nylon, synthetic fibers, synthetic rubbers, lubricants, dyes, detergents, drugs, and pesticides. Major sources of atmospheric releases include vehicle exhaust emissions, evaporative gasoline fumes, emissions from vehicle service stations, and industrial emissions. Other sources of atmospheric benzene include cigarette smoke and landfill emissions. Acute inhalation exposure to benzene can result in death, while high levels can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. Eating or drinking foods containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, and death. The USEPA has classified benzene as a "known" human carcinogen.

I.2.2.6 Chromium VI¹⁶

Chromium is a naturally occurring element found in rocks, animals, plants, soil, and in volcanic dust and gases. Chromium VI is the second most stable chromium compound, after chromium III and is used for chrome plating, dyes and pigments, leather tanning, and wood preservation. Human activities, including driving and using motor vehicles/other diesel and gasoline fueled equipment, are responsible for the majority of chromium VI environmental releases into air, water, and soil. In air, chromium is present mostly as fine dust particles and eventually settles out of the atmosphere. Human exposure can occur via inhalation of contaminated air or ingestion of contaminated food and water. Acute inhalation of high levels of chromium VI primarily causes irritation to the nose, including nosebleeds, ulcers and holes in the nasal septum. Ingesting large amounts of chromium VI can cause stomach upsets and ulcers, convulsions, kidney and liver damage, and death. The USEPA has classified chromium VI as a "known" human carcinogen.

I.2.2.7 Diesel Particulate Matter¹⁷

Diesel exhaust is a complex mixture of thousands of individual gaseous and particulate compounds emitted from diesel-fueled combustion engines. Diesel particulate matter is formed

¹⁵ Summary based on the Agency for Toxic Substance and Disease Registry *ToxFAQ for Benzene*, <http://www.atsdr.cdc.gov/tfacts3.html>, September 1997.

¹⁶ Summary based on the Agency for Toxic Substance and Disease Registry *ToxFAQ for Chromium*, <http://www.atsdr.cdc.gov/tfacts7.html>, February 2001.

¹⁷ Summary based on the California Air Resources Board and Office of Environmental Health Hazard Assessment. *Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant*, approved by the Scientific Review Panel in April 1998 and USEPA, *Health Assessment Document for Diesel Engine Exhaust*, EPA/600/8-90/057F, May 2002.

primarily through the incomplete combustion of diesel fuel. Particulate matter in diesel exhaust can be emitted from on- and off-road vehicles, stationary area sources, and stationary point sources. Diesel exhaust particulate matter is removed from the atmosphere through physical processes including atmospheric fall-out and washout by rain. Humans can be exposed to airborne diesel particulate matter or via deposited diesel particulates on water, soil, and vegetation. Acute inhalation exposure to diesel particulates has shown increased symptoms of irritation, cough, phlegm, chronic bronchitis, and inhibited pulmonary function. The USEPA has concluded that diesel particulate matter is likely to be carcinogenic to humans by inhalation.

I.2.2.8 Formaldehyde¹⁸

At room temperature, formaldehyde is a colorless, flammable gas that has a distinct, pungent smell. Formaldehyde is a product of incomplete combustion and is emitted into the air by burning wood, coal, kerosene, and natural gas, by automobiles, and by cigarettes; it is also a naturally occurring substance. Formaldehyde can be released to soil, water, and air by industrial sources and can off-gas¹⁹ from materials made with it. Humans can be exposed to formaldehyde through inhalation of contaminated air and smog. Low levels of formaldehyde can cause irritation of the eyes, nose, throat, and skin. Some epidemiological studies found an increased incidence of nose and throat cancer in exposed individuals, whereas other studies could not confirm this finding. The USEPA has classified formaldehyde as a "probable" human carcinogen.

I.2.2.9 Naphthalene²⁰

Naphthalene is a white solid with the odor of mothballs or tar, and is found naturally in fuels when they are burned. Burning tobacco or wood also produces naphthalene. The major commercial use of naphthalene is in the manufacture of polyvinyl chloride (PVC) plastics. Naphthalene is released into the air through the burning of tobacco, wood, oil and coal. Exposure to large amounts of naphthalene may damage or destroy some red blood cells. This condition is called hemolytic anemia, with symptoms including fatigue, lack of appetite, restlessness, and pale skin. Exposure to large amounts of naphthalene may also cause nausea, vomiting, diarrhea, blood in the urine, and a yellow color to the skin. The USEPA has classified naphthalene as a "possible" human carcinogen.

I.2.2.10 Nickel²¹

Nickel is an abundant silvery-white metal. Nickel is a commonly found element in nature, as well as in many alloys that humans are exposed to. Airport-related sources of nickel include

¹⁸ Summary based on the Agency for Toxic Substance and Disease Registry *ToxFAQ for Formaldehyde*, <http://www.atsdr.cdc.gov/tfacts111.html>, July 1999.

¹⁹ The emission of chemicals from building materials, furniture, textiles and bedding

²⁰ Summary based on the Agency for Toxic Substance and Disease Registry *ToxFAQ for Naphthalene*, <http://www.atsdr.cdc.gov/tfacts67.html>, September 2003.

²¹ Summary based on the Agency for Toxic Substance and Disease Registry *ToxFAQ for Nickel*, <http://www.atsdr.cdc.gov/tfacts15.html>, September 2003.

ground support equipment, motor vehicles, and heating plants. The most common effect of nickel in humans is an allergic reaction. People can become sensitized to nickel through dermal contact with nickel-containing jewelry or other items. Sensitized individuals can then have an allergic reaction to subsequent dermal, inhalation, or ingestion exposure to nickel. The USEPA has classified nickel as a "known" human carcinogen.

I.2.2.11 Toluene²²

Toluene is a colorless, clear liquid that occurs naturally in crude oil. It is also produced in the process of manufacturing gasoline and other fuels from crude oil. Airport-related sources of toluene include aircraft, ground support equipment, motor vehicles, heating plants, and gasoline fuel storage tanks. Low to moderate levels of toluene can affect the nervous system and cause tiredness, confusion, weakness, memory loss, nausea, loss of appetite, and hearing and color vision loss. Inhaling high levels of toluene in a short time can make a person feel light-headed, dizzy, or sleepy, and can cause unconsciousness and death. The USEPA has assigned toluene as "not classifiable" as to human carcinogenicity.

I.3 UNCERTAINTIES/LIMITATIONS

The primary purpose of an EIS is to serve as an action-forcing device to insure that the policies and goals defined in the National Environmental Policy Act are infused into the ongoing programs and actions of the Federal Government. The EIS is to provide full and fair discussion of significant environmental impacts to inform decision makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment. Section 1502.22²³ of the Council on Environmental Quality (CEQ) Regulations state that "when an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an EIS and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking."

Before developing a detailed methodology (protocol) to consider HAP emissions associated with activity and development at O'Hare, a thorough review was undertaken of the state-of-the-science concerning the evaluation of HAPs. The purpose of this section is to document the uncertainties and limitations of the methodology used in this analysis. The following are discussed:

- HAP Emission Estimates and Speciation Profiles
- HAP Toxicity Determinations
- Health Risk Assessments

²² Summary based on the Agency for Toxic Substance and Disease Registry *ToxFAQ for Toluene*, <http://www.atsdr.cdc.gov/tfacts56.html>, February 2001.

²³ Section 1502.22 of the Council on Environmental Quality Regulations (Incomplete or Unavailable Information),

I.3.1 HAP Emission Estimates and Speciation Profiles

To identify a quantity of an individual HAP, speciation factors are used. These factors estimate the quantity of an individual HAP based on emissions of volatile organic compounds and particulate matter.

Nationwide, limited testing has been performed to identify and quantify HAP emissions levels associated with airport sources in general and aircraft engines in particular. Therefore, the speciation profiles or factors used in this evaluation are based on available research. The speciation profiles adopted by regulatory agencies are intended to be used to develop gross estimates of HAP emissions on a state- and region-wide basis and not to assess site-specific impacts at the project level (such as an individual airport). As such, although the HAP speciation profiles are based on the best data, information, and techniques currently available, the factors are subject to a high degree of imprecision and uncertainty.

The criteria pollutant emission factors within the models that were used to assess the air quality effects of on-road vehicles reflect progressive improvements in engine technology and fuels. Use of these emission factors results in substantially fewer motor vehicle-related HAP pollutant estimates in the future (a decrease of approximately 70 percent from 2002 to 2018). Conversely, the aircraft HAP speciation profiles do not reflect comparable improvements in aircraft engines. This is particularly difficult when attempting to identify appropriate aircraft engine emission data. The lack of appropriate future data places a limitation on the usefulness and reliability of the projection of HAP speciation profiles for aircraft jet engines. Improvements in jet engine design and materials technology have already resulted in the production of engines that, due to higher pressure ratios, reduce the products of incomplete combustion that include HAPs. These improvements are not reflected in this evaluation because of the lack of emission testing data for newer aircraft engines.

Further, additional progress in combustion technology has been demonstrated to be feasible and jet engines incorporating the technology are in the planning stage. Notably, the available speciation profiles were developed from tests of older jet engines. By assuming no change in the speciation profiles over the analysis period, as this evaluation does, it is reasonable to assume that the aircraft-related HAP emissions using these factors would be over-estimated, resulting in a conservative scenario.

Of particular interest is the HAP speciation profile for 1,3-butadiene. The speciation profile for this compound was obtained from a dataset considered to be outdated.²⁴ Newer engines incorporate a number of technical advances that affect air emissions. They are more fuel efficient, have improved combustors and fuel atomizers, use different fuel, and are subject to more stringent USEPA exhaust emission standards, and thus emit fewer exhaust pollutants. Thus, the older speciation profiles for 1,3-butadiene likely result in an overestimate of this HAP emission.

²⁴ Spicer, C.W. et al., 1984. Composition and Photochemical Reactivity of Turbine Engine Exhaust, March.

Further, there are a very limited number of data points available to characterize an entire aircraft fleet. In most cases, there were no emissions data for a specific aircraft type and surrogate data from a related aircraft type is used to estimate emissions. The lack of HAP speciation profiles for the entire O'Hare aircraft fleet mix and the representativeness of the available speciation profiles as a forecast of speciation profiles for future years (especially beyond 2018) provide a level of uncertainty in the aircraft-related HAP emission calculations.

There are also no emission factors for several key pollutants, particularly metals. In these cases, surrogate data from selected vehicle or stationary sources is used to estimate emissions. As an example, in the USEPA speciation profile for particulate matter, combustion of aircraft jet fuel in aircraft engines was assumed to be the same as combustion of No. 2 fuel oil in an industrial boiler.²⁵ Thus, the level of metals emissions related to turbine engine aircraft were estimated using the elemental analysis of Jet A fuel conducted by the US Navy²⁶ and the Jet A consumption rate provided in the Emissions and Dispersion Modeling System for a specific engine. These assumptions were reviewed and accepted by the FAA, USEPA, and IEPA. In addition to limitations associated with a fuel analysis and its applicability to estimate emissions, the result of an elemental analysis can vary by source of the fuel. Metal content in a given fuel is dependent on the fuel type, on the geographic source of the raw feed that is used to make the fuel (the crude oil), and on the refining process.

With respect to ground support equipment emissions, the analysis did not assume any reductions in emissions with replacement of conventionally-fueled vehicles with alternatively-fueled vehicles in the future. As such, the levels of ground support equipment emissions can be considered conservative (for all alternatives, including the No Action Alternative).

Finally, with respect to diesel particulate matter, some tests evaluate this pollutant as a single pollutant while other tests consider, individually, the myriad different compounds that adhere to particles. A portion of the estimated benzene and other polycyclic aromatic hydrocarbons generated with the speciation profiles is based on calculations of these compounds as constituents of diesel particulate matter. Based on the findings of other studies that considered diesel particulate separately as a single pollutant, this method appears to underestimate the health risk due to the fact that it does not look at the cumulative risk of exposure to multiple chemicals. To be conservative, this evaluation assumed that the calculated exhaust from on-road vehicles, off-road vehicles and diesel powered ground support equipment was all diesel particulate matter. Diesel particulate matter was therefore included in the evaluation both as a single pollutant and as a sum of its individual HAP components. Notably, use of this assumption may result in a "double counting" of some compounds.

The FAA consulted with the USEPA and IEPA while developing the methodology discussed in **Section I.7.1.2, Speciation Profiles**, with the knowledge that the data available for such analysis is incomplete and in some cases scientifically inadequate. USEPA concurred with this

²⁵ Pamela Vanderbilt and John Lowe, *Health Risk Assessment of Air Toxics from Airports*, February 28, 2002.

²⁶ Shumway, L.A., 2000. Trace Element and Polycyclic Aromatic Hydrocarbon Analysis of Jet Engine Fuels: Jet A, JP-5, JP-8, December.

methodology.²⁷ A HAPs emission inventory was prepared using procedures described in the HAP Protocol (dated February 25, 2003) to disclose the potential increases in HAP emission based on available data, despite the limitations of the data.

The level of metals emissions related to turbine engine aircraft and auxiliary power units were estimated using the elemental analysis of Jet A fuel conducted by the US Navy²⁸ and the Jet A consumption rate for the O'Hare specific engines provided in EDMS. In addition to limitations associated with fuel analysis and its applicability to estimate emissions, the result of an elemental analysis can vary by source of the fuel. Metal content in a given fuel is dependant on the fuel type, on the geographic source of the raw feed that is used to make the fuel (the crude oil), and on the refining process.

I.3.2 HAP Toxicity

It is difficult to accurately predict the incidence of human disease or the types of effects that chemical exposures have on humans. For example, the unit risk values and the reference concentrations that provide the toxicity weighting values used in this evaluation are based on toxicological data that are typically obtained and, indeed, most often only available from animal studies. Adverse effects at high doses for short exposure durations in animals are then extrapolated to estimate the effects on humans at low doses for long exposure durations. The affected organs, the type of adverse effects and the severity of the effects may all differ between study animals and humans (inter-species differences), or between humans and humans (intra-species differences). These differences are often associated with variations in the particular toxic kinetics, or movement, of a chemical through the exposed organism, such as the absorption, distribution, metabolism, and excretion of the chemical. The human health and environmental effects of aircraft-related HAPs combined with HAPs from other sources are not well documented. In addition, as previously stated, basic toxicity values assume a constant lifetime exposure to a given chemical concentration. Toxicity values are not able to account for changes in a person's age, size, geographical residence, health, or location (indoors vs. outdoors, home vs. work, etc.) over time. All of these uncertainties affect the interpretation and usefulness of the toxicity values and, in turn, the emission-toxicity values.

The toxicity values used in this evaluation are based only on chronic (long-term) effects and do not provide information regarding acute (short-term) toxicity. For chronic effects, the same level of research and data is not available for all the HAPs and the toxicity values thus are derived from several different sources, some more rigorous than others. To the extent possible, the toxicity values are based solely on inhalation risk values. However, in some cases where inhalation risk values were unavailable, oral risk values (oral slope factors and oral reference doses) were used to derive the inhalation toxicity weights. This may underestimate or overestimate the actual toxicity value because of differences between inhalation and oral

²⁷ King, Suzanne, USEPA Region 5 Facsimile to Mike MacMullen, FAA, December 17, 2004.

²⁸ Shumway, L.A., 2000. Trace Element and Polycyclic Aromatic Hydrocarbon Analysis of Jet Engine Fuels: Jet A, JP-5, JP-8, December.

exposures in the rate and degree of absorption into the bloodstream. The error margin introduced by this step depends on the target organs of a particular chemical's toxicity. Since inhalation would be the primary exposure route for these chemicals, other exposure pathways (e.g. ingestion, dermal) would only be small contributors and were not considered in this analysis. Also, previous studies have found that alternate exposure routes do not typically change the overall risk.²⁹

The method used in this evaluation for calculating non-carcinogen emission-toxicity values is based on the potency of the chemical and the uncertainty of characterizing that chemical's toxicity. As such, the number of different effects caused and the relative severity of these effects are not incorporated. Thus, the health risks of the proposed airport development alternatives are not quantified in terms of a dose-response model.

As a final note, the emission-toxicity values were based on estimates of total emission mass. Actual ambient air concentrations, however, would vary around the vicinity of the airport and depend on additional factors such as source/receptor relationship and meteorological conditions. The actual health risk, in turn, would depend not only on the toxicity and the ambient air concentrations of the HAPs but also on the inhalation rate (varies with activity), proportion of time spent in different locations of people exposed to the HAPs, as well as their exposure to HAPs and other chemicals generated by non-airport sources.

I.3.3 Health Risk Assessments

There is considerable uncertainty in the quantitative analysis of airport-related HAP emissions, HAP toxicity determinations, and the relative evaluation of human health risks associated with exposure to HAPs. Health risk assessments have been conducted by others (see the discussion of other studies in **Section I.6, Airport-Related HAP Studies**) using computer models to convert the HAP emissions estimates from tons per year to ambient concentrations at specific receptor locations. These models are subject to error due to the variability of air patterns and the myriad factors that can alter the final concentration of a contaminant in the air. These factors contribute to several dispersion modeling limitations, including 1) dispersion models are more reliable for predicting long-term concentrations than for estimating short-term concentrations at specific locations; and 2) dispersion models are reasonably reliable in predicting the magnitude of the highest concentrations likely to occur, but without respect to a specific time or location.

Model estimates of concentrations that occur at a specific time and site are poorly correlated with actual observed concentrations and are much less reliable. Therefore, it is difficult to correlate monitoring results to modeled air concentrations and it is correspondingly difficult to make predictions about potential human exposures at specific locations. Also, Gaussian plume models use hourly meteorological data which, while allowing for variation in data with changes

²⁹ LAWA, 2004, *LAX Master Plan Final EIS/EIR, Human Health Risk Assessment*, Technical Report 14a., prepared for the Los Angeles World Airports Authority.

in altitude, are assumed to be uniform horizontally. Consequently, the accuracy of modeling results degrades as distance from the source increases.

Another source of error in human health risk assessment is the assumption typically employed that an individual is constantly exposed to a particular chemical over a 70-year lifetime. This assumption does not account for changes in a person's age, size, health, geographical residence, or location (indoors vs. outdoors, home vs. work, etc.) over time. The following discussion addresses specific issues associated with the comparative approach that was implemented (and the results of which were presented in this report) as an alternative to a health risk assessment.

The FAA, USEPA, and IEPA concur that at this time it is not appropriate to analyze the health related effects of HAPs associated with proposed airport development projects, such as those proposed at O'Hare. The influence of proposed airport development on the health of those living in the vicinity of O'Hare cannot currently be quantified in a meaningful way. While the methodology identified for this analysis indicates that emissions of HAPs would increase with any of the Build Alternatives when compared to the No Action Alternative, it is not possible to meaningfully identify whether these emission levels are likely to adversely impact human health. Given all the limitations and uncertainties previously discussed, such a health risk assessment would not assist the NEPA decision makers or the public understand whether exposure to some level of emissions resulting from the project would be harmful.

I.4 STATUTES/AIRPORT-RELATED GUIDANCE

The following presents a discussion of applicable statutes and guidance related to airports and airport-related sources.

I.4.1 Statutes

I.4.1.1 National Environmental Policy Act

In accordance with the National Environmental Policy Act (NEPA), Federal agencies are required to identify and describe potential impacts to the human and natural environments resulting from their action(s). To facilitate compliance with the National Environmental Policy Act, the FAA has adopted guidance (FAA Order 1050.1E *Considering Impacts: Policies and Procedures*) that defines the steps for considering air quality issues. The FAA and the USEPA have not adopted any official guidance concerning the evaluation of HAPs impacts in a National Environmental Policy Act document. Accordingly, this information is provided for disclosure purposes only. Notably, the FAA developed the HAPs Protocol for this EIS in coordination with USEPA and IEPA.

I.4.1.2 Clean Air Act

The Clean Air Act of 1970³⁰ and its 1990 Amendments³¹ establish the primary framework for controlling air pollution in the ambient environment throughout the U.S. The Clean Air Act focuses on reducing air pollution through several forms of control. These include setting standards, permitting sources of pollutants, and requiring use of certain pollution control devices. The USEPA has responsibility for developing and enforcing regulations to implement the Clean Air Act.

Under the Clean Air Act, USEPA established the National Ambient Air Quality Standards (NAAQS). These standards apply to what are known as criteria pollutants. The criteria pollutants include ozone and particulate matter in the ambient air. There are currently no such standards for HAPs. **Section 5.6, Air Quality, in Chapter 5, Environmental Consequences,** provides a detailed discussion of the NAAQS. The NAAQS by regulating emissions of volatile organic compounds and particulate matter also results in reduction in HAPs.

The identified HAPs are subject to the requirements of Section 112 - *National Emission Standards for Hazardous Air Pollutants* of the Clean Air Act.³² These requirements apply to emissions from both major stationary sources and minor stationary sources which are part of area sources. **Table I-2** lists the classifications of the source types regulated under Section 112. The regulated stationary sources encompass a wide range of facilities, including industrial manufacturing plants, electrical generating plants, surface coating activities, gasoline distribution centers, oil/gas refineries, petrochemical plants, and metal foundries. Aircraft engine test cells located at airports are also regulated as stationary sources.³³ Other airport-related sources that may also be regulated include aircraft repair/maintenance facilities and central heating plants. Aircraft are considered to be mobile sources, but are not subject to the requirements of Section 112.

**TABLE I-2
CLASSIFICATIONS OF CLEAN AIR ACT REGULATED SOURCES**

Classification	Definition	Listed Examples
Major Stationary	Sources that emit, or have the potential to emit, more than 10 tons/year of any one HAP or 25 tons/year of a combination of HAPs	Chemical plants, oil refineries, steel mills, aerospace manufacturers aircraft engine test cells
Area Stationary	Sources that emit, or have the potential to emit, less than 10 tons/year of any one HAP or less than 25 tons/year of a combination of HAPs	Hospital sterilizers, dry cleaning facilities, paint stripping operations.
Mobile	Motor vehicles and their fuels	Automobiles, trucks, farm and construction equipment

Source: Select Resource Materials and Annotated Bibliography on the Topic of Hazardous Air Pollutants (HAPS) Associated with Aircraft, Airports, and Aviation, Federal Aviation Administration, July 1, 2003.

³⁰ The Clean Air Act of 1970, 42 U.S.C. §7401.

³¹ The 1990 Clean Air Act Amendments, 42 U.S.C. §7401.

³² Sec. 112. National emission standards for hazardous air pollutants.

³³ Federal Register, Volume 68, May 27, 2003.

Besides the passenger and employee-related motor vehicles and delivery trucks that are O'Hare-related, the only other source at O'Hare that could potentially be subject to Section 112, is the heating and cooling plant. However, this source is not considered a major stationary source of HAP emissions because its potential emissions are less than 10 tons per year of a single HAP and less than 25 tons per year of any combination of HAPs.

The Clean Air Act also assigns USEPA with the authority to control emissions from new engines and vehicles, including off-road vehicles (e.g., ground support equipment used at airports). However, mobile sources are regulated differently than stationary sources. These sources are regulated by placing limitations on emissions from newly manufactured engines. The USEPA has designated 21 HAPs as mobile source air toxics, or HAPS that are emitted by motor vehicles and non-road engines. These HAPs include volatile organic compounds and heavy metals. The non-road category of HAP sources includes construction equipment and airport ground support equipment. The USEPA has established rules for diesel-fueled non-road equipment which will result in extensive reductions in particulate matter. These rules apply to newly manufactured engines beginning in the year 2008 and will be fully phased in by the year 2014.

Section 231 of the Clean Air Act,³⁴ establishes emission standards for commercial and general aviation aircraft engines. These regulations apply to all gas turbine engine civil aircraft including turboprop, turbofan and turbojet engines. There are limitations to these regulations based on maintaining minimum engine thrust (rated output) requirements to ensure safety. The standards do not directly address HAPs. As adopted in 1973, the aircraft-related standards apply to smoke and to the exhaust products of carbon monoxide, nitrogen oxides, and hydrocarbons – also known as volatile organic compounds. These standards indirectly regulate HAPs through the control of volatile organic compounds. The FAA ensures compliance with the regulations by reviewing and approving certification test plans, procedures, test reports, and engine emission certification levels.

I.4.1.3 Toxic Substances Control Act

In addition to the Clean Air Act, other federal laws and regulations have helped to control HAPs in the ambient environment. These include the Toxic Substances Control Act³⁵ which supplements Section 112 (Hazardous Air Pollutants) by allowing the USEPA to screen toxic chemicals and require reporting or testing of those that may pose an environmental or human-health hazard. There are approximately 75,000 chemical substances listed in the Toxic Substances Control Act inventory at this time. The Clean Air Act allows the USEPA to use this inventory, and other mechanisms promulgated in the Toxic Substances Control Act, to understand the toxicity and persistence of certain chemical. This enhances USEPA's ability to implement specific actions to substantially reduce the public health risks posed by the release of HAPs.

³⁴ Part B - Aircraft Emission Standards, Sec. 231. Establishment of Standards.

³⁵ 15 USC 35.

In response to the Toxic Substances Control Act, the USEPA developed the National Air Toxics Program, a program to characterize and address air toxics^{36,37}. As part of the National Air Toxics Program, the USEPA initiated the National Air Toxics Assessment and the Integrated Urban Air Toxics Strategy – a multifaceted approach to assessing HAPs and their sources. Essentially, the purpose of the National Air Toxics Assessment is to collect and evaluate information on ambient levels of HAPs, including near- and long-term patterns and trends; develop reliable tools and techniques for conducting emission inventories and dispersion modeling of HAPs; and identify the primary areas of concern (or “risks”) to the human and natural environments associated with these air contaminants. In addition, should the information and analyses reveal HAPs or their source categories that are presently unregulated, unlisted or pose a public health risk, Section 112 of the Clean Air Act allows for these sources to be further evaluated and, if necessary, regulated.

I.4.2 Airport-Related Guidance

The FAA has adopted procedures and guidelines that address the evaluation of a wide variety of impacts to the human and natural environment associated with airport and airway improvement projects. These guidelines are primarily intended to assist the sponsors of an airport improvement project in complying with the environmental assessment and reporting requirements of the National Environmental Policy Act.

The general guidelines by which the FAA prepares environmental documentation are contained in FAA Order 1050.1E.³⁸ The FAA guidelines that are specific to airports are contained in FAA Order 5050.4A.³⁹ Orders 1050.1E and 5050.4A are used to assess projects and actions involving new airports, new or extended runways as well as other improvements subject to evaluation under the National Environmental Policy Act. As a supplement to FAA Order 5050.4A, the FAA also developed a comprehensive guidebook specifically for the preparation of air quality impact assessments required under NEPA and the Clean Air Act. Commonly referred to as the *Air Quality Handbook*,⁴⁰ these guidelines include detailed instructions on the preparation of emission inventories for airports and procedures for conducting atmospheric dispersion modeling.

The current listing of FAA guidelines and publications pertaining to the assessment of air quality conditions associated with airports, aircraft and aviation are provided in **Table I-3**. Although these resources provide valuable information and tools for conducting air quality impact assessments for aircraft and airport operations, they do not currently offer guidance on HAPs. While no specific FAA or USEPA guidance exists related to the evaluation of airport-

³⁶ USEPA, 2000, Review of Draft Air Toxics Monitoring Strategy Concept Paper, Science Advisory Board, Air Toxics Monitoring Subcommittee, EPA-SAB-EC-00-015.

³⁷ USEPA, 2000, Documentation for the 1996 Base Year National Toxics Inventory for Aircraft Sources, prepared by Eastern Research Group, Inc., prepared for Emissions Factor and Inventory Group (MD-14), Emissions, Monitoring and Analysis Division, June 2, 2000.

³⁸ FAA Order 1050.1E Environmental Impacts, Policies, and Procedures, June 8, 2004.

³⁹ FAA Order 5050.4A Airport Environmental Handbook, October 8, 1985 (The FAA announced the release of Draft Order 5050.4B on December 16, 2004).

⁴⁰ FAA, Air Quality Handbook, Air Quality Procedures for Civilian Airports and Air Force Bases, April 1997.

related HAPs, the methodology used in this evaluation was prepared by the FAA and their EIS consultant, with review and acceptance by the USEPA.⁴¹

**TABLE I-3
FAA ENVIRONMENTAL AND AIR QUALITY ASSESSMENT GUIDELINES**

Guideline	Application	Comments
FAA Order 1050.1E - Environmental Impacts: Policies and Procedures, Appendix A, Section 2.	Guidelines on the requirements for, and the assessment of, air quality impacts associated with airport and airfield infrastructure improvements.	Contains no specific references to HAPs.
FAA Order 5050.4A - Airport Environmental Handbook	Guidelines on the requirements for, and the assessment of, environmental impacts associated with new airports, new or extended runways and other airport improvements. Air quality is one of 20 environmental disciplines identified.	The FAA announced the release of Draft Order 50504B on December 16, 2004. Contains no specific guidance related to the evaluation of HAPs.
Air Quality Handbook. Air Quality Procedures for Civilian Airports and Air Force Bases	Comprehensive guidelines on the preparation of airport related air quality assessments including emission inventories and dispersion modeling.	Contains specific recommendations for conducting emissions inventory and dispersion modeling of criteria pollutants, including volatile organic compounds. Does not reference HAPs.
Source: Select Resource Materials and Annotated Bibliography on the Topic of Hazardous Air Pollutants (HAPS) Associated with Aircraft, Airports, and Aviation, Federal Aviation Administration, July 1, 2003.		

I.5 TRENDS

This section of the document provides the results of an evaluation of trends in national, regional, and local HAP concentrations in the ambient (outdoor) air and in emission inventory data. The data was extracted from the databases of agencies whose goal is the evaluation and/or control of HAPs.

I.5.1 Ambient Measurements

There are more than 4,000 ambient (outdoor) air monitoring stations in the US. Concentrations of HAPs are measured at approximately 300 of the stations. The HAP monitoring stations are sparsely distributed throughout the US and are most commonly located in highly populated areas and/or close to major emission sources.

The repository for the HAP data is the USEPA's Air Quality System;⁴² the data is readily obtainable from the USEPA's AirData website.⁴³ Currently, measured HAP concentration data

⁴¹ Meeting Minutes from June 16, 2004 Meeting with USEPA, IEPA, and FAA.

⁴² USEPA Air Quality System <http://www.epa.gov/ttn/airs/airsaqs/>

⁴³ <http://www.epa.gov/air/data/index.html>

is available for a 10 year period starting in the year 1994 (partial data for the year 2004). Notably, the USEPA's AirData does not have data for diesel particulate matter.

I.5.1.1 National

The number of monitors measuring a HAP or number of HAPs varies by state. When considering the ten year period from 1995 through 2004, very few monitors were in continuous use. It is recognized that the number of monitoring sites and the locations of the sites could affect an evaluation of trends. Therefore, two sets of data were extracted for the purpose of this evaluation. The first set included data from monitors that were operational each of the ten years from 1995 through 2004. The second set included data from the monitors that were operational each of the most recent five years (2000 through 2004). Data meeting these criteria are available for 1,3-butadiene, acetaldehyde, acrolein, benzene, chromium VI, formaldehyde, and toluene.

The average annual mean concentrations of the evaluated HAPs for the period 1995 through 2004 are provided in **Table I-4**. The average annual mean concentrations of the evaluated HAPs for the period 2000 through 2004 are provide in **Table I-5**. Notably, the number of sites considered in the average annual values varies by evaluated period due to the number of monitors sampling a particular pollutant. As shown, over the ten year period from 1995 through 2004, concentrations of 1,3-butadiene, benzene, and toluene decreased while concentrations of formaldehyde increased. Notably, the increase in formaldehyde concentrations is based on a small sample size (only 5 monitors nationwide). As shown in **Table I-5**, over the 5 year period from 2000 though 2004, concentrations of acrolein, benzene, formaldehyde, and toluene decreased while concentrations of 1,3-butadiene and acetaldehyde increased slightly. The majority of the reduction is due to the USEPA's technology-based emission standards for industrial and combustion sources and control measures for motor vehicles and fuels.

**TABLE I-4
NATIONAL TRENDS IN AMBIENT LEVELS OF HAPS: TEN YEAR PERIOD
(1995-2004)**

Year	Average Mean Ambient Concentration (ppbC)(a)			
	1,3-Butadiene	Benzene	Formaldehyde	Toluene
95	1.18	5.34	1.18	13.21
96	0.71	3.75	1.44	10.40
97	0.83	4.10	1.21	11.36
98	0.91	3.39	1.20	8.89
99	0.77	3.69	1.54	8.52
00	0.67	3.41	1.79	9.19
01	0.54	3.84	1.81	7.98
02	0.53	2.65	1.61	7.42
03	0.48	2.78	1.30	6.56
04	0.42	2.59	1.46	5.35
Number of Monitors	29	36	5	31
Percent Increase/Decrease				
95-04	-64	-51	+24	-60

Note: (a) 24-hour samples
ppbC = parts per billion carbon
Source: USEPA AirData (<http://www.epa.gov/air/data/geosel.html>).

**TABLE I-5
NATIONAL TRENDS IN AMBIENT LEVELS OF HAPS: FIVE YEAR PERIOD
(2000-2004)**

Year	Average Mean Ambient Concentration (ppbC)(a)					
	1,3-Butadiene	Acetaldehyde	Acrolein	Benzene	Formaldehyde	Toluene
00	0.70	2.43	0.32	3.62	2.97	8.94
01	0.59	2.61	0.35	3.45	3.02	8.13
02	0.59	2.88	0.50	2.84	3.16	6.83
03	0.58	3.50	0.55	2.74	3.21	6.19
04	0.71	2.47	0.40	2.79	2.23	5.74
Number of Monitors	102	62	3	155	65	152
Percent Increase/Decrease	+1	+2	-25	-23	-25	-36
00-04						

Note: (a) 24-hour samples
ppbC = parts per billion carbon
Source: USEPA AirData (<http://www.epa.gov/air/data/geosel.html>).

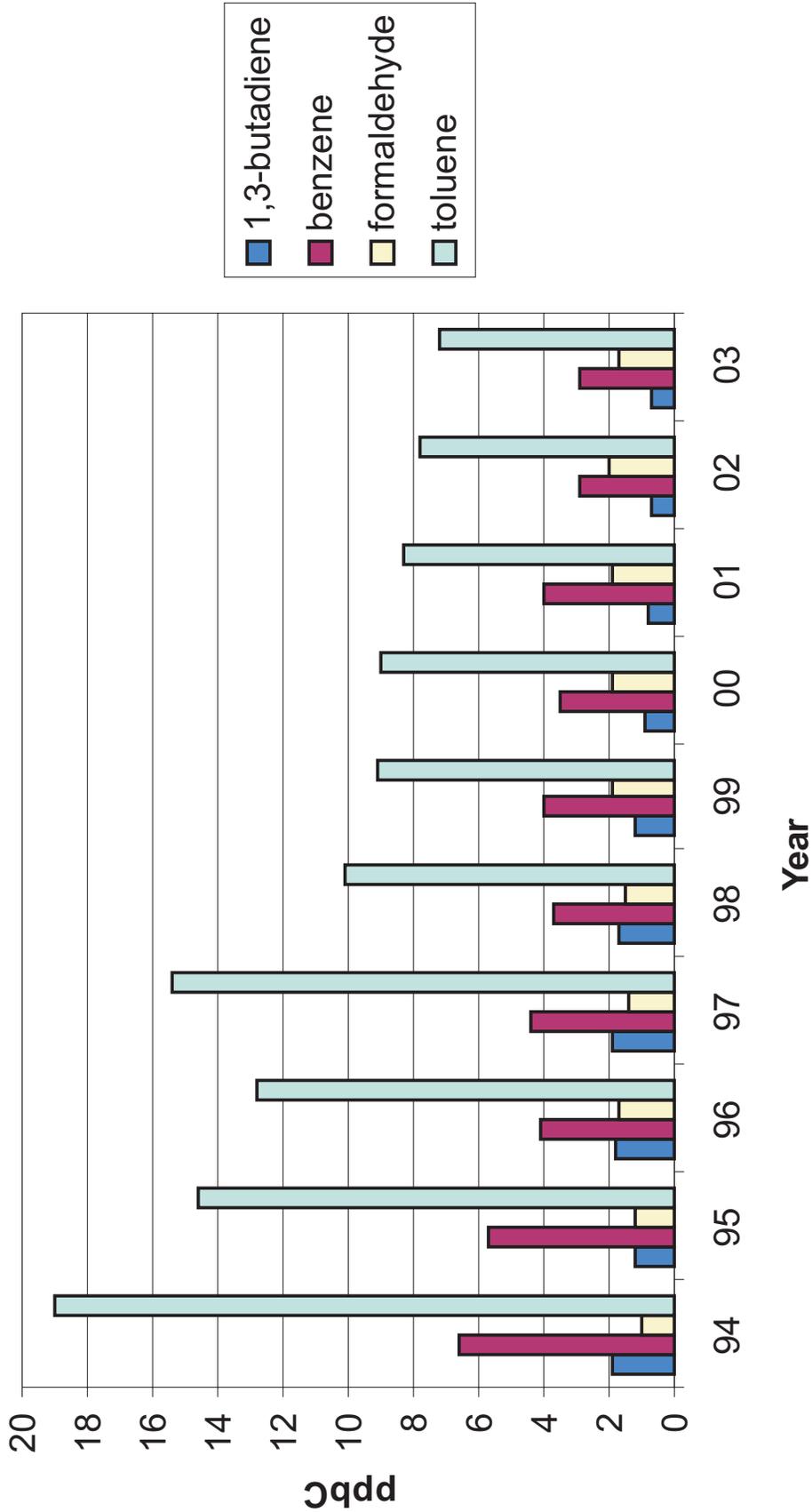
Exhibits I-1 and I-2 illustrate the national average concentrations of HAPs from 1995 through 2004 and from 2000 through 2004, respectively. Additional reductions in all HAPs are expected to continue at least through the year 2020 due to USEPA-mandated controls on motor vehicles and their fuels, including the introduction of reformulated gasoline and low sulfur diesel fuel. According to the USEPA, the mandated controls on industrial and commercial sources are projected to reduce annual HAP emissions by approximately 1.5 million tons while controls on

the emissions of motor vehicles are expected to result in approximately 75 percent less HAPs being emitted into the air by the year 2020 (when compared to 1990 levels).⁴⁴

I.5.1.2 Regional

The number of HAP monitoring sites within Cook and DuPage counties also varies by year and pollutant (**Table I-6**). A review of the USEPA AirData indicates that none of the HAP-specific monitors were operational every year from 1995 through 2004 (for a ten year period). As such, an evaluation of trends in ambient concentrations of HAPs is not possible for this period. For the period from 2000 through 2004 (five years), only 2 sites were operational every year. Both of the sites are located in Cook County. One site is in Northbrook (750 Dundee Road) and the other site is in downtown Chicago (1000 E. Ohio Street). The locations of the sites are illustrated on **Exhibit I-3**. Data from these sites were reviewed to evaluate recent trends in concentrations of acetaldehyde, benzene, formaldehyde, and toluene (the pollutants for which data are available).

⁴⁴ USEPA - <http://www.epa.gov/air/toxicair/newtoxics.html#progress>



PpbC = Parts per Billion Carbon

Source: Environmental Sciences Associates, 2004.

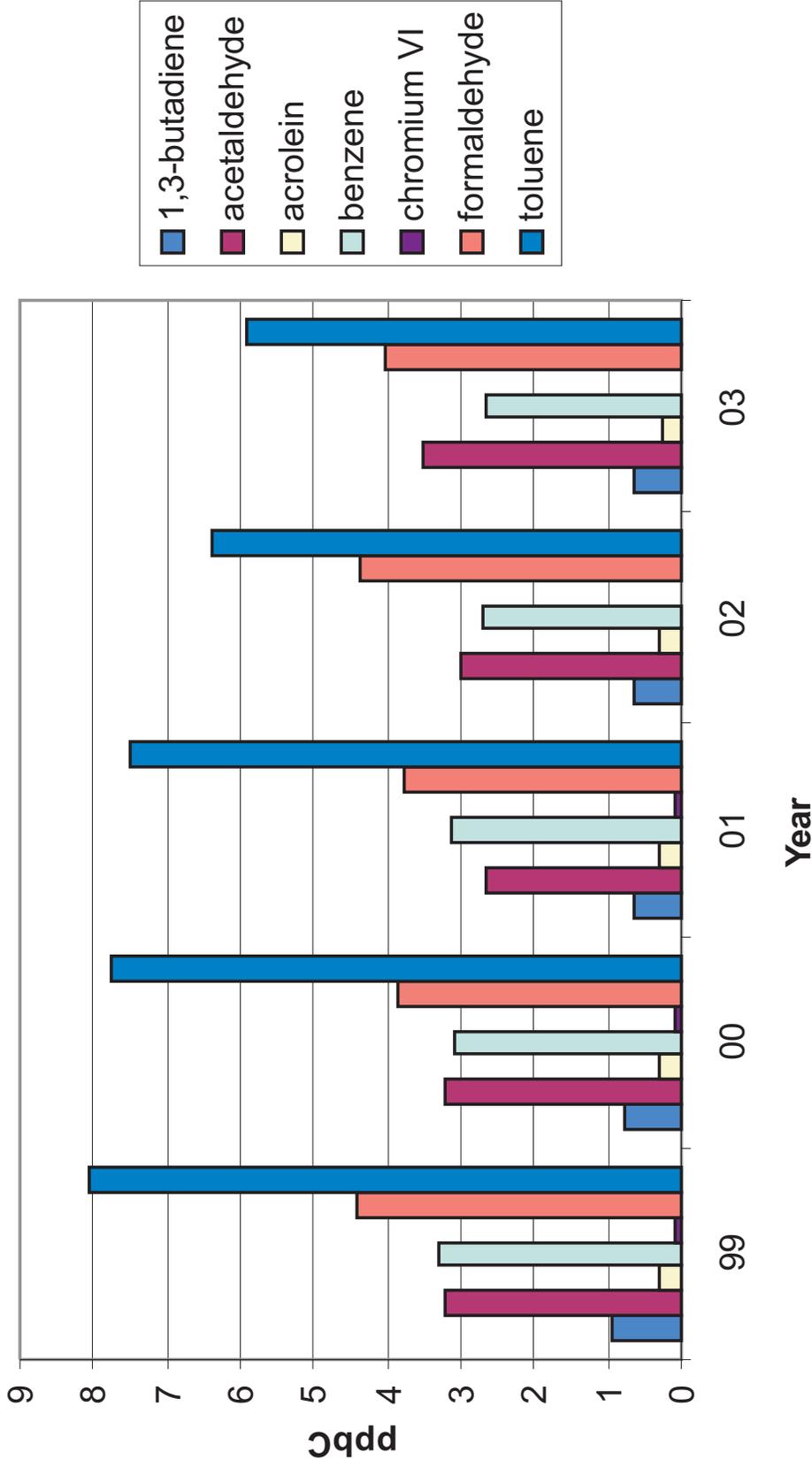


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**National Trends in Ambient
HAP Levels: 1995-2004**

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PpbC = Parts per Billion Carbon

Source: Environmental Sciences Associates, 2004.



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**National Trends in Ambient
HAP Levels: 2000-2004**

**TABLE I-6
NUMBER OF REGIONAL HAP MONITORING SITES**

Year	Number of Monitors Within Cook and DuPage Counties (by Year)									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1,3-Butadiene	4	-	-	-	-	4	-	2	2	3
Acetaldehyde	1	1	2	2	2	5	1	3	3	3
Acrolein	-	-	-	-	-	-	-	-	-	-
Arsenic(a)	-	-	-	-	-	1	2	3	3	3
Benzene(b)	5	1	2	2	2	5	2	3	3	3
Chromium VI	-	-	-	-	-	-	-	-	-	-
Diesel Particulate	-	-	-	-	-	-	-	-	-	-
Formaldehyde	1	1	2	2	2	5	1	3	3	3
Naphthalene	-	-	-	-	-	-	-	-	-	-
Nickel(a)	-	-	-	-	-	1	2	3	3	4
Toluene	5	1	2	2	2	5	2	3	3	3

Notes: (a) In particulate matter 2.5 microns or less in size

(b) including benzene from gasoline

(-) = No monitors were in operation during this year.

Source: USEPA AirData (<http://www.epa.gov/air/data/geosel.html>).

As shown in **Table I-7**, over the five year period from 2000 through 2004, concentrations of acetaldehyde, benzene, formaldehyde, and toluene decreased (notably, levels of formaldehyde increased in the years 2001, 2002, and 2003 but decreased in 2004 to a level below the level measured in the year 2000). Again, the majority of the reduction is due to the USEPA's technology-based emission standards for industrial and combustion sources and control measures for motor vehicles and fuels. **Exhibit I-4** illustrates the regional average mean concentrations of HAPs from 2000 through 2004.

**TABLE I-7
REGIONAL TRENDS IN AMBIENT LEVELS OF HAPS: FIVE YEAR PERIOD (2000-2004)**

Year	Average Mean Ambient Concentration (ppbC)(a)			
	Acetaldehyde	Benzene	Formaldehyde	Toluene
00	1.23	1.06	1.14	3.88
01	1.42	1.31	1.77	4.67
02	1.20	1.04	3.59	4.07
03	0.96	0.67	5.59	2.48
04	0.66	0.78	0.70	2.54
Number of Monitors	1	2	1	2
Percent Incr/Decr 00-04	-46	-26	-39	-35

Notes: (a) 24-hour samples

ppbC = parts per billion carbon

Source: USEPA AirData



Source: USEPA AirData

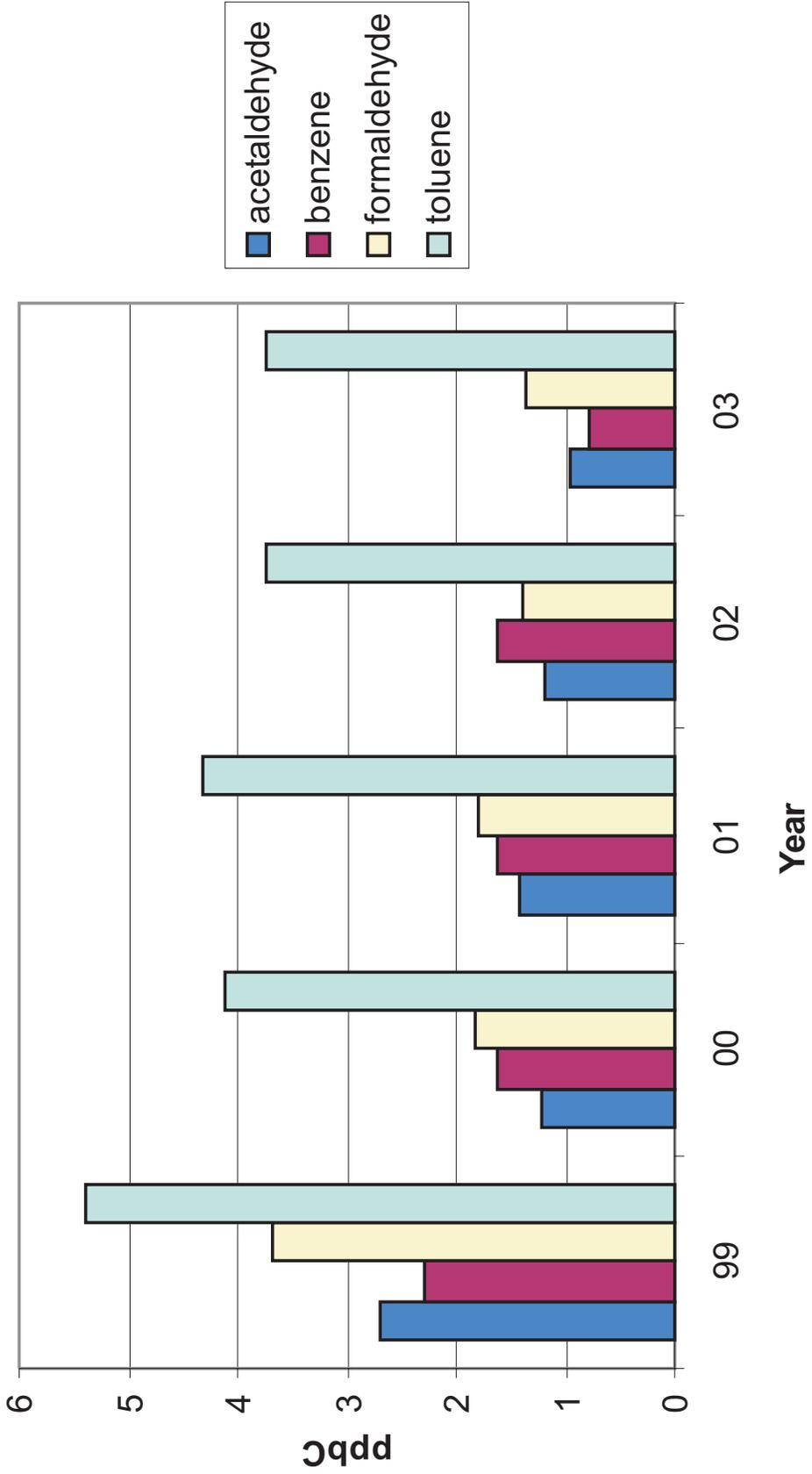


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**HAP Monitoring Sites:
Northbrook, Downtown Chicago**

► **Exhibit I-3**



PpbC = Parts per Billion Carbon

Source: Environmental Sciences Associates, 2004.



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**Regional Trends in Ambient
HAP Levels: 2000-2004**

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I.5.2 Emission Inventories

Two primary sources of HAP emission inventories were identified:

- The USEPA National Toxics Inventory, and
- The Great Lakes Commission⁴⁵ Regional Air Pollutant Inventory Development System (RAPIDS).

These data were reviewed to evaluate regional trends in emission estimates over time. Notably, emission inventories are not based on actual measurements of individual HAPs, but rather on computerized estimation tools. The most recent year of data available from the USEPA database was 1996. As such, this agency's data was not used in the trend evaluation. The Great Lakes Commission databases include inventories for 1996 and 2001. The Great Lakes Commission prepares detailed, basin-wide (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, and Ontario) data on the source and emission levels of HAPs. Notably, the inventories do not include data for diesel particulate matter.

The Commission's HAP inventory for Cook and DuPage counties for the year 1996⁴⁶ is provided in **Table I-8**. Based on this data, point/area sources emitted approximately 41 percent of the total inventoried emissions and mobile sources (on- and off-road) emitted approximately 59 percent of the total emissions.

Table I-9 provides the Great Lakes Commission's inventory for the year 2001.⁴⁷ In 2001, the Great Lakes Commission's inventories indicate that on-road vehicles emitted approximately 43 percent of the total inventoried HAP emissions while area/other sources emitted approximately 39 percent. The remaining emissions were emitted by non-road vehicles/equipment (14 percent) and major stationary sources (4 percent).

Data in **Table I-10** compares the Great Lake Commission's 1996 and 2001 inventories. Based on the comparison, total HAP emissions of 1,3-butadiene, arsenic, chromium VI, naphthalene, and nickel decrease while emissions of acetaldehyde, acrolein, benzene, formaldehyde, toluene increased during this time period with mobile sources (on- and off-road) emitting more in 2001 than in 1996. Notably, the majority of the differences between the 1996 and 2001 inventories are likely due to changes in source activity levels but differences could also be a result of differences in data collection techniques, assumptions, and/or emission factors.

⁴⁵ The GLC Rapids Steering Committee is comprised of representatives from the Illinois Environmental Protection Agency, the Indiana Department of Environmental Management, the Michigan Department of Environmental Quality, the Minnesota Pollution Control Agency, the New York Department of Environmental Conservation, the Ohio Environmental Protection Agency, the Pennsylvania Department of Environmental Protection, the Wisconsin Department of Natural Resources, and the Ontario Ministry of Environment.

⁴⁶ 1996 Inventory for Toxic Air Emissions: A Product of the Great Lakes Regional Air Toxics Project, Part I: Point and Area Sources, Great Lakes Commission, December 1999 and 1996 Inventory for Toxic Air Emissions, Part II: Mobile Sources, Great Lakes Commission, February 2000.

⁴⁷ 2001 Inventory of Toxic Air Emissions, Point, Area and Mobile Sources, Great Lakes Commission, April 2004.

**TABLE I-8
GREAT LAKES COMMISSION HAP INVENTORY: 1996**

Pollutant	County	Tons			Percent Contribution		
		Point/Area(a)	Mobile(b)	Total	Point/Area	Mobile	Total
1,3-Butadiene	Cook	0.05	1223.41	1223.46	0%	100%	100%
	DuPage	0.01	277.33	277.33	0%	100%	100%
	Total	0.06	1500.74	1500.79	0%	100%	100%
Acetaldehyde	Cook	3.71	517.41	521.12	1%	99%	100%
	DuPage	0.44	106.42	106.87	0%	100%	100%
	Total	4.15	623.83	627.99	1%	99%	100%
Acrolein	Cook	4.11	88.01	92.12	4%	96%	100%
	DuPage	0.48	10.63	11.11	4%	96%	100%
	Total	4.59	98.64	103.23	4%	96%	100%
Arsenic	Cook	0.20	4.43	4.64	4%	96%	100%
	DuPage	0.01	1.02	1.03	1%	99%	100%
	Total	0.21	5.45	5.66	4%	96%	100%
Benzene	Cook	498.27	1145.32	1643.59	30%	70%	100%
	DuPage	91.35	260.39	351.75	26%	74%	100%
	Total	589.62	1405.71	1995.34	30%	70%	100%
Chromium VI	Cook	3.34	2.14	5.49	61%	39%	100%
	DuPage	0.04	0.49	0.54	8%	92%	100%
	Total	3.39	2.63	6.02	56%	44%	100%
Formaldehyde	Cook	368.27	1497.36	1865.64	20%	80%	100%
	DuPage	49.88	301.66	351.54	14%	86%	100%
	Total	418.15	1799.02	2217.17	19%	81%	100%
Naphthalene	Cook	260.86	11.44	272.30	96%	4%	100%
	DuPage	44.28	0.19	44.46	100%	0%	100%
	Total	305.14	11.63	316.76	96%	4%	100%
Nickel	Cook	8.85	0.67	9.53	93%	7%	100%
	DuPage	0.53	0.15	0.69	77%	23%	100%
	Total	9.38	0.83	10.21	92%	8%	100%
Toluene	Cook	5316.39	4587.05	9903.44	54%	46%	100%
	DuPage	954.65	1096.15	2050.81	47%	53%	100%
	Total	6271.04	5683.20	11954.24	52%	48%	100%

Notes: (a) Point sources are stationary sources such as factories, hazardous waste incinerators, and power plants.
Area sources are sources such as dry cleaners and gas stations.

(b) Mobile sources are highway vehicles and non-road equipment.

Source: <http://www.glc.org/air/inventory/1996/>. Compiled by Environmental Science Associates, Inc. [TPC], 2004.

**TABLE I-9
GREAT LAKES COMMISSION HAP INVENTORY: 2001**

Pollutant	County	Tons					Percent Contribution				
		Mobile Sources					Mobile Sources				
		Major(a)	Area / Other(b)	On- Road	Non- Road	Total	Major	Area / Other	On- Road	Non- Road	Total
1,3-Butadiene	Cook	28.4	0.0	341.8	136.8	507.0	6%	0%	67%	27%	100%
	DuPage	18.9	0.0	52.6	33.5	105.0	18%	0%	50%	32%	100%
	Total	47.3	0.0	394.5	170.3	612.1	8%	0%	64%	28%	100%
Acetaldehyde	Cook	1.96	2.04	916.75	268.57	1189.32	0%	0%	77%	23%	100%
	DuPage	0.11	0.35	141.21	53.93	195.59	0%	0%	72%	28%	100%
	Total	2.07	2.39	1057.95	322.50	1384.91	0%	0%	76%	23%	100%
Acrolein	Cook	1.79	34.93	62.55	49.70	148.96	1%	23%	42%	33%	100%
	DuPage	0.10	5.12	9.64	4.60	19.46	1%	26%	50%	24%	100%
	Total	1.89	40.04	72.18	54.30	168.42	1%	24%	43%	32%	100%
Arsenic	Cook	0.25	0.02	0.27	0.09	0.63	39%	4%	43%	14%	100%
	DuPage	0.01	0.00	0.04	0.03	0.08	8%	4%	50%	37%	100%
	Total	0.25	0.03	0.31	0.12	0.71	36%	4%	44%	17%	100%
Benzene	Cook	94.12	104.70	2336.58	805.88	3341.28	3%	3%	70%	24%	100%
	DuPage	1.27	23.38	359.82	220.98	605.46	0%	4%	59%	36%	100%
	Total	95.38	128.08	2696.40	1026.86	3946.73	2%	3%	68%	26%	100%
Chromium VI	Cook	0.29	0.00	0.89	0.10	1.28	23%	0%	70%	8%	100%
	DuPage	0.00	0.00	0.14	0.11	0.25	<1%	0%	56%	44%	100%
	Total	0.29	0.00	1.03	0.20	1.52	19%	0%	68%	13%	100%
Formaldehyde	Cook	171.89	19.07	1329.70	672.75	2193.42	8%	1%	61%	31%	100%
	DuPage	28.63	3.03	204.86	124.00	360.52	8%	1%	57%	34%	100%
	Total	200.52	22.10	1534.56	796.75	2553.93	8%	1%	60%	31%	100%
Naphthalene	Cook	58.67	132.43	67.01	8.29	266.41	22%	50%	25%	3%	100%
	DuPage	0.37	22.90	10.32	2.43	36.01	1%	64%	29%	7%	100%
	Total	59.04	155.33	77.33	10.72	302.42	20%	51%	26%	4%	100%
Nickel	Cook	5.68	0.23	0.17	0.22	6.30	90%	4%	3%	4%	100%
	DuPage	0.11	0.04	0.03	0.01	0.18	59%	21%	14%	6%	100%
	Total	5.79	0.26	0.19	0.23	6.48	89%	4%	3%	4%	100%
Toluene	Cook	948.82	9921.34	7258.30	1803.32	19931.77	5%	50%	36%	9%	100%
	DuPage	83.61	2453.46	1117.72	465.41	4120.21	2%	60%	27%	11%	100%
	Total	1032.42	12374.80	8376.02	2268.73	24051.98	4%	51%	35%	9%	100%

Notes: (a) Major sources are sources that emit more than 10 tons annually of a single HAP or more than 25 tons annually of a combination of HAPs.

(b) Area/other sources are sources that emit less than 10 tons annually of a single HAP or less than 25 tons annually of a combination of HAPs.

Source: <http://www.glc.org/air/inventory/2001/>. Compiled by Environmental Science Associates, Inc. [TPC], 2004.

**TABLE I-10
GREAT LAKES COMMISSION HAP INVENTORIES: 1996/2001**

Pollutant	County	Tons		Increase/Decrease	
		1996	2001	Total	Percent
1,3-Butadiene	Cook	1223.46	507.00	-716.46	-59%
	DuPage	277.33	105.00	-172.33	-62%
	Total	1500.79	612.10	-888.69	-59%
Acetaldehyde	Cook	521.12	1189.32	668.20	128%
	DuPage	106.87	195.59	88.72	83%
	Total	627.99	1384.91	756.92	121%
Acrolein	Cook	92.12	148.96	56.84	62%
	DuPage	11.11	19.46	8.35	75%
	Total	103.23	168.42	65.19	63%
Arsenic	Cook	4.64	0.63	-4.01	-86%
	DuPage	1.03	0.08	-0.95	-92%
	Total	5.66	0.71	-4.95	-87%
Benzene	Cook	1643.59	3341.28	1697.69	103%
	DuPage	351.75	605.46	253.71	72%
	Total	1995.34	3946.73	1951.39	98%
Chromium VI	Cook	5.49	1.28	-4.21	-77%
	DuPage	0.54	0.25	-0.29	-54%
	Total	6.02	1.52	-4.5	-75%
Formaldehyde	Cook	1865.64	2193.42	327.78	18%
	DuPage	351.54	360.52	8.98	3%
	Total	2217.17	2553.93	336.76	15%
Naphthalene	Cook	272.30	266.41	-5.89	-2%
	DuPage	44.46	36.01	-8.45	-19%
	Total	316.76	302.42	-14.34	-5%
Nickel	Cook	9.53	6.30	-3.23	-34%
	DuPage	0.69	0.18	-0.51	-74%
	Total	10.21	6.48	-3.73	-37%
Toluene	Cook	9903.44	19931.77	10028.33	101%
	DuPage	2050.81	4120.21	2069.40	101%
	Total	11954.24	24051.98	12097.74	101%

Source: <http://www.glc.org/air/inventory/1996/> and <http://www.glc.org/air/inventory/2001/>. Compiled by Environmental Science Associates, Inc. [TPC], 2004.

I.6 AIRPORT-RELATED HAP STUDIES

The following provides a review of available HAP-related evaluations for previous (historical) O'Hare-specific studies and studies that have been performed at, or in the vicinity of, other airports. The evaluations included emission inventories and/or ambient measurements of HAPs. The following evaluations were reviewed:

- O'Hare specific or related HAP Studies
 - City of Chicago Study (1999)
 - Park Ridge Study (2000)
 - IEPA Air Toxics Monitoring Program (2000)
 - O'Hare and Midway Study (2001)
 - Air Screening Assessment-Cook County, Illinois and Lake County, Indiana (2004)

- Other airport-related studies
 - Midway Study (1993)
 - Seattle-Tacoma International Airport (1993)
 - Santa Monica Municipal Airport (1999)
 - John Wayne International Airport/Proposed Orange County International Airport (2000)
 - Los Angeles International Airport (2000)
 - Teterboro Airport (2001)
 - Oakland International Airport (2002)
 - Ted Stevens Anchorage Airport (2003)

I.6.1 O'Hare-Specific or Related HAP Studies

I.6.1.1 City of Chicago Study

In 1999, the City of Chicago conducted two air quality studies for O'Hare.^{48,49} Both studies quantified emissions of volatile organic compounds for aircraft and other emission sources within a 10 mile radius of O'Hare. In one study, a monitoring program was conducted to determine if soot deposited near O'Hare came from aircraft operations or from typical urban activities such as truck and car traffic and/or industrial and manufacturing operations. The results indicated that soot near O'Hare did not chemically resemble jet fuel or jet engine exhaust, but was more closely related to general urban pollutants, motor vehicle exhaust, and soot from burning heavier fuels, such as fuel oil.

The purposes of the other study were to better understand 1) the relative contribution of aircraft using O'Hare to air quality in the areas immediately surrounding the Airport and 2) the progress that has been made in reducing aircraft emissions from aircraft using O'Hare. Five substances evaluated were volatile organic compounds, benzene, 1,3-butadiene, formaldehyde, and polycyclic organic matter.

The findings of both studies include these results:

- Aircraft emitted only 1.6 percent of volatile organic compounds in and around O'Hare.
- Aircraft emitted less than 2.5 percent of local benzene, less than 12 percent of the 1,3-butadiene and less than 21 percent of the formaldehyde.
- Off-airport motor vehicles were the number one source of emissions of all the substances studied. For example, motor vehicles emitted over 20 times the amount of benzene as aircraft.
- Motor vehicles in communities near O'Hare emitted over 75 times the quantity of the polycyclic organic matter (unburned hydrocarbons that are in particulate form) with suspected health effects than aircraft using the Airport.
- Total volatile organic compound emissions from aircraft using O'Hare during 1998 were 33 percent lower than IEPA estimates of 1990 O'Hare aircraft emissions. A similar decrease in the emissions of individual air toxics was expected.

⁴⁸ KM Chng, 1999, Findings Regarding Source Contribution to Soot Deposition, O'Hare International Airport and Surrounding Communities, prepared for the City of Chicago, December 1999, KM Chng Report No. 991102.

⁴⁹ Chicago Department of Aviation, Press release summarizing testing at O'Hare International Airport, December 19, 1999. Website: http://www.flychicago.com/doa/avi_news/doa_avi_news_pr_12.shtm. Accessed October 20, 2004.

I.6.1.2 Park Ridge Study

The City of Park Ridge, Illinois conducted a preliminary study of the HAPs emitted from O'Hare in August of 2000.⁵⁰ The purposes of the study included "1) a preliminary confirmation (on a limited "snapshot" basis), if possible, as to whether toxic emissions from O'Hare operations were actually crossing the fence line (or property line) at O'Hare, 2) a preliminary assessment of the health risks in surrounding residential communities caused solely by toxic emissions from O'Hare; and 3) a health risk assessment of the fence line concentrations in the snapshot study."

To determine if emissions from O'Hare were crossing the fence line of the Airport's property, the City of Park Ridge conducted a preliminary study from which the results were meant to "provide a basis for the demonstration of the need for further investigation by responsible agencies." Ambient (outdoor) sampling was used to form the basis of the conclusions. A minimal amount of sampling was performed (three 24-hour samples, five 8-hour samples in two locations, and two sets of grab samples (samples obtained over a few minutes or less)). Based on these measurements, it was reported that O'Hare did contribute to the overall burden of respirable dust downwind from the Airport and that ambient concentrations of aldehydes were found at increased levels downwind from the Airport. Of the 219 volatile compounds sampled, 92 were identifiable and 78 were found to be at increased levels downwind of O'Hare. Of the 78 samples, 22 were found to be at higher levels than at a Jardin monitoring station (assumed to be the background monitoring station). Based on the results, the study concluded that "lessons learned from this study can now be used to design and implement a more comprehensive investigation that will ultimately provide a more detailed picture of the affect that air pollution from O'Hare International Airport has on the surrounding communities."

The preliminary health risk assessment and the health risk assessment of fence line concentrations was then performed by the City of Park Ridge. The assessment consisted of an "emissions/dispersion/receptor risk analysis". To conduct the dispersion component of the analysis, the USEPA's Industrial Source Complex Short-Term (ISCST3) computer model was used. Based on their assessment, the City of Park Ridge concluded that the maximum hypothetical cancer risk at O'Hare's property line was approximately 1 in 10,000, and that the individual cancer risks associated with operations at O'Hare exceeded 1 in 100,000 over an area approximately 40 miles (assuming a 70 year exposure for an individual).

It is assumed that the Park Ridge analysis was performed before or during the Spring of 2000 because the report was published in the Summer of 2000. In April of 2000, the USEPA proposed that a newer state-of-the-practice dispersion model, AERMOD,⁵¹ replace the ISCST3 model because AERMOD provided a better characterization of plume dispersion. As stated in the Park Ridge report, the results of their analysis "should be considered preliminary, and could be refined through additional air monitoring or more sophisticated emission, dispersion, and exposure

⁵⁰ City of Park Ridge, Illinois, 2000. Preliminary Study and Analysis of Toxic Air Pollutant Emissions from O'Hare International Airport and the Resulting Health Risks Created by these Toxic Emissions in Surrounding Residential Communities, August 2000.

⁵¹ 65 FR 21506 and 68 FR 18440

modeling". USEPA's statements regarding the AERMOD dispersion model suggest that use of this more refined modeling would result in different conclusions for the same type of study. Because of the numerous variables in dispersion models, it is not known if the results would be higher or lower than reported in the Park Ridge analysis.

I.6.1.3 IEPA Air Toxics Monitoring Program

During 2000, the IEPA funded a six month measurement program of airport-related airborne contaminants as part of its urban air toxics monitoring program.⁵² The purpose of the program "was to collect information that could help assess the relative impact of airport related emissions and levels of airborne contaminants characteristic of large urban areas." Specifically, the toxics monitoring program was designed to provide data to meet four objectives:⁵³

- 1) Measure the concentrations of specific compounds of concern;
- 2) Assess the geographic variability of various compounds in the Chicago area and perform a comparison of levels measured at the two O'Hare sites to those recorded at the remaining three Chicago area locations;
- 3) Compare Chicago area results to data collected for other large U.S. cities; and
- 4) Determine if the emissions associated with O'Hare Airport have a measurable impact on air quality in areas adjacent to the airport.

Measurements were obtained at five sampling sites: two near O'Hare International Airport (in Bensenville and Schiller Park); one site in Northbrook just downwind (North) of the urban core; one at Washington School in Southeast Chicago to represent the highly industrialized setting of this area, and one in Lemont, an area impacted by refineries and on the southwestern edge of the metropolitan area.

According to IEPA's report, the accumulated monitoring results obtained from the five site monitoring network provided the following findings:

- 1) The average concentrations measured at O'Hare Airport for many of the target compounds were found to be comparable with the concentrations found at the other Chicago area sites;
- 2) The highest concentrations of several target urban air toxic compounds were found to be spread between several sites but generally the highest levels for many of the air toxics were found to occur in Southeast Chicago; and
- 3) The lowest concentrations of most target compounds were measured at Lemont.

⁵² Chicago O'Hare Airport Air Toxic Monitoring Program, June-December 2000, Final Report Illinois EPA, Bureau of Air, May 2002.

⁵³ Chicago O'Hare Airport Air Toxic Monitoring Program, June-December 2000, Final Report Illinois EPA, Bureau of Air, May 2002.

Taken as a group of target compounds, these data indicate that the highest concentration of air toxic compounds in the Chicago area was found in industrialized Southeast Chicago, not in the vicinity of O'Hare.

I.6.1.4 O'Hare and Midway Study

In 2001, the Illinois Department of Public Health published an evaluation of the cancer incidence within communities that are in close proximity to the Chicago O'Hare and Midway Airports.⁵⁴ The study reviewed cases reported in the Illinois State Cancer Registry (1987-1997) for groups close to the airports and compared the data to reference groups eight miles from the airports. The report concluded that no evidence of an increased cancer risk within the communities that are in close proximity to the O'Hare or Midway airports was evident.

I.6.1.5 Air Screening Assessment-Cook County, Illinois, and Lake County, Indiana

A report was released in March of 2004 that assessed the cumulative hazard associated with inhalation of HAPs from large ("major") stationary and smaller ("area") sources, as well as on- and off-road mobile sources, in Cook County, Illinois and Lake County, Indiana (including emission sources at O'Hare).⁵⁵ The assessment was prepared by Argonne National Laboratory with input from a workgroup consisting of members of the public, as well as federal, state, and local government. This study used data from sources such as USEPA's Toxic Release Inventory, the Great Lakes Commission's Regional Air Pollutant Inventory Development System (RAPIDS), and ambient air monitoring data. The information was used to identify geographic areas, emission sources/subsectors, and pollutants associated with relative carcinogenic or noncarcinogenic hazard levels.

A few geographic areas of Cook County and Lake County were identified as areas with higher hazard levels, specifically along the Lake County (Indiana) lakeshore, Southeastern Chicago and central Chicago. With regard to emission sources/subsectors, mobile sources were found to be the largest contributor to the hazards from air toxics. The major contributor to mobile source noncarcinogenic hazards was airport-related, e.g. aircraft and airport service vehicle emissions. The study also concluded that a relatively small number of pollutants generally accounted for a large portion of the hazard levels. These HAPs included 1,2-dibromoethane, 1,3-butadiene, acrolein, benzene, carbon tetrachloride, chloroform, chromium VI, and formaldehyde.

⁵⁴ Shen T, Lehnerr M. Cancer Incidence in Populations living near Chicago O'Hare and Midway Airports, Illinois 1987-1997. Epidemiological Report Series 01:6. Springfield, IL: Illinois Department of Public Health, November 2001.

⁵⁵ Argonne National Laboratory, Environmental Assessment Division and Decision and Information Sciences Division, United States Department of Energy, *Air Screening Assessment for Cook County, Illinois, and Lake County, Indiana*, March 2004.

I.6.2 Other Airport-Related HAP Studies

I.6.2.1 Midway Airport

In 1993, the USEPA (Region V) conducted an evaluation of cancer risks in Southwest Chicago from air pollution and calculated a cancer risk by pollutant for Midway Airport.⁵⁶ The purpose of this study was to estimate cancer risks from air toxics in Southwest Chicago. The study area is approximately 16 square miles, and about 93,854 people live in the study area. The emissions inventory included 174 industrial point sources, area sources, road vehicles, emissions from sources at Midway Airport, and non-road mobile source emissions, such as lawn mowers and snow blowers. Air dispersion modeling was then used to estimate the concentrations of the pollutants, and the modeled estimates were compared to monitored concentrations. Cancer risk was estimated for each pollutant based on the unit risk of each chemical, and these were summed up for all pollutants and source categories to determine lifetime risk.⁵⁷

The study found that 1,3-butadiene is the most prominent pollutant contributing to risk in the area. This pollutant is emitted mostly from mobile sources such as automobile, aircraft, and non-road equipment engines. Other major pollutant contributors are hexavalent chromium (plating sources) and formaldehyde (photochemical reactions). The study estimated that Chicago Midway Airport was responsible for 11 percent of the total lifetime excess cancer risk from air pollution in the area.

I.6.2.2 Seattle-Tacoma International Airport

In 1993, the Port of Seattle conducted an air monitoring study in the vicinity of the Seattle-Tacoma International Airport (Sea-Tac).⁵⁸ The results indicated that off-site, the measurements taken both up- and down-wind were not easily differentiated or different from levels found in other urban areas. In 1995, another air monitoring program was conducted by the Port.⁵⁹ In this program, volatile organic compounds/HAPs were sampled using USEPA-approved methods. The study concluded that the ratios of several key volatile organic compounds were indicative of automobile exhaust and did not resemble the volatile organic compounds profiles associated with aircraft emissions.

⁵⁶ Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southwest Chicago, USEPA Region V, Air and Radiation Division, April 1993.

⁵⁷ USEPA, 2004. Air Toxics Community Assessment and Risk Reduction Projects Database. Website: <http://yosemite.epa.gov/oar/CommunityAssessment.nsf/0/c800613b3e28ce4a85256be2005f5fc5?> Accessed October 20, 2004.

⁵⁸ Port of Seattle, 1995, *Final Report: Air Quality Survey*, Seattle-Tacoma International Airport, January.

⁵⁹ McCulley, Frick & Gilman, Inc., 1995, *Air Quality Survey*, Seattle-Tacoma International Airport, Final Report, prepared for Port of Seattle Aviation Planning Department.

I.6.2.3 Santa Monica Municipal Airport

In 1999, the Los Angeles Unified School District published a report which contained a health risk assessment that was designed to evaluate the potential health impacts of airport operations on the students and staff who attended local schools in proximity to Santa Monica Municipal Airport. The study reported that there were "...uncertainties associated with discrete variates or assumptions (e.g., aircraft exhaust emission factors) used to perform the assessment...".

I.6.2.4 John Wayne International Airport/Proposed Orange County International Airport

In 2000, Orange County commissioned a health risk assessment for John Wayne International Airport and for the proposed Orange County International Airport (at the site of the closed El Toro Navy Base) in conjunction with the preparation of the California Environmental Quality Act (CEQA) Environmental Impact Report No. 573.⁶⁰ Twenty three toxic substances were included in the assessment. Emissions were quantified for aircraft operations, ground support equipment operations, fuel trucks, and fuel storage tanks.

The study concluded that the primary HAPs from aircraft included formaldehyde, acetaldehyde, benzene, and 1,3-butadiene. The study also identified two distinct areas of elevated cancer risks – one in the vicinity of each airport. Primary contributors to cancer risks are diesel particulate matter 10 microns or less (about 67 percent) and 1,3-butadiene (about 20 percent), benzene (5 percent), formaldehyde (5 percent). Ground support equipment produce most particulate matter emissions and aircraft in idle or taxi mode produced most 1,3-butadiene emissions (about 95 percent).

I.6.2.5 Los Angeles International Airport

In 1999, the South Coast Air Quality Management District (SCAQMD) conducted a general evaluation of cancer risks associated with HAPs from all sources in the South Coast Air Basin.⁶¹ Based on HAP monitoring data from 10 stations within the area, the report stated that the carcinogenic risk from exposure to HAPs is about 1,400 per million. The SCAQMD found that 80 percent of the excess lifetime cancer risk was due to mobile sources (i.e. motor vehicles, trains, ships, aircraft, etc.), and 10 percent was attributable to stationary sources. The study states that the cancer risk is dominated by diesel particulate matter (about 70 percent of the risk) from truck traffic in the area, and the highest levels are in south-central and east Los Angeles, particularly near freeways.

In the year 2000, a human health risk assessment was conducted for the Los Angeles International Airport (LAX) in conjunction with the joint state and Federal *LAX Master Plan*

⁶⁰ Lindberg DE, Castleberry J, Price RO. A human health risk assessment of the John Wayne and Proposed Orange County international Airports in Orange County, California, June 21, 2000.

⁶¹ South Coast Air Quality Management District, 1999, Multiple Air Exposure Study in the South Coast Air Basin (MATES-II), Draft Final Report.

*Final EIS/EIR.*⁶² Extensive air quality analyses (including emission inventories, dispersion modeling and health risk assessments) were conducted in support of federal and/or state environmental impact assessments for the proposed improvements to the Airport.

The objective of the human health risk assessment (commissioned specifically in response to California Environmental Quality Act (CEQA)) was to determine the increased incremental health risk, if any, associated with the implementation of the LAX Master Plan for people working at LAX and for people living, working, or attending school in communities near the Airport. The study used methods of estimating risks that were developed by the California Environmental Protection Agency and the USEPA. The approach of the study was to identify the most predominant sources of HAPs. The report concluded that cancer risks associated with LAX operations are mostly due to exposure of diesel particulates, benzene, and 1,3 butadiene and that the non-cancer risks are dominated by acrolein from jet engine exhaust. The report states that levels of benzene and 1,3-butadiene were elevated in the vicinity of LAX.

The FAA acknowledges that because the FAA and City of Los Angeles jointly conducted the NEPA analysis and CEQA analysis for proposed improvements at Los Angeles International Airport (LAX) in a single document, a Human Health Risk Assessment (HHRA) regarding human exposure to toxic air pollutants (TAPs) was included in the Draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR)(January 2001) and Supplement to the Draft EIS/EIR (July 2003), with a clear explanation that the information was included only for purposes of CEQA compliance. Based on case law, an HHRA is required under CEQA, but not NEPA. Furthermore, the Environmental Justice section of the Final EIS (January 2005) for proposed master plan improvements at Los Angeles World Airports included a reproduction and summary of this same HHRA. The EJ section clearly states that the reproduction and summary of the TAPs analysis was included for informational purposes only. In addition, it states that there are no federal standards for exposure to TAPs and that data necessary to make conclusive statements was lacking. Finally, the LAX ROD reiterates and clarifies "As indicated in Volume A of the [LAX] Final EIS, there are no federal standards regarding exposure to TAPs. Furthermore, there is an absence of TAPs emissions data and limitations on TAPs speciation profiles for commercial jet aircraft engines. As a result, the data that would be necessary to make scientifically supportable conclusions is lacking. As is clearly indicated in Volume A of Part 1 of the [LAX] Final EIS, Section A.2.2.4, page A.2-88, the HHRA is not being relied upon by the FAA in evaluating the choice among alternatives presented in the [LAX] Final EIS. Therefore, the information, analyses, and conclusions reached in the CEQA HHRA analysis and presented in Volume A of the [LAX] Final EIS are not relied upon in this Record of Decision, and do not constitute a part of the [LAX] Final EIS for purposes of NEPA compliance."⁶³

⁶² LAWA, 2004, LAX Master Plan Final EIS/EIR, Human Health Risk Assessment, Technical Report 14a., prepared for the Los Angeles World Airports Authority. <http://www.laxmasterplan.org/>

⁶³ FAA, Record of Decision, Proposed LAX Master Plan Improvements, May 20, 2005, p. 23 (<http://www.laxmasterplan.org/publications.cfm>)

I.6.2.6 Teterboro Airport

In 2001, a short-term study was conducted to measure ambient concentrations of select HAPs near the Teterboro Airport.⁶⁴ One purpose of the study was to determine if HAPs from the Airport could be distinguished from background sources. The sampling was conducted over a 2-day period at six locations both on and off the airport. Volatile organic compounds, polycyclic aromatic hydrocarbons, and aldehydes were measured using automated equipment, wipe samples, and laboratory methods.

The study reported that benzene, toluene, ethylbenzene, xylene, 1,3-butadiene and trimethylbenzene levels near the Teterboro Airport were higher than reported at other sampling locations. The study also concluded that airport operations did appear to be affecting air quality in the immediate vicinity of the Airport. However, the study indicated that, for many HAPs, the differences between upwind and downwind concentrations were very small.

I.6.2.7 Oakland International Airport (OAK)

A human health risk assessment was completed for Oakland International Airport in 2003 as part of the CEQA document for their proposed Airport Development Program.⁶⁵ The assessment was conducted in accordance with a modeling protocol developed by the Port of Oakland in consultation with the Bay Area Air Quality Management District and the California Air Resources Board. The protocol included an estimation of the types and amounts of HAPs released from the various sources found at the Airport and an estimation of possible concentrations of HAPs in air near the Airport using emissions estimates and air dispersion modeling.

Substances were identified (in this case, HAPs) that may be released in sufficient quantities to present a public health risk. The risk assessment considered estimation of the types and amounts of HAPs released from the various sources found at the Oakland Airport and an estimation of concentrations of HAP in the ambient (outdoor) air near the Airport. Residents, off-airport workers, school children, and on-airport workers were evaluated separately. The report states that the HAPs from airport sources that were found to be of greatest concern were diesel particulates, 1,3-butadiene, benzene, and acrolein.

The OAK risk assessment focused on the "incremental" risk from the project (not the total risk). Of the incremental emissions, the report states that the largest contributor to cancer risk for residents was diesel particulate matter from ground support equipment operations in the terminal area. The incremental cancer risks for residents living near OAK were reported to be less than the threshold of significance in the year 2010 and that no significant impacts to the residents is anticipated after implementation of the project build alternative.

⁶⁴ Environ Corp., 2001, Screening Air Quality Evaluation of the Teterboro Airport, Teterboro, New Jersey, prepared of the Coalition for Public Health and Safety, Moonachie, New Jersey.

⁶⁵ CDM, 2003. Ambient Air Quality Human Health Risk Assessment for the Oakland International Airport Draft Report, prepared for the Port of Oakland Environmental Planning Department.

I.6.2.8 Ted Stevens Anchorage International

In 2003, Anchorage's Department of Health and Human Services conducted a study to "address concerns about toxic air pollution and associated odors in parklands and neighborhoods adjacent to the Ted Stevens Anchorage International Airport."⁶⁶ One of the primary objectives of the study was to "characterize the "typical" range of 24-hour average concentrations for specific volatile organic compounds in the ambient air in the vicinity of the airport during the winter and compare these to other parts of Anchorage." Six sampling sites were located in close proximity to Ted Stevens Anchorage International or on Airport property. Four sampling sites were located in areas more distant from the airport but near potential sources of HAPs (heavily traveled roadways and the Port of Anchorage). Thirty-three HAP compounds were considered as "target" compounds for this study. Of the 33 HAPs, only five were measured in concentrations above established reporting limits (limits at which a compound is considered not present) or were not subject to questionable data quality. These compounds were benzene, toluene, ethylbenzene, m,p-xylene, o-xylene, ethane, and ethyne. A comparison of the data provided in this report indicates that measured levels of the five compounds were approximately 65 to 260 percent higher at the sites distant from the airport than at the airport.

I.6.3 Summary

Available HAP-related evaluations for previous (historical) O'Hare-specific studies and studies that have been performed at, or in the vicinity of, other airports were reviewed. The evaluations included emission inventories and/or ambient measurements of HAPs.

Four studies were performed specifically for O'Hare. These studies were performed by/for the City of Chicago, the City of Park Ridge, the IEPA, and the Illinois Department of Public Health. Three of the four studies (City of Chicago, IEPA, and Illinois Department of Public Health) performed indicate that not all of the emission sources are unique to the Airport, that HAP concentration levels are comparable to levels in other areas of the region that are not influenced by the Airport (the levels themselves are not unique), and that no increased incidence of cancer has been identified for residents near the Airport. The Park Ridge study concluded that "lessons learned from this study can now be used to design and implement a more comprehensive investigation that will ultimately provide a more detailed picture of the affect that air pollution from O'Hare International Airport has on the surrounding communities." However the Park Ridge report states the results of their analysis "should be considered preliminary, and could be refined through additional air monitoring or more sophisticated emission, dispersion, and exposure modeling".

HAP-related studies prepared for nine other airports were also reviewed. One study concluded that the airport was responsible for a small percentage of the total lifetime excess cancer risk to residents, and two concluded that HAP concentration levels are comparable to levels in other non-airport influenced areas. The results of two additional studies concluded that the airport-related HAPs comprising the greatest carcinogenic risk were 1,3-butadiene, acetaldehyde,

⁶⁶ Municipality of Anchorage Department of Health and Human Services, *Ted Stevens Anchorage International Airport Air Toxics Monitoring Study*, April 21 2003.

benzene, formaldehyde, and diesel particulate matter with one of these studies indicating that the greatest non-carcinogenic risk was due to the pollutant acrolein. One study concluded that airport operations did appear to be affecting air quality in the immediate vicinity of the Airport. However, the study states that for most of the HAPs, the differences between upwind and downwind concentrations were very small. The final study reported that there were "...uncertainties associated with discrete variates or assumptions (e.g., aircraft exhaust emission factors) used to perform the assessment...".

I.7 HAPS EVALUATION METHODOLOGY

In response to Scoping comments from the IEPA, the USEPA, and the public, a HAP evaluation was prepared for the EIS. While the effects on human health from HAPs was raised in Scoping, the USEPA, the IEPA, and the FAA concur that at this time it is not appropriate to conduct a human health risk assessment for the HAPs discussed in this Appendix. The influence of proposed airport development on the health of those living in the vicinity of O'Hare cannot currently be quantified in a meaningful way. Collectively, the agencies believe that given the absence of HAP emissions data and the limitations of HAP speciation profiles for commercial jet aircraft engines, a sound human health risk assessment cannot be accomplished.⁶⁷

The FAA consulted with the USEPA and IEPA while developing the methodology for this HAP evaluation with the knowledge that the data available for such an evaluation is incomplete and in some cases scientifically inadequate. The evaluation was performed using procedures described in the HAP Protocol⁶⁸ for the purpose of disclosing the potential for increases in HAP emissions based on available data, despite limitations of the data.

To evaluate the potential for changes in emission levels of HAPs with the Build Alternatives, this evaluation compares future HAP emission levels that would result from implementation of the proposed Airport development alternatives (Alternatives C, D, and G) to future HAP levels that would occur with Alternative A (No Action Alternative).

The following discusses the methodology used to prepare the HAP emission inventories and to prioritize the HAPs according to the carcinogenic and non-carcinogenic toxicities. As previously stated, the methodologies used in this evaluation were prepared in consultation with the USEPA and the IEPA.⁶⁹

I.7.1 Emission Inventories

Estimates of air pollutant and pollutant precursor⁷⁰ emissions are known as emission inventories. For airport-related assessments, emissions inventories summarize the total

⁶⁷ King, Suzanne, USEPA Region 5 Facsimile to Mike MacMullen, FAA, December 17, 2004.

⁶⁸ Analysis Protocol for Hazardous Air Pollutants, February 25, 2003

⁶⁹ Meeting Minutes from June 16, 2004 Meeting with USEPA, IEPA, and FAA.

⁷⁰ Defined as emissions of pollutants which react in the atmosphere to form other pollutants for which a health-based standard has been established.

quantity of each pollutant emitted by aircraft, motor vehicles, and other airport-related emission sources within a defined area. For the evaluation of the proposed Airport development alternatives, annual emissions were estimated for airport-related sources and from motor vehicles on the major roadways in the vicinity of the Airport.

The HAPs evaluation is based on the results of the criteria air pollutant and pollutant precursor emission inventories for particulate matter and volatile organic compounds. Documentation of the methodologies and assumptions used to develop the criteria air pollutant/precursor emission inventories is provided in **Section 5.6, Air Quality**, in **Chapter 5, Environmental Consequences** and **Appendix J, Air Quality**.

I.7.1.1 Evaluated Sources

HAP emission estimates were prepared for the following sources:

- Aircraft
- Ground support equipment and auxiliary power units
- Roadways (Airport and non-Airport-related motor vehicles; on and off Airport property)
- Parking lots (motor vehicles on Airport only)
- Construction activities
- Stationary sources, and
- Training fires.

The inclusion of the source categories was determined through consultation with the USEPA and IEPA⁷¹ and was based on the availability and reliability of HAPs speciation profiles. Minor source categories such as aircraft maintenance facilities that include painting/solvent were not included in the criteria air pollutant evaluation or the HAP evaluation because emissions from these sources are likely to be minimal and/or suitable speciation profiles could not be identified. Speciation profiles of a particular HAP are essentially “the portion or percentage” of either the total volatile organic compounds or particulate matter estimates.

I.7.1.2 Speciation Profiles

The speciation profiles used in this evaluation were selected in consultation with the USEPA and IEPA.⁷² A summary of the sources of the speciation profiles is provided in **Table I-11**. For the purpose of selecting the profiles, the following three documents were developed. The documents summarize available information and the proposed evaluation methodologies:

- Analysis Protocol for Hazardous Air Pollutants (February 25, 2004),

⁷¹ Analysis Protocol for Hazardous Air Pollutants, February 25, 2004 and Hazardous Air Pollutant Speciation Profiles, June 29, 2004.

⁷² Hazardous Air Pollutant Speciation Profiles, June 29, 2004.

- Turbine Engine Aircraft Hazardous Air Pollutant (HAP) Speciation Profiles (June 2, 2004), and
- Hazardous Air Pollutant Speciation Profiles (June 29, 2004).

**TABLE I-11
SPECIATION PROFILE REFERENCES**

Turbine Aircraft	USAF, 1999. Aircraft Engine and Auxiliary Power Unit Emissions Testing: Volumes 1-3, March.
Elemental Mass Fractions for Turbine Aircraft	Shumway, 2000. <i>Trace Element and Polycyclic Aromatic Hydrogen Analysis of Jet Engine Fuels: Jet A, JP-5, JP-8</i> , December.
Piston Aircraft	CARB, 2000. <i>Speciation Profiles and Size Fractions</i> , December.
Diesel Construction Equipment and Gasoline Construction Equipment/Ground Support Equipment	USEPA, 2002. <i>Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Non-Road Components of the National Emissions Inventory</i> .
Diesel Ground Support Equipment	USAF, 2002. <i>Air Emission Inventory Guidance Document for Mobile Sources at Air Force Installations</i> , January.
Motor Vehicles	MOBILE6.2
Heating Plant (Oil-Fired)	USEPA, 1998. <i>Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources</i> , September.
Heating Plant (Gas-Fired)	USEPA, 1998. <i>Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources</i> , September.
Airport Rescue and Firefighting Facilities	Environmental Quality Management, Emissions Testing of Fire Fighter Training Facility – Goodfellow Air Force Base, Texas.
Storage Tanks	USEPA TANKS Databases
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004	

These documents detail the development and selection of the speciation profiles used in this analysis. The documents are provided in **Attachment I-2**. Since the methodology coordination was performed, profiles were identified that speciate the level of individual HAPs for the aircraft operating modes of idle, approach, climbout, and takeoff. These speciation profiles are provided in **Table I-12**.

I.7.2 Evaluation of HAP Emissions

The speciated HAPs were evaluated by their total emission level and their respective toxicity values.⁷³ By considering toxicity values, the evaluation accounts for the fact that a small

⁷³ Toxicity is defined by USEPA as “Deleterious or adverse biological effects elicited by a chemical, physical, or biological agent.” <http://www.epa.gov/iris/gloss8.htm#t>. Toxicity values are used by USEPA to characterize the risks associated with HAPs. <http://www.epa.gov/oppt/rsei/docs/toxwght97.pdf>

emission level of a highly toxic HAP is more detrimental than an equivalent emission level of a HAP with a lower toxicity.

**TABLE I-12
TURBINE AIRCRAFT ENGINE SPECIATION PROFILES**

Pollutant	Speciation Profiles (pounds per pound of total hydrocarbons)			
	Idle	Approach	Climbout	Takeoff
Acetaldehyde	0.00390	0.00509	0.00336	0.00328
Acrolein	0.00275	0.00220	0.00391	0.00363
Benzene	0.01551	0.02665	0.01411	0.01935
1,3-Butadiene	0.02689	0.01222	0.04706	0.00599
Ethylbenzene	0.00137	0.00503	0.00274	0.00414
Formaldehyde	0.09372	0.21816	0.08378	0.08334
Isobutyraldehyde	0.00194	0.09340	0.08466	0.09291
Naphthalene	0.00310	0.00121	0.00154	0.00111
Toluene	0.00692	0.03225	0.01395	0.01325
Styrene	0.00183	0.00311	0.00297	0.00380
Xylenes	0.00307	0.01268	0.00782	0.01154
Acenaphthene	0.00013	0.00094	0.00108	0.00130
Acenaphthylene	0.00021	0.00094	0.00108	0.00130
Anthracene	0.00013	0.00094	0.00108	0.00130
Benzo(ghi)perylene	0.00013	0.00094	0.00108	0.00130
Benzo(bk)fluoranthene	0.00013	0.00094	0.00108	0.00130
Benzo(a)anthracene	0.00013	0.00094	0.00108	0.00130
Benzo(a)pyrene	0.00013	0.00094	0.00108	0.00130
Chrysene	0.00013	0.00094	0.00108	0.00130
Fluoranthene	0.00014	0.00094	0.00113	0.00130
Fluorene	0.00015	0.00094	0.00108	0.00130
Indeno(123cd)pyrene	0.00013	0.00094	0.00108	0.00130
Phenanthrene	0.00016	0.00095	0.00108	0.00130
Propionaldehyde	0.01419	0.00644	0.02480	0.00316
Pyrene	0.00014	0.00094	0.00108	0.00130

Sources: USAF (Gerstle, T., P. Virag, M. Wade, L. Kimm), 1999. *Aircraft Engine and Auxiliary Power Unit Emissions Testing: Volume 1, Executive Summary*, U.S. Air Force, Institute for Environment, Safety and Occupational Health Risk Analysis, Brooks Air Force Base, Texas. IERA-RS-BR-TR-1999-0006-Vol.1. March.
Spicer, C.W. et al., 1984, *Composition and Photochemical Reactivity of Turbine Engine Exhaust*, prepared by Battelle Laboratories, prepared for the Air Force Engineering & Services Center, March.

For the HAPs considered to be carcinogenic, the toxicity values were based on published inhalation unit risk values. USEPA defines unit risk values as the upper-bound estimate of the risk of a person developing cancer if a person were constantly exposed to one unit of concentration of a particular chemical over the person's lifetime.⁷⁴ The unit risk values take in to account whether or not a particular HAP is a possible, probable, or known human carcinogen.

⁷⁴ USEPA, Glossary of Integrated Risk Information System (<http://www.epa.gov/iris/gloss8.htm#u>).

For the HAPs considered to be non-carcinogens, inhalation reference concentrations⁷⁵ or oral reference doses⁷⁶ were used. Inhalation reference concentrations and oral reference doses are exposure concentrations or rates that are considered to be safe, given daily exposure to a particular HAP over an average person's lifetime.

I.7.2.1 Toxicity Values

The sources of the toxicity values used in this evaluation were USEPA's Integrated Risk Information System⁷⁷ (IRIS), USEPA's Risk Screening Environmental Indicators (RSEI) Chronic Human Health Methodology, Technical Appendix A (a companion to USEPA's Toxic Release Inventory database)⁷⁸, the California Environmental Protection Agency (CalEPA),⁷⁹ and a report prepared by the Argonne National Laboratory⁸⁰ in which regional emissions of HAPs were evaluated for Cook County, Illinois and Lake County, Indiana.

There were a few HAPs for which toxicity values were unavailable because 1) very few studies have been conducted, and/or 2) the chemicals have a relatively low toxicity. Toxicity values were not available for the following 15 HAPs:

- 7,12-dimethylchloroanthrene: This compound was not found in the scientific databases.
- Benzo(g,h,i)perylene: This compound is in the pyrene family and is a polycyclic aromatic hydrocarbon. This substance would have a similar toxicity value to other polycyclic aromatic hydrocarbons. Emissions of this compound were estimated to be very low and would not measurably contribute to the total toxic emissions.
- Phenanthrene: This compound is also a polycyclic aromatic hydrocarbon and is present in too small an amount to contribute measurably to the total toxic emissions.
- 2,2,4-trimethylpentane: This compound is similar to gasoline. It is flammable and is toxic only at high levels, much higher than would result from this project.
- Iron, scandium, strontium, tin, and zirconium: These compounds are non-carcinogenic metals that would be solids emitted during combustion from sources that have fuels

⁷⁵ Defined by USEPA to be "An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime." Source: USEPA, Glossary of Integrated Risk Information System (<http://www.epa.gov/iris/gloss8.htm#u>).

⁷⁶ Defined by USEPA to be "An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime." Source: USEPA, Glossary of Integrated Risk Information System (<http://www.epa.gov/iris/gloss8.htm#u>).

⁷⁷ <http://www.epa.gov/iris/>

⁷⁸ USEPA, *Risk-Screening Environmental Indicators (RSEI) Chronic Human Health Methodology, RSEI Version 2.1*, USEPA, Office of Pollution Prevention and Toxics, Washington, DC, January 2004. (<http://www.epa.gov/tri/>)

⁷⁹ CalEPA Office of Environmental Health Hazard Assessment (OEHHA), Toxicity Criteria Database, <http://www.oehha.ca.gov/risk/ChemicalDB/>.

⁸⁰ Argonne National Laboratory, Environmental Assessment Division and Decision and Information Sciences Division, United States Department of Energy, *Air Screening Assessment for Cook County, Illinois, and Lake County, Indiana*, March 2004.

containing these substances. The allowed threshold levels for these substances are similar to levels allowed for the criteria pollutants particulate matter 10 and 2.5 microns or less which are much higher levels than the other HAPs.

- Butane, ethane, pentane, and propane: Listed as HAPs under the CAA because they are flammable and only present a hazard at facilities that store or use large quantities of these compounds.
- Propionaldehyde and acenaphthylene: The toxicity values of these compounds could not be found in the scientific databases.

The toxicity values used in this HAP evaluation are provided in **Tables I-13** and **I-14**. For carcinogens, the assumed exposure pathway was inhalation. The source of each carcinogenic toxicity value and the carcinogenic classifications are also provided in **Table I-13**. **Table I-14** also provides the assumed type of exposure (daily or continuous inhalation), and source of toxicity values for non-carcinogens.

Notably, carcinogenic and non-carcinogenic emissions were evaluated separately (some HAPs produce both carcinogenic and non-carcinogenic effects). Therefore, some HAPs were assigned two toxicity values and are presented in both **Table I-13** and **Table I-14**. The toxicity weights in **Tables I-13** and **I-14** are discussed in **Section I.7.3, Emission-Toxicity Values**.

I.7.2.2 Confidence in Toxicity Values

The unit risk values and reference concentrations used in this evaluation are based on toxicological data that are often obtained from animal studies. Adverse effects at high doses for short exposure durations in animals are extrapolated to estimate the effects on humans at low doses for long exposure durations. The affected organs, the type of adverse effects and the severity of the effects may all differ between study animals and humans (inter-species differences), or between humans and humans (intra-species differences). These differences are often associated with variations in the particular toxic kinetics, or movement, of a chemical through the exposed organism, such as the absorption, distribution, metabolism, and excretion of the chemical. In addition, basic risk values (inhalation unit risk estimates; reference doses; reference concentrations) assume a constant lifetime exposure to a given chemical concentration.

**TABLE I-13
TOXICITY VALUES – POSSIBLE, PROBABLE, KNOWN CARCINOGENS**

Pollutant	Carcinogenic		Source	Classification	Toxicity Weight(e)
	Toxicity Value (mg/m ³)	Pathway			
1,3-Butadiene(d)	0.28	Inhalation	RSEI	Known	2000
3-Methylchloranthrene(a)	6.3	Inhalation	CalEPA	---	45000
Acetaldehyde	0.0022	Inhalation	IRIS	Probable	16
Arsenic	4.3	Inhalation	IRIS	Known	31000
Benzene	0.0078	Inhalation	IRIS	Known	56
Benzo(a)anthracene(d)	0.21	Inhalation	Argonne	Probable	1500
Benzo(a)pyrene(d)	2.1	Inhalation	Argonne	Probable	15000
Benzo(b,k)fluoranthene(d)	0.21	Inhalation	Argonne	Probable	1500
Beryllium	2.4	Inhalation	IRIS	Probable	17000
Cadmium	1.8	Inhalation	IRIS	Probable	13000
Chromium VI	12	Inhalation	IRIS	Known	86000
Chrysene	0.011	Inhalation	CalEPA	Probable	80
Cobalt(b)	---	Inhalation	RSEI	---	34000
Dibenzo(ah)anthracene(d)	2.1	Inhalation	Argonne	Probable	15000
Dichlorobenzene(f)	0.011	Inhalation	CalEPA	Possible	800
Diesel Particulate Matter	0.3	Inhalation	CalEPA	Probable	2143
Formaldehyde	0.013	Inhalation	RSEI	Probable	95
Indeno(1,2,3-c,d)pyrene(d)	0.21	Inhalation	Argonne	Probable	1500
Naphthalene(c)	--	--	--	Possible	--
Nickel	0.49	Inhalation	Argonne	Known	3500
Octachlorodioxin(g)	3.8	Inhalation	CalEPA	Known	27143

Notes: (a) 3-Methylchloranthrene – The USEPA does not classify this compound as a possible, probable, or known carcinogen. CalEPA provides a carcinogenic toxicity value but does not classify the compound.
 (b) Cobalt – The carcinogenic toxicity weight for cobalt was obtained from the USEPA's Risk Screening Environmental Indicators. This document does not provide a toxicity value or classify this compound.
 (c) Although the USEPA identifies naphthalene as a possible carcinogen, the agency does not provide carcinogenic toxicity values for this compound.
 (d) Toxicity values were calculated based on published toxicity weights and algorithms for assigning toxicity weights.
 (e) Algorithms for assigning toxicity weights:

Known and probable carcinogens: - Inhalation Unit Risk (risk per mg/m³)/0.00014
 Possible carcinogens - Inhalation Unit Risk (risk per mg/m³)/0.00014*10

(f) Toxicity value and weight for 1,4 dichlorobenzene.

(g) Toxicity value and weight for 1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin

Sources: USEPA Integrated Risk Information System (IRIS), <http://www.epa.gov/iris>, last updated December 2, 2004, accessed December 2004;

CalEPA Office of Environmental Health Hazard Assessment (OEHHA), Toxicity Criteria Database, <http://www.oehha.ca.gov/risk/ChemicalDB/>, accessed December 2004;

USEPA Risk Screening Environmental Indicators (RSEI) Technical Appendix A, Listing of All Toxicity Weights for TRI Chemicals and Chemical Categories, Office of Pollution Prevention and Toxics, Washington, DC, August 2004;

Argonne National Laboratory, Environmental Assessment Division and Decision and Information Sciences Division, United States Department of Energy, Air Screening Assessment for Cook County, Illinois, and Lake County, Indiana, March 2004.

**TABLE I-14
TOXICITY VALUES - NON-CARCINOGENS**

Pollutant	Daily Exposure (RfD) or Continuous Inhalation			Toxicity					
	Toxicity Value	Exposure (RfC)	Source	Toxicity Weights(b)	Pollutant	Toxicity Value	Exposure (RfC)	Source	Toxicity Weights(b)
1,1,1-Trichloroethane	1	RfC	RSEI	2	Fluoranthene	0.04	RfD	IRIS	13
1,3-Butadiene	0.002	RfC	IRIS	900	Fluorene	0.04	RfD	IRIS	13
2-Methylnaphthalene	0.004	RfD	IRIS	125	Fluoride	0.06	RfD	IRIS	8
Acenaphthene	0.06	RfD	IRIS	8	Formaldehyde(a)	0.003	RfC	RSEI	600
Acetaldehyde	0.009	RfC	IRIS	200	Isobutyraldehyde(a)	0.035	RfC	RSEI	51
Acrolein	0.00002	RfC	IRIS	90000	Lead(a)	0.0000568	RfD	RSEI	8800
Anthracene	0.3	RfD	IRIS	2	Manganese	0.00005	RfC	IRIS	36000
Antimony	0.0004	RfD	IRIS	1250	Mercury	0.0003	RfC	IRIS	6000
Arsenic	0.0003	RfD	IRIS	1667	Molybdenum	0.005	RfD	IRIS	100
Barium	0.07	RfD	IRIS	7	Naphthalene	0.003	RfC	IRIS	600
Benzene	0.03	RfC	IRIS	60	n-Hexane	0.2	RfC	IRIS	9
Beryllium	0.00002	RfC	IRIS	90000	Nickel(a)	0.00005	RfC	RSEI	36000
Cadmium(a)	0.00002	RfC	RSEI	90000	Phosphorous(a)	0.6	RfC	RSEI	3
Calcium(a)	0.001	RfD	RSEI	500	Pyrene	0.03	RfD	IRIS	17
Chloride(a)	0.0002	RfC	RSEI	9000	Selenium(a)	0.0005	RfC	RSEI	3600
Chromium III	1.5	RfD	IRIS	0.33	Styrene	1	RfC	IRIS	2
Chromium VI	0.0001	RfC	IRIS	18000	Titanium	0.001	RfC	RSEI	18000
Cobalt(a)	0.00002	RfC	RSEI	90000	Toluene	0.4	RfC	RSEI	5
Copper(a)	0.0024	RfC	RSEI	750	Vanadium(a)	0.00703	RfD	RSEI	71
Dichlorobenzene	0.8	RfC	IRIS	2	Xylenes	0.6	RfC	RSEI	3
Diesel Particulate Matter	0.005	RfC	IRIS	360	Zinc(a)	0.0353	RfC	RSEI	51
Ethylbenzene	1	RfC	IRIS	2					

Notes: (a) Toxicity values were calculated based on published toxicity weights and algorithms for assigning toxicity weights. RfDs and RfCs are estimates (with uncertainty) spanning perhaps an order of magnitude of daily exposure (RfD) or continuous inhalation exposure (RfC), to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious non-cancer effects during a lifetime. RfC = Reference Concentration (mg/m³); RfD = Reference Dose (mg/kg-day)

(b) Algorithm for assigning toxicity weights: 0.5 / RfD (mg/kg-day) or 1.8 / RfC (mg/m³)

Sources: USEPA Integrated Risk Information System (IRIS), <http://www.epa.gov/iris>, last updated December 2, 2004, accessed December 2004; CalEPA Office of Environmental Health Hazard Assessment (OEHHA), Toxicity Criteria Database, <http://www.oehha.ca.gov/risk/ChemicalDB/>, accessed December 2004; USEPA Risk Screening Environmental Indicators (RSEI) Technical Appendix A, Listing of All Toxicity Weights for TRI Chemicals and Chemical Categories, Office of Pollution Prevention and Toxics, Washington, DC, August 2004; Argonne National Laboratory, Environmental Assessment Division and Decision and Information Sciences Division, United States Department of Energy, Air Screening Assessment for Cook County, Illinois, and Lake County, Indiana, March 2004.

The toxicity values used in the evaluation are based only on chronic long-term effects. For chronic effects, the same level of research and data is not available for all the HAPs and the toxicity weights thus are derived from several different sources, some more rigorous than others. To the extent possible, the toxicity values are based solely on inhalation risk values. However, in some cases where inhalation risk values were unavailable, oral risk values (oral slope factors and oral reference doses) were used. This may underestimate or overestimate the actual toxicity value because of differences between inhalation and oral exposures in the rate and degree of absorption into the bloodstream. The error margin introduced by this step depends on the target organs of a particular chemical's toxicity. Since inhalation would be the primary exposure route for these chemicals, other exposure pathways (e.g. ingestion, dermal) would only be small contributors and were not considered in this analysis. Also, previous studies have found that alternate exposure routes do not change the overall risk.⁸¹

The USEPA provides detailed summaries regarding toxicity values on their IRIS database (www.epa.gov/iris). Information is provided regarding the principal studies used to derive the toxicity values and USEPA's confidence in the values. The CalEPA, through its Office of Environmental Health Hazard Assessment (OEHHA) identifies "candidate chemicals" to be considered as carcinogens or as "developmental and reproductive toxicants" (non-carcinogens).

I.7.3 Emission-Toxicity Values

Emission-toxicity values were used in this evaluation to identify the individual HAPs and HAP emission sources of most interest. The emission-toxicity values were obtained by multiplying the total emission level of each HAP (total amount of each HAP emitted by all sources) by an applicable carcinogenic and/or non-carcinogenic toxicity weight. The emission-toxicity value methodology was developed by USEPA's Office of Pollution Prevention and Toxics (OPPT) in response to a need to screen HAPs.⁸²

For HAPs considered to be carcinogenic, the toxicity weights were calculated using inhalation unit risks. Unit risks are measures of the risk of a person developing cancer if the person were constantly exposed to one unit of concentration of a particular chemical over the person's lifetime. The risks take in to account whether or not a particular HAP is a known, probable, or possible human carcinogen. For HAPs considered to be non-carcinogens, inhalation reference concentrations or oral reference doses are used. The inhalation concentrations and oral doses are threshold concentrations that are considered to be safe, given daily exposure to a particular HAP over an average person's lifetime.

The emissions-toxicity values are unitless indexes and are intended to show the relative hazard potential of each HAP. The degree to which the emissions-toxicity values are indicators of actual air quality conditions is unknown. Many factors, including the source/receptor relationship and meteorological conditions, influence ambient air concentrations. Therefore, the

⁸¹ LAWA, 2004, *LAX Master Plan Final EIS/EIR, Human Health Risk Assessment*, Technical Report 14a., prepared for the Los Angeles World Airports Authority

⁸² King, Suzanne, USEPA Region 5 Facsimile to Mike MacMullen, FAA, December 16, 2004.

highest emissions-toxicity value may not result in the highest pollutant concentration in the ambient air.

The following is an example of how an emissions-toxicity value was calculated for benzene. In this example, it is assumed that an estimated 66.328 tons of benzene would be emitted over the period of a year by all sources within the study area.

- 1) Based on data in **Table I-13**, the carcinogenic toxicity value for benzene is 0.0078. This value is the inhalation unit risk per milligram (mg) per cubic meter (m³).
- 2) Because benzene is designated by the USEPA to be a known carcinogen, the USEPA's algorithm to calculate the toxicity weight (provided in the "Notes" section of **Table I-13**)⁸³ is:

$$\text{Inhalation unit risk (per mg/m}^3\text{)}/0.00014$$

- 3) Therefore, the calculated toxicity weighting factor for benzene is 56.

$$\text{Inhalation unit risk (0.0078) / 0.00014} = 56 \text{ (rounded to a whole number)}$$

- 4) To calculate the emissions-toxicity value, the total mass emitted amount (66.328 tons) is multiplied by the toxicity weighting factor (56). To facilitate the discussion of HAPs, the values were also divided by 10,000. Therefore, the emissions-toxicity value for benzene, in this example, is 0.4.

$$\text{Amount of benzene emitted (66.328) x Toxicity Weighting Factor (56)}/10,000 = 0.4 \text{ (rounded to a whole number)}$$

I.8 EXISTING CONDITION AND ALTERNATIVES ANALYSIS

Because emission rates of the individual pollutants and pollutant precursors evaluated in this EIS increase/decrease annually due to changes in motor vehicle fleet mixes (as older vehicles are retired and newer vehicles are introduced in to the fleet and as vehicles within the fleet age), the alternatives air quality analysis assumes specific years to evaluate the potential increases/decreases in these emissions with and without the proposed improvements.

For the purpose of the air quality analysis, the Original Schedule assumes that the construction would begin in the year 2004 and continue through the year 2014, that the years 2007, 2009, and 2013 represent the last year of Construction Phase I, Construction Phase II, and Build Out, and the year 2018 represents Build Out + 5 conditions. The Compressed Schedule assumes that construction would begin in the year 2005 and continue through the year 2014, that the years 2007, 2009, and 2013 represent the last year of Construction Phase I, Construction Phase II, and

⁸³ See the "Notes" on **Table I-13** and **Table I-14** for the appropriate algorithms to calculate the toxicity weights for other carcinogenic and non-carcinogenic pollutants, respectively.

Build Out, and the year 2018 represents Build Out + 5 conditions. Finally, the Delayed Schedule assumes that construction would begin in the year 2005 and continue through the year 2015, that the years 2008, 2010, and 2014 represent the last year of Construction Phase I, Construction Phase II, and Build Out, and that the year 2019 represents Build Out + 5 conditions.

Compressed Schedule

Airport Operations – As previously discussed, the Compressed Schedule assumes that the first runway would be operational in the fall of 2007. To be conservative, the air quality analysis assumes that the runway would be in place for the entire year of 2007. As such, the methodologies used to estimate emissions with the Compressed Schedule were the same as those described for the Original Schedule.

Construction - When compared to the Original Schedule, the Compressed Schedule would change the level of pollutant and pollutant precursor emissions estimated for Construction Phase I only. The emission estimates for the Compressed Schedule were based on a schedule of construction activity prepared by the City of Chicago's consulting team (CCT) after review and acceptance by the FAA's TPC. The emission factors, models, and assumptions regarding demolition and fugitive particulate matter were the same as for the Compressed Schedule. Construction activities for individual projects were assumed to begin in the year 2005 and extend through the year 2014.

Delayed Schedule

The Delayed Schedule assumes that construction would begin in the year 2005 and continue through the year 2015 with the years 2008, 2010, and 2014 representing the last year of Construction Phase I, Construction Phase II, and Build Out, and the year 2019 representing Build Out +5 conditions.

The change in HAP emissions with the proposed airport improvements was performed for each scenario. A discussion of the changes in emission levels with the proposed improvements is provided in **Section I.8.6, Summary**.

Based on the results of the evaluation, 11 of the 66 HAPs emitted from sources operating at and in the vicinity of O'Hare contributed approximately 99 percent to the total while accounting for emissions and toxicity levels of the evaluated scenarios. The remaining 55 HAPs accounted for less than 1 percent. The 11 HAPs were 1,3-butadiene, acetaldehyde, acrolein, arsenic, benzene, chromium VI, diesel particulate matter, formaldehyde, naphthalene, toluene, and nickel. **Attachment I-1** of this Appendix provides detailed descriptions of each of the 11 HAPs.

It should be noted that Alternative A (No Action Alternative) assumes a constrained Airport operational forecast. Use of the constrained forecast limits the number of aircraft operations with Alternative A (No Action Alternative) but reflects more realistic (and acceptable) aircraft delay times without the proposed improvements. For example, in Construction Phase I, the departure queue delay is estimated to be 4.2 minutes per operation with or without the proposed build alternatives. However, the number of forecast annual aircraft operations with Alternative A (No Action Alternative) is 974,000, while the number of forecast annual

operations with Alternatives C, D, and G is 1,026,300—a higher level of annual operations with the build alternatives than with Alternative A (No Action Alternative). Use of the constrained forecast for Alternative A (No Action Alternative) results in a conservative estimate of changes in emission levels when compared with the proposed Build Alternatives.

1.8.1 Existing Condition

The following presents and compares the estimated HAP emissions for the Existing (2002) Condition for the 11 HAPs of interest. As shown in **Table I-15**, in the year 2002 the total amount of HAPs emitted would be 343 tons with motor vehicles and ground support equipment contributing approximately 82 percent of the emissions.

**TABLE I-15
HAP EMISSIONS – EXISTING CONDITION**

Pollutants	Tons Emitted in 2002					Emissions-Toxicity Value	
	Aircraft	GSE/APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non-carcinogenic
1,3-Butadiene	10.513	4.245	4.831	-	19.590	3.9	1.8
Acetaldehyde	1.568	3.549	7.232	-	12.348	<0.1	0.2
Acrolein	1.100	0.316	0.700	-	2.117	-	19.1
Arsenic	-	<0.001	0.013	<0.001	0.013	<0.1	<0.1
Benzene	6.358	20.303	39.666	0.001	66.328	0.4	0.4
Chromium VI	-	<0.001	0.004	<0.001	0.004	<0.1	<0.1
Diesel Particulate Matter	-	6.655	33.352	-	40.007	8.6	1.4
Formaldehyde	38.802	7.432	15.997	0.066	62.298	0.6	3.7
Naphthalene	1.197	0.359	1.467	0.170	3.194	-	0.2
Toluene	3.171	38.108	95.639	0.001	136.919	-	0.1
Nickel	-	<0.001	0.008	0.004	0.012	<0.1	<0.1
Total	62.710	80.967	198.910	0.243	342.830		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The HAPs with the highest level of total emissions were toluene, formaldehyde, benzene, diesel particulate matter, and 1,3-butadiene (40, 18, 12, 19, and 12 percent of the emissions, respectively). Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.

When considering both the level of emissions and the toxicity values (the emissions-toxicity values), the carcinogenic HAPs of most interest are diesel particulate matter, 1,3-butadiene, and formaldehyde. The sources contributing the most to the carcinogenic emissions-toxicity values of diesel particulate matter is on-road motor vehicles. The source contributing the most to the carcinogenic emissions-toxicity values of 1,3-butadiene and formaldehyde is aircraft. The non-carcinogenic HAPs of most interest are acrolein, formaldehyde, and 1,3-butadiene. The source contributing the most to the non-carcinogenic emissions-toxicity values of these HAPs is aircraft.

I.8.2 Construction Phase I

The following presents and compares the estimated HAP emissions for Construction Phase I with Alternative A (No Action Alternative) and the Build Alternatives (Alternatives C, D, and G) for the 11 HAPs of interest.

I.8.2.1 Original Schedule

Alternative A (No Action)

As shown in **Table I-16**, with Alternative A the total amount of HAPs emitted would be 228 tons with motor vehicles and ground support equipment emitting approximately 77 percent of the emissions. The individual HAPs emitted the most would be toluene, formaldehyde, benzene, diesel particulate matter, and 1,3-butadiene (37, 21, 19, 11, and 7 percent of the emissions, respectively).

Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.

**TABLE I-16
HAP EMISSIONS – ORIGINAL SCHEDULE - CONSTRUCTION PHASE I –
ALTERNATIVE A (NO ACTION ALTERNATIVE)**

Pollutants	Tons Emitted Last Year of Phase					Emissions-Toxicity Value	
	Aircraft	GSE/APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non-carcinogenic
1,3-Butadiene	8.738	4.245	2.198	-	15.180	3.0	1.4
Acetaldehyde	1.298	3.530	3.372	-	8.200	<0.1	0.2
Acrolein	0.912	0.316	0.329	-	1.558	-	14.0
Arsenic	-	<0.001	0.016	<0.001	0.016	<0.1	<0.1
Benzene	5.248	20.210	18.873	0.001	44.332	0.2	0.3
Chromium VI	-	<0.001	0.005	-	0.005	<0.1	<0.1
Diesel Particulate Matter	-	5.904	18.822	-	24.726	5.3	0.9
Formaldehyde	31.984	7.459	7.558	0.064	47.065	0.4	2.8
Naphthalene	0.998	0.372	0.813	0.180	2.363	-	0.1
Toluene	2.564	37.924	44.028	0.001	84.518	-	<0.1
Nickel	-	<0.001	0.010	0.003	0.013	<0.1	<0.1
Total	51.743	79.960	96.024	0.249	227.976		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Alternative C, D, and G

The estimated emission levels of HAPs with Alternatives C, D, or G are provided in **Table I-17**. As shown, the total amount of HAPs emitted would be 249 tons (an increase of 21 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-17
HAP EMISSIONS (TONS) – ORIGINAL SCHEDULE - CONSTRUCTION PHASE I –
ALTERNATIVES C, D, AND G**

Pollutant	Tons Emitted Last Year of Phase					Emissions-Toxicity Values		
	Aircraft	GSE/ APU(a)	Construction	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	9.868	4.400	0.001	2.250	-	16.518	3.3	1.5
Acetaldehyde	1.465	3.660	0.017	3.452	-	8.594	<0.1	0.2
Acrolein	1.029	0.328	0.001	0.337	-	1.695	-	15.3
Arsenic	-	<0.001	<0.001	0.016	<0.001	0.017	0.1	<0.1
Benzene	5.921	20.954	0.007	19.322	0.001	46.205	0.3	0.3
Chromium VI	-	<0.001	<0.001	0.005	<0.001	0.005	<0.1	<0.1
Diesel Particulate Matter	-	6.087	16.770	19.233	-	42.090	9.0	1.5
Formaldehyde	36.112	7.730	0.038	7.737	0.066	51.684	0.5	3.1
Naphthalene	1.127	0.383	<0.001	0.833	0.190	2.532	-	0.2
Toluene	2.893	39.322	0.005	45.074	0.001	87.295	-	<0.1
Nickel	-	<0.001	<0.001	0.010	0.004	0.014	<0.1	0.1
Total	58.415	82.864	16.839	98.270	0.263	256.650		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions by HAP and by source with Alternatives C, D, or G is provided in **Table I-18**. As shown, depending on pollutant, HAP emissions would increase from 2 to 38 percent when compared to Alternative A (No Action Alternative) with diesel particulate matter increasing the most. The source contributing the most to the emissions increase would be construction equipment.

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; as these pollutants have the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (84, 90, and 85 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

I.8.2.2 Compressed Schedule

Alternative A (No Action)

As shown in **Table I-19**, with Alternative A the total amount of HAPs emitted would be 228 tons with motor vehicles and ground support equipment emitting approximately 77 percent of the emissions. The individual HAPs emitted the most would be toluene, formaldehyde, benzene, diesel particulate matter, and 1,3-butadiene (37, 21, 19, 11, and 7 percent of the emissions, respectively).

TABLE I-18
HAP EMISSIONS - ORIGINAL SCHEDULE - CONSTRUCTION PHASE I –
DIFFERENCE BETWEEN ALTERNATIVE A AND ALTERNATIVES C, D, AND G

Pollutant	Increase in Emissions (Tons) Last Year of Phase					Total
	Aircraft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	
1,3-Butadiene	1.130	0.155	0.001	0.052	-	1.338
Acetaldehyde	0.167	0.130	0.017	0.080	-	0.394
Acrolein	0.117	0.012	0.001	0.008	-	0.137
Arsenic	-	<0.001	<0.001	<0.001	<0.001	0.001
Benzene	0.673	0.744	0.007	0.449	<0.001	1.872
Chromium VI	-	<0.001	<0.001	<0.001	<0.001	<0.001
Diesel Particulate Matter	-	0.183	16.770	0.411	-	17,364
Formaldehyde	4.128	0.271	0.038	0.180	0.003	4.619
Naphthalene	0.129	0.012	<0.001	0.019	0.010	0.169
Toluene	0.328	1.398	0.005	1.046	<0.001	2.777
Nickel	-	<0.001	<0.001	<0.001	0.002	0.002

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

**TABLE I-19
HAP EMISSIONS – COMPRESSED SCHEDULE - CONSTRUCTION PHASE I –
ALTERNATIVE A (NO ACTION ALTERNATIVE)**

Pollutants	Tons Emitted Last Year of Phase					Emissions-Toxicity Values	
	Aircraft	GSE/APU(a)	Motor	Stationary	Total	Carcinogenic	Non-carcinogenic
			Vehicles	Sources			
1,3-Butadiene	8.740	4.240	2.200	-	15.180	3.0	1.4
Acetaldehyde	1.300	3.530	3.370	-	8.200	<0.1	0.2
Acrolein	0.912	0.316	0.329	-	1.557	-	14.0
Arsenic	-	<0.001	0.016	<0.001	0.016	<0.1	<0.1
Benzene	5.250	20.200	18.900	0.001	44.351	0.2	0.3
Chromium VI	-	<0.001	0.005	-	0.005	<0.1	<0.1
Diesel Particulate Matter	-	5.900	18.800	-	24.700	5.3	0.9
Formaldehyde	32.000	7.460	7.560	0.064	47.084	0.4	2.8
Naphthalene	1.000	0.372	0.813	0.180	2.365	-	0.1
Toluene	2.560	37.900	44.000	0.001	84.461	-	<0.1
Nickel	-	<0.001	0.010	0.003	0.013	<0.1	<0.1
Total	51.762	79.918	96.003	0.249	227.932		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.

Alternative C, D, and G

The estimated emission levels of HAPs with Alternatives C, D, or G are provided in **Table I-20**. As shown, the total amount of HAPs emitted would be 255 tons (an increase of 27 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-20
HAP EMISSIONS – COMPRESSED SCHEDULE - CONSTRUCTION PHASE I –
ALTERNATIVES C, D, AND G**

Pollutant	Tons Emitted Last Year of Phase						Emissions-Toxicity Values	
	Aircraft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non-carcinogenic
1,3-Butadiene	9.870	4.400	0.001	2.250	-	16.521	3.3	1.5
Acetaldehyde	1.470	3.660	0.027	3.450	-	8.607	<0.1	0.2
Acrolein	1.030	0.328	0.002	0.337	-	1.697	-	15.3
Arsenic	-	<0.001	<0.001	0.016	<0.001	0.017	0.1	<0.1
Benzene	5.920	21.000	0.010	19.300	0.001	46.231	0.3	0.3
Chromium VI	-	<0.001	<0.001	0.005	<0.001	0.005	<0.1	<0.1
Diesel Particulate Matter	-	6.090	30.295	19.200	-	55.585	11.9	2.0
Formaldehyde	36.100	7.730	0.064	7.740	0.067	52.000	0.5	3.1
Naphthalene	1.130	0.383	<0.001	0.833	0.190	2.536	-	0.2
Toluene	2.890	39.300	0.008	45.100	0.001	87.299	-	<0.1
Nickel	-	<0.001	<0.001	0.010	0.004	0.014	<0.1	0.1
Total	58.410	82.891	24.071	98.242	0.263	270.512		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions by HAP and by source with Alternatives C, D, or G is provided in **Table I-21**. As shown, depending on pollutant, HAP emissions would increase from 2 to 63 percent when compared to Alternative A (No Action) with diesel particulate matter increasing the most. The source contributing the most to the emissions increase would be construction equipment.

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; as these pollutants have the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (84, 89, and 85 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

**TABLE I-21
HAP EMISSIONS - COMPRESSED SCHEDULE - CONSTRUCTION PHASE I –
DIFFERENCE BETWEEN ALTERNATIVE A AND ALTERNATIVES C, D, AND G**

Pollutant	Increase in Emissions (Tons) Last Year of Phase					
	Aircraft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	Total
1,3-Butadiene	1.130	0.160	0.001	0.050	-	1.341
Acetaldehyde	0.170	0.130	0.027	0.080	-	0.407
Acrolein	0.118	0.012	0.002	0.008	-	0.140
Arsenic	-	<0.001	<0.001	<0.001	<0.001	0.001
Benzene	0.670	0.800	0.010	0.400	<0.001	1.881
Chromium VI	-	<0.001	<0.001	<0.001	-	<0.001
Diesel Particulate Matter	-	0.190	30.295	0.400	-	30.885
Formaldehyde	4.100	0.270	0.064	0.180	0.003	4.616
Naphthalene	0.130	0.011	<0.001	0.020	0.010	0.171
Toluene	0.330	1.400	0.008	1.100	<0.001	2.838
Nickel	-	<0.001	<0.001	<0.001	0.002	0.002

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

I.8.2.3 Delayed Schedule

Alternative A (No Action)

As shown in **Table I-22**, with Alternative A (No Action Alternative) the total amount of HAPs emitted would be 229 tons with motor vehicles and ground support equipment emitting approximately 77 percent of the emissions. The individual HAPs emitted the most would be toluene, formaldehyde, benzene, diesel particulate matter, and 1,3-butadiene (37, 21, 19, 11, and 7 percent of the emissions, respectively).

Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.

Alternative C, D, and G

The estimated emission levels of HAPs with Alternatives C, D, or G are provided in **Table I-23**. As shown, the total amount of HAPs emitted would be 255 tons (an increase of 26 tons when compared to Alternative A (No Action Alternative)).

TABLE I-22
HAP EMISSIONS – DELAYED SCHEDULE - CONSTRUCTION PHASE I –
ALTERNATIVE A (NO ACTION ALTERNATIVE)

Pollutants	Tons Emitted Last Year of Phase					Emissions-Toxicity Values	
	Aircraft	GSE/APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non-carcinogenic
1,3-Butadiene	8.625	4.198	2.234	-	15.057	3.0	1.4
Acetaldehyde	1.282	3.486	3.437	-	8.206	<0.1	0.2
Acrolein	0.901	0.313	0.336	-	1.550	-	14.0
Arsenic	-	<0.001	0.017	<0.001	0.017	0.1	<0.1
Benzene	5.186	19.958	19.086	0.001	44.231	0.2	0.3
Chromium VI	-	<0.001	0.006	-	0.006	<0.1	<0.1
Diesel Particulate Matter	-	6.455	17.038	-	23.493	5.0	0.8
Formaldehyde	31.607	7.338	7.723	0.064	46.782	0.4	2.8
Naphthalene	0.985	0.401	0.861	0.180	2.427	-	0.1
Toluene	2.538	37.446	44.427	0.001	84.413	-	<0.1
Nickel	-	<0.001	0.011	0.003	0.013	<0.1	<0.1
Total	51.125	79.645	95.177	0.249	226.197		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

TABLE I-23
HAP EMISSIONS – DELAYED SCHEDULE - CONSTRUCTION PHASE I –
ALTERNATIVES C, D, AND G

Pollutant	Tons Emitted Last Year of Phase					Emissions-Toxicity Values		
	Aircraft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non-carcinogenic
1,3-Butadiene	10.111	4.391	0.001	2.277	-	16.780	3.4	1.5
Acetaldehyde	1.501	3.643	0.016	3.503	-	8.663	<0.1	0.2
Acrolein	1.055	0.327	0.001	0.343	-	1.726	-	15.5
Arsenic	-	<0.001	<0.001	0.017	<0.001	0.018	0.1	<0.1
Benzene	6.065	20.856	0.006	19.453	0.001	46.381	0.3	0.3
Chromium VI	-	<0.001	<0.001	0.006	<0.001	0.006	<0.1	<0.1
Diesel Particulate Matter	-	6.658	13.674	17.183	-	37.515	8.0	1.4
Formaldehyde	39.975	7.737	0.034	7.871	0.066	52.684	0.5	3.2
Naphthalene	1.155	0.420	<0.001	0.877	0.192	2.644	-	0.2
Toluene	2.958	39.126	0.004	45.282	0.001	87.372	-	<0.1
Nickel	-	<0.001	<0.001	0.011	0.004	0.015	<0.1	0.1
Total	59.820	83.158	13.736	96.824	0.265	253.803		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions by HAP and by source with Alternatives C, D, or G is provided in **Table I-24**. As shown, depending on pollutant, HAP emissions would increase from 2 to 37 percent when compared to Alternative A (No Action Alternative) with diesel particulate matter increasing the most. The source contributing the most to the emissions increase would be construction equipment.

**TABLE I-24
HAP EMISSIONS – DELAYED SCHEDULE - CONSTRUCTION PHASE I –
DIFFERENCE BETWEEN ALTERNATIVE A AND ALTERNATIVES C, D, AND G**

Pollutant	Increase in Emissions (Tons) Last Year of Phase					Total
	Aircraft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	
1,3-Butadiene	1.486	0.193	0.001	0.043	-	1.723
Acetaldehyde	0.219	0.157	0.016	0.066	-	0.457
Acrolein	0.153	0.015	0.001	0.006	-	0.175
Arsenic	-	<0.001	<0.001	<0.001	<0.001	0.000
Benzene	0.879	0.898	0.006	0.367	<0.001	2.149
Chromium VI	-	<0.001	<0.001	<0.001	<0.001	0.000
Diesel Particulate Matter	-	0.204	13.674	0.144	-	14.022
Formaldehyde	5.368	0.348	0.034	0.149	0.003	5.902
Naphthalene	0.170	0.018	<0.001	0.017	0.012	0.217
Toluene	0.420	1.680	0.004	0.854	<0.001	2.959
Nickel	-	<0.001	0.000	<0.001	0.002	0.002

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; as these pollutants have the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (88, 93, and 90 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

I.8.3 Construction Phase II

The following presents and compares the estimated HAP emissions for Construction Phase II with Alternatives A (No Action Alternative) and Alternatives C, D, and G for the 11 HAPs of interest.

I.8.3.1 Original and Compressed Schedule

Alternative A (No Action)

As shown in **Table I-25**, with Alternative A (No Action Alternative) the total amount of HAPs emitted would be 210 tons with motor vehicles and ground support equipment emitting approximately 77 percent of the emissions. The individual HAPs emitted the most would be

toluene, formaldehyde, benzene, diesel particulate matter, and 1,3-butadiene (37, 21, 19, 11, and 7 percent of the emissions, respectively).

**TABLE I-25
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES -
CONSTRUCTION PHASE II – ALTERNATIVE A (NO ACTION ALTERNATIVE)**

Pollutants	Tons Emitted Last Year of Phase					Emissions-Toxicity Values	
	Aircraft	GSE/APU(a)	Motor	Stationary	Total	Carcinogenic	Non-carcinogenic
			Vehicles	Sources			
1,3-Butadiene	8.182	4.185	1.870	-	14.237	2.8	1.3
Acetaldehyde	1.224	3.477	2.885	-	7.586	<0.1	0.2
Acrolein	0.858	0.312	0.278	-	1.448	-	13.0
Arsenic	-	<0.001	0.019	<0.001	0.019	0.1	<0.1
Benzene	4.966	19.915	15.876	0.001	40.758	0.2	0.2
Chromium VI	-	<0.001	0.006	-	0.006	0.1	<0.1
Diesel Particulate Matter	-	7.756	14.849	-	22.606	4.8	0.8
Formaldehyde	30.374	7.355	6.478	0.064	44.271	0.4	2.7
Naphthalene	0.933	0.377	0.751	0.180	2.241	-	0.1
Toluene	2.477	37.372	36.846	0.001	76.697	-	<0.1
Nickel	-	<0.001	0.012	0.003	0.014	<0.1	0.1
Total	49.015	80.748	79.871	0.249	209.882		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.

Alternative C, D, and G

The estimated emission levels of HAPs with Alternatives C, D, or G are provided in **Table I-26**. As shown, the total amount of HAPs emitted would be 234 tons (an increase of 24 tons when compared to Alternative A (No Action Alternative)).

The estimated increase in emissions with Alternatives C, D, or G by HAP and by source is provided in **Table I-27**. As shown, depending on pollutant, HAP emissions would increase from 1 to 21 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

**TABLE I-26
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES –
CONSTRUCTION PHASE II – ALTERNATIVES C, D, AND G**

Pollutant	Tons Emitted Last Year of Phase						Emissions-Toxicity Values	
	Air-craft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non-carcinogenic
1,3-Butadiene	10.610	4.448	<0.001	1.901	-	16.958	3.4	1.5
Acetaldehyde	1.579	3.705	0.005	2.932	-	8.220	<0.1	0.2
Acrolein	1.108	0.331	<0.001	0.283	-	1.721	-	15.5
Arsenic	-	<0.001	<0.001	0.019	<0.001	0.020	0.1	<0.1
Benzene	6.390	21.223	0.002	16.133	0.001	43.748	0.2	0.3
Chromium VI	-	<0.001	<0.001	0.006	<0.001	0.006	0.1	<0.1
Diesel Particulate Matter	-	8.182	5.018	15.054	-	28.255	6.1	1.0
Formaldehyde	39.039	7.793	0.011	6.583	0.070	53.495	0.5	3.2
Naphthalene	1.211	0.397	<0.001	0.763	0.195	2.566	-	0.2
Toluene	3.143	39.838	0.001	37.442	0.001	80.425	-	<0.1
Nickel	-	<0.001	<0.001	0.012	0.005	0.017	<0.1	0.1
Total	63.079	85.916	5.037	81.127	0.273	235.432		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

**TABLE I-27
HAP EMISSIONS - ORIGINAL AND COMPRESSED SCHEDULES -
CONSTRUCTION PHASE II – DIFFERENCE BETWEEN ALTERNATIVE A AND
ALTERNATIVES C, D, AND G**

Pollutant	Increase in Emissions (Tons) Last Year of Phase					
	Aircraft	GSE/ APU(a)	Construction	Motor Vehicles	Stationary Sources	Total
1,3-Butadiene	2.428	0.263	<0.001	0.030	-	2.721
Acetaldehyde	0.355	0.228	0.005	0.047	-	0.635
Acrolein	0.250	0.019	<0.001	0.004	-	0.274
Arsenic	-	<0.001	<0.001	<0.001	<0.001	0.001
Benzene	1.423	1.308	0.002	0.257	<0.001	2.990
Chromium VI	-	<0.001	<0.001	<0.001	<0.001	<0.001
Diesel Particulate Matter	-	0.426	5.018	0.205	-	5.649
Formaldehyde	8.664	0.439	0.011	0.105	0.006	9.225
Naphthalene	0.278	0.019	<0.001	0.012	0.015	0.325
Toluene	0.665	2.466	0.001	0.596	<0.001	3.728
Nickel	-	<0.001	<0.001	<0.001	0.002	0.003

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (89, 94, and 91 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

I.8.3.2 Delayed Schedule

Alternative A (No Action)

As shown in **Table I-28**, with Alternative A (No Action Alternative) the total amount of HAPs emitted would be 207 tons with motor vehicles and ground support equipment emitting approximately 77 percent of the emissions. The individual HAPs emitted the most would be toluene, formaldehyde, benzene, diesel particulate matter, and 1,3-butadiene (37, 21, 19, 11, and 7 percent of the emissions, respectively).

Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.

**TABLE I-28
HAP EMISSIONS – DELAYED SCHEDULE - CONSTRUCTION PHASE II –
ALTERNATIVE A (NO ACTION ALTERNATIVE)**

Pollutants	Tons Emitted Last Year of Phase					Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	7.903	4.155	1.896	-	13.954	2.8	1.3
Acetaldehyde	1.182	3.456	2.938	-	7.576	<0.1	0.2
Acrolein	0.829	0.309	0.283	-	1.422	-	12.8
Arsenic	-	<0.001	0.020	<0.001	0.021	0.1	<0.1
Benzene	4.800	19.799	15.954	0.001	40.554	0.2	0.2
Chromium VI	-	<0.001	0.007	-	0.007	0.1	<0.1
Diesel Particulate Matter	-	8.356	13.202	-	21.558	4.6	0.8
Formaldehyde	29.346	7.292	6.612	0.064	43.313	0.4	2.6
Naphthalene	0.901	0.403	0.793	0.180	2.276	-	0.1
Toluene	2.398	37.161	36.986	0.001	76.546	-	<0.1
Nickel	-	<0.001	0.013	0.003	0.015	<0.1	0.1
Total	47.359	80.932	78.704	0.249	207.243		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Alternative C, D, and G

The estimated emission levels of HAPs with Alternatives C, D, or G are provided in **Table I-29**. As shown, the total amount of HAPs emitted would be 237 tons (an increase of 29 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-29
HAP EMISSIONS – DELAYED SCHEDULE - CONSTRUCTION PHASE II –
ALTERNATIVES C, D, AND G**

Pollutant	Tons Emitted Last Year of Phase					Emissions-Toxicity Values		
	Aircraft	GSE/ APU(a)	Construction	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	10.891	4.493	<0.001	1.950	-	17.334	3.5	1.6
Acetaldehyde	1.620	3.743	0.004	3.021	-	8.388	<0.1	0.2
Acrolein	1.138	0.334	<0.001	0.291	-	1.763	-	15.9
Arsenic	-	<0.001	<0.001	0.021	<0.001	0.021	0.1	<0.1
Benzene	6.554	21.444	0.002	16.407	0.001	44.407	0.2	0.3
Chromium VI	-	<0.001	<0.001	0.007	<0.001	0.007	0.1	<0.1
Diesel Particulate Matter	-	8.981	4.010	13.527	-	26.517	5.7	1.0
Formaldehyde	40.016	7.870	0.009	6.800	0.070	54.765	0.5	3.3
Naphthalene	1.243	0.431	<0.001	0.815	0.198	2.688	-	0.2
Toluene	3.218	40.254	0.001	38.037	0.001	81.511	-	<0.1
Nickel	-	<0.001	<0.001	0.013	0.005	0.018	<0.1	0.1
Total	64.681	87.548	4.026	80.889	0.276	237.421		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions with Alternatives C, D, or G by HAP and by source is provided in **Table I-30**. As shown, depending on pollutant, HAP emissions would increase from 2 to 26 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (89, 94, and 91 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

**TABLE I-30
HAP EMISSIONS - DELAYED SCHEDULE - CONSTRUCTION PHASE II –
DIFFERENCE BETWEEN ALTERNATIVE A AND ALTERNATIVES C, D, AND G**

Pollutant	Increase in Emissions (Tons) Last Year of Phase					Total
	Aircraft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	
1,3-Butadiene	2.989	0.338	<0.001	0.054	-	3.380
Acetaldehyde	0.438	0.287	0.004	0.083	-	0.812
Acrolein	0.308	0.025	<0.001	0.008	-	0.341
Arsenic	-	<0.001	<0.001	0.001	<0.001	0.001
Benzene	1.754	1.644	0.002	0.453	<0.001	3.853
Chromium VI	-	<0.001	<0.001	<0.001	<0.001	0.000
Diesel Particulate Matter	-	0.625	4.010	0.325	-	4.959
Formaldehyde	10.671	0.578	0.009	0.188	0.006	11.452
Naphthalene	0.342	0.028	<0.001	0.023	0.018	0.412
Toluene	0.820	3.092	0.001	1.051	<0.001	4.965
Nickel	-	<0.001	<0.001	<0.001	0.002	0.003

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

I.8.4 Build Out

The following presents and compares the estimated HAP emissions for Build Out with Alternative A (No Action Alternative) and Alternatives C, D, and G for the 11 HAPs of interest.

I.8.4.1 Original and Compressed Schedule

Alternative A (No Action)

As shown in **Table I-31**, with Alternative A (No Action Alternative) the total amount of HAPs emitted would be 173 tons with motor vehicles and ground support equipment emitting approximately 73 percent of the emissions. The individual HAPs emitted the most would be toluene, formaldehyde, benzene, diesel particulate matter, and 1,3-butadiene (34, 23, 19, 11, and 7 percent of the emissions, respectively).

Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.

**TABLE I-31
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT –
ALTERNATIVE A (NO ACTION ALTERNATIVE)**

Pollutants	Tons Emitted Last Year of Phase					Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	7.621	4.141	1.052	-	12.814	2.6	1.2
Acetaldehyde	1.141	3.455	1.681	-	6.277	<0.1	0.1
Acrolein	0.803	0.307	0.163	-	1.273	-	11.5
Arsenic	-	<0.001	0.025	<0.001	0.026	0.1	<0.1
Benzene	4.645	19.808	8.378	0.001	32.831	0.2	0.2
Chromium VI	-	<0.001	0.008	-	0.008	0.1	<0.1
Diesel Particulate Matter	-	10.465	8.752	-	19.217	4.1	0.7
Formaldehyde	28.383	7.229	3.864	0.064	39.539	0.4	2.4
Naphthalene	0.866	0.385	0.590	0.180	2.021	-	0.1
Toluene	2.342	37.197	19.457	0.001	58.997	-	<0.1
Nickel	-	<0.001	0.016	0.003	0.018	<0.1	0.1
Total	45.800	82.987	43.986	0.249	173.021		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Alternative C

The estimated emission levels of HAPs with Alternative C are provided in **Table I-32**. As shown, the total amount of HAPs emitted would be 214 tons (an increase of 41 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-32
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT –
ALTERNATIVE C**

Pollutant	Tons Emitted Last Year of Phase						Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Construction	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	10.664	4.574	<0.001	1.459	-	16.697	3.3	1.5
Acetaldehyde	1.582	3.835	0.002	2.291	-	7.710	<0.1	0.2
Acrolein	1.114	0.339	<0.001	0.221	-	1.674	-	15.1
Arsenic	-	<0.001	<0.001	0.027	0.001	0.028	0.1	<0.1
Benzene	6.398	21.994	0.001	11.903	0.001	40.297	0.2	0.2
Chromium VI	-	<0.001	<0.001	0.009	<0.001	0.009	0.1	<0.1
Diesel Particulate Matter	-	11.321	0.860	9.306	-	21.487	4.6	0.8
Formaldehyde	38.964	7.940	0.005	5.203	0.080	52.192	0.5	3.1
Naphthalene	1.217	0.423	<0.001	0.688	0.207	2.535	-	0.2
Toluene	3.121	41.325	0.001	27.523	0.002	71.971	-	<0.1
Nickel	-	<0.001	<0.001	0.017	0.007	0.024	<0.1	0.1
Total	63.060	91.750	0.898	58.649	0.298	214.625		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions with Alternative C by HAP and by source is provided in **Table I-33**. As shown, depending on pollutant, HAP emissions would increase from 6 to 32 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

**TABLE I-33
HAP EMISSIONS - ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT –
DIFFERENCE BETWEEN ALTERNATIVE A AND ALTERNATIVE C**

Pollutant	Increase in Emissions (Tons) Last Year of Phase					Total
	Aircraft	GSE/ APU(a)	Construction	Motor Vehicles	Stationary Sources	
1,3-Butadiene	3.043	0.434	<0.001	0.407	-	3.884
Acetaldehyde	0.441	0.380	0.002	0.610	-	1.433
Acrolein	0.311	0.031	<0.001	0.058	-	0.401
Arsenic	-	<0.001	<0.001	0.002	<0.001	0.002
Benzene	1.754	2.186	0.001	3.525	<0.001	7.466
Chromium VI	-	<0.001	<0.001	0.001	<0.001	0.001
Diesel Particulate Matter	-	0.856	0.860	0.554	-	2.270
Formaldehyde	10.581	0.711	0.005	1.339	0.016	12.652
Naphthalene	0.351	0.038	<0.001	0.098	0.027	0.514
Toluene	0.778	4.127	0.001	8.067	0.001	12.974
Nickel	-	<0.001	<0.001	0.001	0.005	0.006

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (78, 84, and 78 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

Alternative D

The estimated emission levels of HAPs with Alternative D are provided in **Table I-34**. As shown, the total amount of HAPs emitted would be 218 tons (an increase of 44 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-34
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT –
ALTERNATIVE D**

Pollutant	Tons Emitted Last Year of Phase						Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Construction	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	11.273	4.574	<0.001	1.459	-	17.306	3.5	1.6
Acetaldehyde	1.671	3.835	0.002	2.291	-	7.798	<0.1	0.2
Acrolein	1.177	0.339	<0.001	0.221	-	1.736	-	15.6
Arsenic	-	<0.001	<0.001	0.027	0.001	0.028	0.1	<0.1
Benzene	6.750	21.994	0.001	11.903	0.001	40.648	0.2	0.2
Chromium VI	-	<0.001	<0.001	0.009	<0.001	0.009	0.1	<0.1
Diesel Particulate Matter	-	11.319	0.860	9.306	-	21.485	4.6	0.8
Formaldehyde	41.086	7.940	0.005	5.203	0.080	54.314	0.5	3.3
Naphthalene	1.287	0.423	<0.001	0.688	0.207	2.605	-	0.2
Toluene	3.277	41.325	0.001	27.523	0.002	72.128	-	<0.1
Nickel	-	<0.001	<0.001	0.017	0.007	0.024	<0.1	0.1
Total	66.520	91.748	0.860	58.649	0.298	218.082		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions with Alternative D by HAP and by source is provided in **Table I-35**. As shown, depending on pollutant, HAP emissions would increase from 6 to 37 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

**TABLE I-35
HAP EMISSIONS - ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT –
DIFFERENCE BETWEEN ALTERNATIVE A AND ALTERNATIVE D**

Pollutant	Increase in Emissions (Tons) Last Year of Phase					
	Aircraft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	Total
1,3-Butadiene	3.652	0.434	<0.001	0.407	-	4.493
Acetaldehyde	0.529	0.380	0.002	0.610	-	1.522
Acrolein	0.374	0.031	<0.001	0.058	-	0.463
Arsenic	-	<0.001	<0.001	0.002	<0.001	0.002
Benzene	2.105	2.186	0.001	3.525	<0.001	7.817
Chromium VI	-	<0.001	<0.001	0.001	<0.001	0.001
Diesel Particulate Matter	-	0.854	0.860	0.554	-	2.269
Formaldehyde	12.704	0.711	0.005	1.339	0.016	14.774
Naphthalene	0.421	0.037	<0.001	0.098	0.027	0.584
Toluene	0.935	4.127	0.001	8.067	0.001	13.130
Nickel	-	<0.001	<0.001	0.001	0.005	0.006

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (81, 86, and 81 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

Alternative G

The estimated emission levels of HAPs with Alternative G are provided in **Table I-36**. As shown, the total amount of HAPs emitted would be 213 tons (an increase of 40 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-36
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT –
ALTERNATIVE G**

Pollutant	Tons Emitted Last Year of Phase						Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Construction	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	10.476	4.574	<0.001	1.459	-	16.509	3.3	1.5
Acetaldehyde	1.555	3.835	0.002	2.291	-	7.683	<0.1	0.2
Acrolein	1.095	0.339	<0.001	0.221	-	1.655	-	14.9
Arsenic	-	<0.001	<0.001	0.027	0.001	0.028	0.1	<0.1
Benzene	6.290	21.994	0.001	11.903	0.001	40.189	0.2	0.2
Chromium VI	-	<0.001	<0.001	0.009	<0.001	0.009	0.1	<0.1
Diesel Particulate Matter	-	11.311	0.860	9.306	-	21.478	4.6	0.8
Formaldehyde	38.309	7.940	0.005	5.203	0.080	51.537	0.5	3.1
Naphthalene	1.195	0.422	<0.001	0.688	0.207	2.513	-	0.2
Toluene	3.072	41.325	0.001	27.523	0.002	71.923	-	<0.1
Nickel	-	<0.001	<0.001	0.017	0.007	0.024	<0.1	0.1
Total	61.993	91.740	0.860	58.649	0.298	213.547		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions with Alternative G, by HAP and by source, is provided in **Table I-37**. As shown, depending on pollutant, HAP emissions would increase from 6 to 30 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (77, 83, and 77 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

**TABLE I-37
HAP EMISSIONS - ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT –
DIFFERENCE BETWEEN ALTERNATIVE A AND ALTERNATIVE G**

Pollutant	Increase in Emissions (Tons) Last Year of Phase					
	Aircraft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	Total
1,3-Butadiene	2.855	0.434	<0.001	0.407	-	3.696
Acetaldehyde	0.414	0.380	0.002	0.610	-	1.406
Acrolein	0.292	0.031	<0.001	0.058	-	0.382
Arsenic	-	<0.001	<0.001	0.002	<0.001	0.002
Benzene	1.645	2.186	0.001	3.525	<0.001	7.358
Chromium VI	-	<0.001	<0.001	0.001	<0.001	0.001
Diesel Particulate Matter	-	0.846	0.860	0.554	-	2.261
Formaldehyde	9.927	0.711	0.005	1.339	0.016	11.997
Naphthalene	0.330	0.037	<0.001	0.098	0.027	0.492
Toluene	0.730	4.127	0.001	8.067	0.001	12.925
Nickel	-	<0.001	<0.001	0.001	0.005	0.006

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

I.8.4.2 Delayed Schedule

Alternative A (No Action)

As shown in **Table I-38**, with Alternative A (No Action Alternative) the total amount of HAPs emitted would be 184 tons with motor vehicles and ground support equipment emitting approximately 73 percent of the emissions. The individual HAPs emitted the most would be toluene, formaldehyde, benzene, diesel particulate matter, and 1,3-butadiene (34, 23, 19, 11, and 7 percent of the emissions, respectively).

**TABLE I-38
HAP EMISSIONS – DELAYED SCHEDULE - BUILD OUT – ALTERNATIVE A
(NO ACTION ALTERNATIVE)**

Pollutants	Tons Emitted Last Year of Phase					Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	7.680	4.125	1.405	-	13.211	2.6	1.2
Acetaldehyde	1.150	3.440	2.217	-	6.807	0.0	0.1
Acrolein	0.809	0.306	0.213	-	1.328	-	12.0
Arsenic	-	<0.001	0.028	<0.001	0.028	0.1	<0.1
Benzene	4.680	19.723	11.369	0.001	35.773	0.2	0.2
Chromium VI	-	0.000	0.009	-	0.009	0.1	<0.1
Diesel Particulate Matter	-	10.767	7.281	-	18.048	3.9	0.6
Formaldehyde	28.600	7.207	5.049	0.064	40.920	0.4	2.5
Naphthalene	0.872	0.394	0.690	0.180	2.137	-	0.1
Toluene	2.360	37.036	26.292	0.001	65.689	-	<0.1
Nickel	-	<0.001	0.017	0.003	0.020	<0.1	0.1
Total	46.151	83.000	54.572	0.249	183.971		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.

Alternative C

The estimated emission levels of HAPs with Alternative C are provided in **Table I-39**. As shown, the total amount of HAPs emitted would be 216 tons (an increase of 44 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-39
HAP EMISSIONS – DELAYED SCHEDULE - BUILD OUT – ALTERNATIVE C**

Pollutant	Tons Emitted Last Year of Phase					Emissions-Toxicity Values		
	Aircraft	GSE/ APU(a)	Construction	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	10.859	4.582	<0.001	1.493	-	16.934	3.4	1.5
Acetaldehyde	1.611	3.839	0.004	2.356	-	7.809	<0.1	0.2
Acrolein	1.134	0.339	<0.001	0.226	-	1.700	-	15.3
Arsenic	-	<0.001	<0.001	0.030	0.001	0.030	0.1	<0.1
Benzene	6.511	22.017	0.001	12.080	0.001	40.611	0.2	0.2
Chromium VI	-	<0.001	<0.001	0.010	<0.001	0.010	0.1	<0.1
Diesel Particulate Matter	-	11.693	1.708	7.756	-	21.157	4.5	0.8
Formaldehyde	39.658	7.957	0.008	5.365	0.080	53.068	0.5	3.2
Naphthalene	1.239	0.435	<0.001	0.733	0.210	2.618	-	0.2
Toluene	3.170	41.366	0.001	27.936	0.002	72.475	-	<0.1
Nickel	-	<0.001	<0.001	0.018	0.007	0.026	<0.1	0.1
Total	64.182	92.228	1.722	58.004	0.301	216.437		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions with Alternative C by HAP and by source is provided in **Table I-40**. As shown, depending on pollutant, HAP emissions would increase from 7 to 34 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (78, 84, and 77 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

**TABLE I-40
HAP EMISSIONS - DELAYED SCHEDULE - BUILD OUT – DIFFERENCE BETWEEN
ALTERNATIVE A AND ALTERNATIVE C**

Pollutant	Increase in Emissions (Tons) Last Year of Phase					Total
	Aircraft	GSE/ APU(a)	Construction	Motor Vehicles	Stationary Sources	
1,3-Butadiene	3.179	0.46	<0.001	0.088	-	3.723
Acetaldehyde	0.461	0.399	0.004	0.139	-	1.002
Acrolein	0.325	0.033	<0.001	0.013	-	0.372
Arsenic	-	<0.001	<0.001	0.002	<0.001	0.002
Benzene	1.831	2.294	0.001	0.711	<0.001	4.837
Chromium VI	-	<0.001	<0.001	0.001	<0.001	0.001
Diesel Particulate Matter	-	0.925	1.708	0.475	-	3.108
Formaldehyde	11.059	0.750	0.008	0.316	0.016	12.148
Naphthalene	0.367	0.041	<0.001	0.043	0.030	0.481
Toluene	0.810	4.331	0.001	1.644	0.001	6.786
Nickel	-	<0.001	<0.001	0.001	0.005	0.006

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Alternative D

The estimated emission levels of HAPs with Alternative D are provided in **Table I-41**. As shown, the total amount of HAPs emitted would be 220 tons (an increase of 47 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-41
HAP EMISSIONS – DELAYED SCHEDULE - BUILD OUT – ALTERNATIVE D**

Pollutant	Tons Emitted Last Year of Phase					Emissions-Toxicity Values		
	Aircraft	GSE/ APU(a)	Construction	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non-carcinogenic
1,3-Butadiene	11.432	4.582	<0.001	1.493	-	17.507	3.5	1.6
Acetaldehyde	1.694	3.839	0.004	2.356	-	7.892	<0.1	0.2
Acrolein	1.193	0.339	<0.001	0.226	-	1.759	-	15.8
Arsenic	-	<0.001	<0.001	0.030	0.001	0.030	0.1	<0.1
Benzene	6.842	22.017	0.001	12.080	0.001	40.942	0.2	0.2
Chromium VI	-	<0.001	<0.001	0.010	<0.001	0.010	0.1	<0.1
Diesel Particulate Matter	-	11.693	1.708	7.756	-	21.156	4.5	0.8
Formaldehyde	41.657	7.957	0.008	5.365	0.080	55.067	0.5	3.3
Naphthalene	1.305	0.435	<0.001	0.733	0.210	2.684	-	0.2
Toluene	3.318	41.366	0.001	27.936	0.002	72.623	-	<0.1
Nickel	-	<0.001	<0.001	0.018	0.007	0.026	<0.1	0.1
Total	67.440	92.228	1.722	58.004	0.301	219.694		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions with Alternative D by HAP and by source is provided in **Table I-42**. As shown, depending on pollutant, HAP emissions would increase from 7 to 39 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

**TABLE I-42
HAP EMISSIONS (TONS) - DELAYED SCHEDULE - BUILD OUT – DIFFERENCE
BETWEEN ALTERNATIVE A AND ALTERNATIVE D**

Pollutant	Increase in Emissions (Tons) Last Year of Phase					Total
	Aircraft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	
1,3-Butadiene	3.752	0.456	<0.001	0.088	-	4.296
Acetaldehyde	0.544	0.399	0.004	0.139	-	1.085
Acrolein	0.384	0.033	<0.001	0.013	-	0.430
Arsenic	-	<0.001	<0.001	0.002	<0.001	0.002
Benzene	2.161	2.294	0.001	0.711	<0.001	5.168
Chromium VI	-	<0.001	<0.001	0.001	<0.001	0.001
Diesel Particulate Matter	-	0.925	1.708	0.475	-	3.108
Formaldehyde	13.067	0.750	0.008	0.316	0.016	14.146
Naphthalene	0.433	0.041	<0.001	0.043	0.030	0.547
Toluene	0.958	4.331	0.001	1.644	0.001	6.934
Nickel	-	<0.001	<0.001	0.001	0.005	0.006

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Alternative G

The estimated emission levels of HAPs with Alternative G are provided in **Table I-43**. As shown, the total amount of HAPs emitted would be 215 tons (an increase of 43 tons when compared to Alternative A (No Action Alternative)).

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (81, 86, and 80 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

The estimated increase in emissions with Alternative G by HAP and by source is provided in **Table I-44**. As shown, depending on pollutant, HAP emissions would increase from 7 to 32 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

**TABLE I-43
HAP EMISSIONS – DELAYED SCHEDULE - BUILD OUT – ALTERNATIVE G**

Pollutant	Tons Emitted Last Year of Phase						Emissions-Toxicity Values	
	Aircraft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non-carcinogenic
1,3-Butadiene	10.574	4.582	<0.001	1.493	-	16.649	3.3	1.5
Acetaldehyde	1.569	3.839	0.004	2.356	-	7.767	<0.1	0.2
Acrolein	1.105	0.339	<0.001	0.226	-	1.671	-	15.0
Arsenic	-	<0.001	<0.001	0.030	0.001	0.030	0.1	<0.1
Benzene	6.347	22.017	0.001	12.080	0.001	40.446	0.2	0.2
Chromium VI	-	<0.001	<0.001	0.010	<0.001	0.010	0.1	<0.1
Diesel Particulate Matter	-	11.693	1.708	7.756	-	21.156	4.5	0.8
Formaldehyde	38.665	7.957	0.008	5.365	0.080	52.075	0.5	3.1
Naphthalene	1.206	0.435	<0.001	0.733	0.210	2.585	-	0.2
Toluene	3.096	41.366	0.001	27.936	0.002	72.402	-	<0.1
Nickel	-	<0.001	<0.001	0.018	0.007	0.026	<0.1	0.1
Total	62.562	92.228	1.722	58.004	0.301	214.816		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

**TABLE I-44
HAP EMISSIONS - DELAYED SCHEDULE - BUILD OUT – DIFFERENCE BETWEEN ALTERNATIVE A AND ALTERNATIVE G**

Pollutant	Increase in Emissions (Tons) Last Year of Phase					
	Aircraft	GSE/APU(a)	Construction	Motor Vehicles	Stationary Sources	Total
1,3-Butadiene	2.894	0.456	<0.001	0.088	-	3.438
Acetaldehyde	0.419	0.399	0.004	0.139	-	0.960
Acrolein	0.296	0.033	<0.001	0.013	-	0.343
Arsenic	-	<0.001	<0.001	0.002	<0.001	0.002
Benzene	1.666	2.294	0.001	0.711	<0.001	4.673
Chromium VI	-	<0.001	<0.001	0.001	<0.001	0.001
Diesel Particulate Matter	-	0.925	1.708	0.475	-	3.108
Formaldehyde	10.065	0.750	0.008	0.316	0.016	11.154
Naphthalene	0.334	0.041	<0.001	0.043	0.030	0.448
Toluene	0.737	4.331	0.001	1.644	0.001	6.713
Nickel	-	<0.001	<0.001	0.001	0.005	0.006

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (77, 83, and 77 percent of the

increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

I.8.5 Build Out + 5

The following presents and compares the estimated HAP emissions for Build Out + 5 with Alternatives A (No Action Alternative) and Alternatives C, D, and G for the 11 HAPs of interest.

I.8.5.1 Original and Compressed Schedule

Alternative A (No Action)

As shown in **Table I-45**, with Alternative A (No Action Alternative) the total amount of HAPs emitted would be 171 tons with motor vehicles and ground support equipment emitting approximately 73 percent of the emissions. The individual HAPs emitted the most would be toluene, formaldehyde, benzene, diesel particulate matter, and 1,3-butadiene (35, 23, 19, 9, and 8 percent of the emissions, respectively).

**TABLE I-45
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT + 5
– ALTERNATIVE A (NO ACTION ALTERNATIVE)**

Pollutants	Tons					Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	7.666	4.152	1.082	-	12.900	2.6	1.2
Acetaldehyde	1.146	3.452	1.730	-	6.327	<0.1	0.1
Acrolein	0.807	0.308	0.168	-	1.283	-	11.5
Arsenic	-	<0.001	0.036	<0.001	0.036	0.1	<0.1
Benzene	4.659	19.790	8.621	0.001	33.071	0.2	0.2
Chromium VI	-	<0.001	0.012	-	0.012	0.1	<0.1
Diesel Particulate Matter	-	11.579	3.963	-	15.542	3.3	0.6
Formaldehyde	28.439	7.276	3.976	0.064	39.756	0.4	2.4
Naphthalene	0.872	0.398	0.607	0.170	2.048	-	0.1
Toluene	2.333	37.152	20.022	0.001	59.507	-	<0.1
Nickel	-	<0.001	0.022	0.003	0.025	<0.1	0.1
Total	45.922	84.106	40.239	0.239	170.507		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.

Alternative C

The estimated emission levels of HAPs with Alternative C are provided in **Table I-46**. As shown, the total amount of HAPs emitted would be 210 tons (an increase of 39 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-46
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT + 5
– ALTERNATIVE C**

Pollutants	Tons					Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	11.563	4.782	1.178	-	17.523	3.5	1.6
Acetaldehyde	1.720	4.001	1.882	-	7.603	<0.1	0.2
Acrolein	1.210	0.354	0.182	-	1.747	-	15.7
Arsenic	-	<0.001	0.039	0.001	0.039	0.1	<0.1
Benzene	6.966	22.950	9.382	0.001	39.299	0.2	0.2
Chromium VI	-	<0.001	0.013	<0.001	0.013	0.1	<0.1
Diesel Particulate Matter	-	13.022	4.289	-	17.312	3.7	0.6
Formaldehyde	42.508	8.316	4.327	0.080	55.231	0.5	3.3
Naphthalene	1.317	0.455	0.661	0.221	2.654	-	0.2
Toluene	3.433	43.116	21.788	0.002	68.338	-	<0.1
Nickel	-	<0.001	0.024	0.007	0.031	<0.1	0.1
Total	68.718	96.996	43.765	0.311	209.790		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions with Alternative C by HAP and by source is provided in **Table I-47**. As shown, depending on pollutant, HAP emissions would increase from 8 to 39 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

**TABLE I-47
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT + 5
– DIFFERENCE BETWEEN ALTERNATIVE A AND ALTERNATIVE C**

Pollutant	Increase in Emissions (Tons)				Total
	Aircraft	GSE/APU(a)	Motor Vehicles	Stationary Sources	
1,3-Butadiene	3.897	0.630	0.095	-	4.623
Acetaldehyde	0.574	0.549	0.153	-	1.275
Acrolein	0.403	0.046	0.015	-	0.464
Arsenic	-	<0.001	0.003	<0.001	0.003
Benzene	2.307	3.160	0.761	<0.001	6.228
Chromium VI	-	<0.001	0.001	<0.001	0.001
Diesel Particulate Matter	-	1.444	0.326	-	1.770
Formaldehyde	14.069	1.040	0.351	0.016	15.476
Naphthalene	0.445	0.057	0.054	0.050	0.606
Toluene	1.100	5.964	1.766	0.001	8.831
Nickel	-	<0.001	0.002	0.005	0.006

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (84, 91, and 87 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

Alternative D

The estimated emission levels of HAPs with Alternative D are provided in **Table I-48**. As shown, the total amount of HAPs emitted would be 216 tons (an increase of 45 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-48
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT + 5
– ALTERNATIVE D**

Pollutants	Tons					Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	12.630	4.782	1.178	-	18.590	3.7	1.7
Acetaldehyde	1.873	4.001	1.882	-	7.756	<0.1	0.2
Acrolein	1.319	0.354	0.182	-	1.855	-	16.7
Arsenic	-	<0.001	0.039	0.001	0.039	0.1	<0.1
Benzene	7.572	22.950	9.382	0.001	39.905	0.2	0.2
Chromium VI	-	<0.001	0.013	<0.001	0.013	0.1	<0.1
Diesel Particulate Matter	-	13.028	4.289	-	17.317	3.7	0.6
Formaldehyde	46.137	8.316	4.327	0.080	58.859	0.5	3.5
Naphthalene	1.440	0.455	0.661	0.221	2.777	-	0.2
Toluene	3.693	43.116	21.788	0.002	68.599	-	<0.1
Nickel	-	<0.001	0.024	0.007	0.031	<0.1	0.1
Total	74.664	97.002	43.765	0.311	215.742		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions with Alternative D by HAP and by source is provided in **Table I-49**. As shown, depending on pollutant, HAP emissions would increase from 8 to 48 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (87, 93, and 89 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

**TABLE I-49
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT + 5
– DIFFERENCE BETWEEN ALTERNATIVE A AND ALTERNATIVE D**

Pollutant	Tons				Total
	Aircraft	GSE/APU(a)	Motor Vehicles	Stationary Sources	
1,3-Butadiene	4.964	0.630	0.095	-	5.690
Acetaldehyde	0.727	0.549	0.153	-	1.429
Acrolein	0.512	0.046	0.015	-	0.573
Arsenic	-	<0.001	0.003	<0.001	0.003
Benzene	2.913	3.160	0.761	<0.001	6.834
Chromium VI	-	<0.001	0.001	<0.001	0.001
Diesel Particulate Matter	-	1.450	0.326	-	1.776
Formaldehyde	17.698	1.040	0.351	0.016	19.104
Naphthalene	0.568	0.057	0.054	0.050	0.729
Toluene	1.360	5.964	1.766	0.001	9.091
Nickel	-	<0.001	0.002	0.005	0.006

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Alternative G

The estimated emission levels of HAPs with Alternative G are provided in **Table I-50**. As shown, the total amount of HAPs emitted would be 209 tons (an increase of 38 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-50
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT + 5
– ALTERNATIVE G**

Pollutants	Tons					Emissions-Toxicity Values	
	Aircraft	GSE/APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non-carcinogenic
1,3-Butadiene	11.508	4.782	1.178	-	17.468	3.5	1.6
Acetaldehyde	1.710	4.001	1.882	-	7.593	<0.1	0.2
Acrolein	1.204	0.354	0.182	-	1.740	-	15.7
Arsenic	-	<0.001	0.039	0.001	0.039	0.1	<0.1
Benzene	6.925	22.950	9.382	0.001	39.258	0.2	0.2
Chromium VI	-	<0.001	0.013	<0.001	0.013	0.1	<0.1
Diesel Particulate Matter	-	13.028	4.289	-	17.317	3.7	0.6
Formaldehyde	42.228	8.316	4.327	0.080	54.950	0.5	3.3
Naphthalene	1.311	0.455	0.661	0.221	2.648	-	0.2
Toluene	3.404	43.116	21.788	0.002	68.310	-	<0.1
Nickel	-	<0.001	0.024	0.007	0.031	<0.1	0.1
Total	68.289	97.002	43.765	0.311	209.368		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions with Alternative G by HAP and by source is provided in **Table I-51**. As shown, depending on pollutant, HAP emissions would increase from 8 to 38 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

**TABLE I-51
HAP EMISSIONS – ORIGINAL AND COMPRESSED SCHEDULES - BUILD OUT + 5
– DIFFERENCE BETWEEN ALTERNATIVE A AND ALTERNATIVE G**

Pollutant	Tons				Total
	Aircraft	GSE/APU(a)	Motor Vehicles	Stationary Sources	
1,3-Butadiene	3.842	0.630	0.095	-	4.568
Acetaldehyde	0.564	0.549	0.153	-	1.266
Acrolein	0.397	0.046	0.015	-	0.458
Arsenic	-	<0.001	0.003	<0.001	0.003
Benzene	2.265	3.160	0.761	<0.001	6.187
Chromium VI	-	<0.001	0.001	<0.001	0.001
Diesel Particulate Matter	-	1.450	0.326	-	1.776
Formaldehyde	13.788	1.040	0.351	0.016	15.194
Naphthalene	0.439	0.057	0.054	0.050	0.600
Toluene	1.071	5.964	1.766	0.001	8.802
Nickel	-	<0.001	0.002	0.005	0.006

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (84, 91, and 87 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

I.8.5.2 Delayed Schedule

Alternative A (No Action)

As shown in **Table I-52**, with Alternative A (No Action Alternative) the total amount of HAPs emitted would be 173 tons with motor vehicles and ground support equipment emitting approximately 73 percent of the emissions. The individual HAPs emitted the most would be toluene, formaldehyde, benzene, diesel particulate matter, and 1,3-butadiene (35, 23, 19, 9, and 8 percent of the emissions, respectively).

**TABLE I-52
HAP EMISSIONS – DELAYED SCHEDULE - BUILD OUT + 5 – ALTERNATIVE A
(NO ACTION ALTERNATIVE)**

Pollutants	Tons					Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	7.666	4.145	1.153	-	12.964	2.6	1.2
Acetaldehyde	1.146	3.446	1.847	-	6.439	<0.1	0.1
Acrolein	0.807	0.308	0.179	-	1.294	-	11.6
Arsenic	-	<0.001	0.036	<0.001	0.036	0.1	<0.1
Benzene	4.659	19.756	9.156	0.001	33.572	0.2	0.2
Chromium VI	-	<0.001	0.012	-	0.012	0.1	<0.1
Diesel Particulate Matter	-	11.592	3.834	-	15.426	3.3	0.6
Formaldehyde	28.439	7.265	4.253	0.064	40.021	0.4	2.4
Naphthalene	0.872	0.399	0.659	0.180	2.110	-	0.1
Toluene	2.333	37.087	21.264	0.001	60.685	-	<0.1
Nickel	-	<0.001	0.023	0.003	0.025	<0.1	0.1
Total	45.922	83.997	42.416	0.249	172.583		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units

(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.

Alternative C

The estimated emission levels of HAPs with Alternative C are provided in **Table I-53**. As shown, the total amount of HAPs emitted would be 215 tons (an increase of 42 tons when compared to Alternative A (No Action Alternative)).

The estimated increase in emissions with Alternative C by HAP and by source is provided in **Table I-54**. As shown, depending on pollutant, HAP emissions would increase from 9 to 42 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (84, 91, and 87 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

**TABLE I-53
HAP EMISSIONS (TONS) – DELAYED SCHEDULE - BUILD OUT + 5 –
ALTERNATIVE C**

Pollutants	Tons					Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	11.818	4.829	1.255	-	17.902	3.6	1.60
Acetaldehyde	1.756	4.040	2.011	-	7.806	<0.1	0.2
Acrolein	1.236	0.358	0.195	-	1.789	-	16.1
Arsenic	-	<0.001	0.039	0.001	0.040	0.1	<0.1
Benzene	7.107	23.175	9.967	0.001	40.251	0.2	0.2
Chromium VI	-	<0.001	0.013	<0.001	0.013	0.1	<0.1
Diesel Particulate Matter	-	13.195	4.175	-	17.370	3.7	0.6
Formaldehyde	43.335	8.398	4.630	0.080	56.442	0.5	3.4
Naphthalene	1.346	0.461	0.718	0.223	2.749	-	0.2
Toluene	3.490	43.539	23.147	0.002	70.177	-	<0.1
Nickel	-	<0.001	0.025	0.007	0.032	<0.1	0.1
Total	70.087	97.996	46.174	0.314	214.571		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

**TABLE I-54
HAP EMISSIONS – DELAYED SCHEDULE - BUILD OUT + 5 – DIFFERENCE
BETWEEN ALTERNATIVE A AND ALTERNATIVE C**

Pollutant	Tons					Total
	Aircraft	GSE/ APU(a)	Motor Vehicles	Stationary Sources		
1,3-Butadiene	4.152	0.684	0.102	-	4.938	
Acetaldehyde	0.610	0.594	0.164	-	1.368	
Acrolein	0.429	0.050	0.016	-	0.495	
Arsenic	-	<0.001	0.003	<0.001	0.004	
Benzene	2.448	3.420	0.811	<0.001	6.679	
Chromium VI	-	<0.001	0.001	<0.001	0.001	
Diesel Particulate Matter	-	1.603	0.341	-	1.944	
Formaldehyde	14.895	1.134	0.377	0.016	16.422	
Naphthalene	0.475	0.062	0.058	0.043	0.639	
Toluene	1.156	6.451	1.883	0.001	9.492	
Nickel	-	<0.001	0.002	0.005	0.007	

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

Alternative D

The estimated emission levels of HAPs with Alternative D are provided in **Table I-55**. As shown, the total amount of HAPs emitted would be 221 tons (an increase of 48 tons when compared to Alternative A (No Action Alternative)).

**TABLE I-55
HAP EMISSIONS – DELAYED SCHEDULE - BUILD OUT + 5 – ALTERNATIVE D**

Pollutants	Tons					Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	12.908	4.829	1.255	-	18.992	3.8	1.7
Acetaldehyde	1.914	4.040	2.011	-	7.964	<0.1	0.2
Acrolein	1.347	0.358	0.195	-	1.900	-	17.1
Arsenic	-	<0.001	0.039	0.001	0.040	0.1	<0.1
Benzene	7.735	23.175	9.967	0.001	40.879	0.2	0.2
Chromium VI	-	<0.001	0.013	<0.001	0.013	0.1	<0.1
Diesel Particulate Matter	-	13.195	4.175	-	17.370	3.7	0.6
Formaldehyde	47.132	8.398	4.630	0.080	60.240	0.6	3.6
Naphthalene	1.472	0.461	0.718	0.223	2.874	-	0.2
Toluene	3.770	43.539	23.147	0.002	70.458	-	<0.1
Nickel	-	<0.001	0.025	0007	0.032	<0.1	0.1
Total	76.278	97.996	46.174	0.314	220.762		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions with Alternative D by HAP and by source is provided in **Table I-56**. As shown, depending on pollutant, HAP emissions would increase from 9 to 51 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

**TABLE I-56
HAP EMISSIONS – DELAYED SCHEDULE - BUILD OUT + 5 – DIFFERENCE
BETWEEN ALTERNATIVE A AND ALTERNATIVE D**

Pollutant	Tons				
	Aircraft	GSE/APU(a)	Motor Vehicles	Stationary Sources	Total
1,3-Butadiene	5.242	0.684	0.102	-	6.028
Acetaldehyde	0.768	0.594	0.164	-	1.526
Acrolein	0.541	0.050	0.016	-	0.606
Arsenic	-	<0.001	0.003	<0.001	0.004
Benzene	3.076	3.420	0.811	<0.001	7.307
Chromium VI	-	<0.001	0.001	<0.001	0.001
Diesel Particulate Matter	-	1.603	0.341	-	1.944
Formaldehyde	18.693	1.134	0.377	0.016	20.219
Naphthalene	0.600	0.062	0.058	0.043	0.764
Toluene	1.437	6.451	1.883	0.001	9.772
Nickel	-	<0.001	0.002	0.005	0.007

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (87, 92, and 89 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

Alternative G

The estimated emission levels of HAPs with Alternative G are provided in **Table I-57**. As shown, the total amount of HAPs emitted would be 214 tons (an increase of 41 tons when compared to Alternative A (No Action Alternative)).

TABLE I-57
HAP EMISSIONS – DELAYED SCHEDULE - BUILD OUT + 5 – ALTERNATIVE G

Pollutants	Tons					Emissions-Toxicity Values	
	Aircraft	GSE/ APU(a)	Motor Vehicles	Stationary Sources	Total	Carcinogenic	Non- carcinogenic
1,3-Butadiene	11.743	4.829	1.255	-	17.827	3.6	1.60
Acetaldehyde	1.745	4.040	2.011	-	7.795	<0.1	0.2
Acrolein	1.228	0.358	0.195	-	1.781	-	16.0
Arsenic	-	<0.001	0.039	0.001	0.040	0.1	<0.1
Benzene	7.064	23.175	9.967	0.001	40.207	0.2	0.2
Chromium VI	-	<0.001	0.013	<0.001	0.013	0.1	<0.1
Diesel Particulate Matter	-	13.195	4.175	-	17.370	3.7	0.6
Formaldehyde	43.072	8.398	4.630	0.080	56.180	0.5	3.4
Naphthalene	1.388	0.461	0.718	0.223	2.740	-	0.2
Toluene	3.470	43.539	23.147	0.002	70.158	-	<0.1
Nickel	-	<0.001	0.025	0.007	0.032	<0.1	0.1
Total	69.659	97.996	46.174	0.314	214.143		

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The estimated increase in emissions with Alternative G by HAP and by source is provided in **Table I-58**. As shown, depending on pollutant, HAP emissions would increase from 9 to 41 percent when compared to Alternative A (No Action Alternative) with formaldehyde increasing the most. The source contributing the most to the increase would be aircraft.

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest; with the highest emissions-toxicity values. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft (84, 91, and 86 percent of the increase, respectively) while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

**TABLE I-58
HAP EMISSIONS – DELAYED SCHEDULE - BUILD OUT + 5 – DIFFERENCE
BETWEEN ALTERNATIVE A AND ALTERNATIVE G**

Pollutant	Tons				Total
	Aircraft	GSE/APU(a)	Motor Vehicles	Stationary Sources	
1,3-Butadiene	4.077	0.684	0.102	-	4.863
Acetaldehyde	0.599	0.594	0.164	-	1.357
Acrolein	0.422	0.050	0.016	-	0.487
Arsenic	-	<0.001	0.003	<0.001	0.004
Benzene	2.404	3.420	0.811	<0.001	6.635
Chromium VI	-	<0.001	0.001	<0.001	0.001
Diesel Particulate Matter	-	1.603	0.341	-	1.944
Formaldehyde	14.633	1.134	0.377	0.016	16.159
Naphthalene	0.466	0.062	0.058	0.043	0.630
Toluene	1.137	6.451	1.883	0.001	9.473
Nickel	-	<0.001	0.002	0.005	0.007

Notes: (a) GSE/APU = ground support equipment/auxiliary power units
(b) - = Not emitted by this source or not applicable

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

I.8.6 Summary

This section of the report provides a summary of the evaluation of increases/decreases in HAP emissions with and without the proposed Airport development alternatives. **Tables I-59, I-60, and I-61** summarize the estimated HAP emissions for each of the evaluated scenarios for the Original, Compressed, and Delayed Schedules, respectively.

Implementation of the No Action Alternative or any of the Build Alternatives would result in both short-term and long-term air quality effects. Over the short-term, air quality conditions would be temporarily affected due to construction activities. Over the long-term, the Build Alternatives would have the potential to affect air quality conditions due to increases in the number of aircraft operations and airport support operations, and changes to aircraft and motor vehicle circulation patterns.

Based on the results of the air quality analysis, key conclusions with respect to the proposed improvements and air quality conditions are:

- Emission loads of HAPs with the Build Alternatives are higher than with Alternative A (No Action Alternative). This conclusion is based on the assumption that operations are constrained appreciably with Alternative A.

**TABLE I-59
SUMMARY OF HAP EMISSIONS – ORIGINAL SCHEDULE**

Phase	Alternative	Total HAP Emissions (tons)	Percent Increase/Decrease	
			From Existing	From Alternative A (No Action Alternative)
Existing (2002)	--	342.830		
Construction Phase I (2007)	Alternative A (No Action)	227.976	-34%	
	Alternatives C, D, and G	256.650	-25%	+13
Construction Phase II (2009)	Alternative A (No Action)	209.882	-39%	
	Alternatives C, D, and G	235.432	-31%	+12%
Build Out (2013)	Alternative A (No Action)	173.021	-50%	
	Alternative C	214.625	-37%	+24%
	Alternative D	218.082	-36%	+26%
	Alternative G	213.547	-38%	+23%
Build Out + 5 (2018)	Alternative A (No Action)	170.507	-50%	
	Alternative C	209.790	-39%	+23%
	Alternative D	215.742	-37%	+27%
	Alternative G	209.368	-39%	+23%

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

**TABLE I-60
SUMMARY OF HAP EMISSIONS – COMPRESSED SCHEDULE**

Phase	Alternative	Total HAP Emissions (tons)	Percent Increase/Decrease	
			From Existing	From Alternative A (No Action Alternative)
Existing (2002)	--	342.830		
Construction Phase I (2007)	Alternative A (No Action)	227.976	-34%	
	Alternatives C, D, and G	263.883	-23%	+16%
Construction Phase II (2009)	Alternative A (No Action)	209.882	-39%	
	Alternatives C, D, and G	235.432	-31%	+12%
Build Out (2013)	Alternative A (No Action)	173.021	-50%	
	Alternative C	214.625	-37%	+24%
	Alternative D	218.082	-36%	+26%
	Alternative G	213.547	-38%	+23%
Build Out + 5 (2018)	Alternative A (No Action)	170.507	-50%	
	Alternative C	209.790	-39%	+23%
	Alternative D	215.742	-37%	+27%
	Alternative G	209.368	-39%	+23%

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

**TABLE I-61
SUMMARY OF HAP EMISSIONS – DELAYED SCHEDULE**

Phase	Alternative	Total HAP Emissions (tons)	Percent Increase/Decrease	
			From Existing	From Alternative A (No Action Alternative)
Existing (2002)	--	342.830	--	--
Construction Phase I (2008)	Alternative A (No Action)	226.197	-34%	
	Alternatives C, D, and G	253.803	-26%	+12%
Construction Phase II (2010)	Alternative A (No Action)	207.243	-40%	
	Alternatives C, D, and G	237.421	-31%	+15%
Build Out (2014)	Alternative A (No Action)	183.971	-46%	
	Alternative C	216.437	-37%	+18%
	Alternative D	219.694	-36%	+19%
	Alternative G	214.816	-37%	+17%
Build Out + 5 (2019)	Alternative A (No Action)	172.583	-50%	
	Alternative C	214.571	-37%	+24%
	Alternative D	220.762	-36%	+28%
	Alternative G	214.143	-38%	+24%

Notes: -- = Not applicable
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

- In Construction Phase I and Construction Phase II, there would be no difference in emission totals related to the individual Build Alternatives (Alternatives C, D, and G). In Build Out and Build Out + 5, differences in emission totals with the Build Alternatives would be one to two percent, when comparing the alternative expected to result in the highest emissions (Alternative D) to the alternative predicted to result in the lowest emissions (Alternative C).
- The HAPs of most interest would be toluene, benzene, diesel particulate matter, formaldehyde, and 1,3-butadiene. Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment and construction equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.
- When considering both individual HAP emissions and toxicity factors, increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest. The source contributing the most to the increase in 1,3-butadiene, formaldehyde, and acrolein would be aircraft while the source contributing the most to the increase in diesel particulate matter would be construction equipment.

I.8.6.1 HAP Emission Comparison by Analysis Year

As shown in **Tables I-59, I-60, and I-61**, total HAP emissions would reduce to levels below the existing condition by Build Out + 5 with Alternatives A, C, D, and G. The reduction would primarily result from reductions in HAP emissions from on-road vehicles due to Federally-mandated emission reduction requirements related to volatile organic compounds.

Notably, when compared to the No Action Alternative (Alternative A), there would be an increase in emissions with Alternatives C, D, and G. The increase would range from approximately nine percent during Construction Phase I, to approximately 25 percent by Build Out + 5. However, while the Build Alternatives would increase HAP emissions when compared to Alternative A (No Action Alternative), in all instances, the levels with the improvements would be less than existing levels. When considering differences in the level of emissions between Alternatives C, D, and G, the evaluation indicates that there would be an approximate three percent difference in total HAP emissions.

Primary HAP Emission Sources and Pollutants

During Construction Phase I, on-road vehicles emit approximately 40 percent of the total HAP emissions, while aircraft, ground support vehicles, and auxiliary power units emit approximately 24 and 33 percent, respectively. By Build Out + 5, the contribution from motor vehicles decreases to approximately 21 percent (regardless of alternative), while the contribution of aircraft, ground support equipment/auxiliary power units increases to approximately 33 and 46 percent, respectively.

The HAPs with the highest emission levels (in order) would be toluene, formaldehyde, benzene, diesel particulate matter, and 1,3-butadiene. Toluene and benzene are primarily emitted from on-road vehicles and gasoline-fueled ground support equipment. Diesel particulate matter is primarily emitted from on-road vehicles and diesel-fueled ground support equipment, while formaldehyde and 1,3-butadiene are primarily emitted by aircraft.

When considering both individual HAP emissions and toxicity factors, the increases in 1,3-butadiene, diesel particulate matter, formaldehyde, and acrolein are of most interest. The source contributing the most to the increase in these pollutants, except diesel particulate matter (see above), would be aircraft (more than 80 percent of the increase, respectively).

I.8.6.2 Effect of the Build Alternatives on Pollutant Sources

Aircraft

The increase in HAP emissions from aircraft with the proposed development alternatives would be directly attributable to the increase in forecast aircraft activity and the increased ground movement time with the improvements. Because aircraft-related HAPs emissions occur primarily as products of incomplete combustion, those alternatives with higher ground movement times result in the higher aircraft-related emissions. Although there was limited available data for the quantification of aircraft-related HAPs, the lack of data would not affect the relative difference between aircraft-related HAP emissions without the improvements and

the level of emissions with the improvements. Additionally, although aircraft-related HAP emission rates would decrease in future years due to improvements in engine technology, the lack of suitable data to support an assumed level of reduction in the analysis would also not affect the relative difference between aircraft-related emissions with and without the proposed improvements. These facts do, however, support the fact that the magnitude of the aircraft-related emissions presented in this evaluation should be considered conservatively high.

Ground Support Equipment

Ground support equipment emissions are directly related to increased annual aircraft operations (the more aircraft using the Airport the more ground support equipment would be needed to support the aircraft). As with aircraft, it should be noted that the analysis (all analysis alternatives and years) did not assume any reduction in future emissions resulting from conversion of the ground support equipment to cleaner fuel vehicles, such as the potential City of Chicago's participation in the FAA's Voluntary Airport Low Emissions (VALE) program. Conversion of vehicles to cleaner fuels would reduce future ground support vehicle-related emissions. Again, while participation in these programs would not affect the relative difference in emissions from this source, the emissions used in this evaluation for the future years should also be considered conservatively high.

On-Road Vehicles

The number of increased passengers with the proposed development alternatives would increase the vehicle-miles-traveled within the evaluation area approximately 2 percent per year. Total emissions resulting from on-road vehicles would be a result of a combination of this increase in vehicle-miles-traveled and the reduction in motor vehicle-related emissions mandated for these vehicles by the USEPA.

Stationary Sources

Increases in stationary source emissions would be directly attributable to the increase in emissions from heating and cooling plants resulting from the additional building square footage that would be constructed with the proposed development alternatives.

I.9 CONSTRUCTION EMISSIONS

I.9.1 Introduction

Airport-related forecasts of aircraft and motor vehicle operations with the proposed airport development alternatives were made for Construction Phase I, Construction Phase II, Build Out, and Build Out + 5 years. In the HAPs evaluation, these phases are assumed to occur in the years 2007, 2009, 2013, and 2018. While the HAP evaluation of alternatives (presented in **Section I.8, Existing Condition and Alternatives Analysis**), does include construction emissions for future years of analysis, it does not provide estimates of the potential increase in HAP emissions for the construction activities that would occur between these years of analysis.

This section of the document discusses the entire construction period beginning in the year 2004 and continuing through the year 2013. Notably, although construction emissions would be slightly less with Alternative D (one less runway is proposed), for the purposes of the HAP evaluation, it was assumed that construction-related HAP emissions would be the same for Alternatives C, D, and G.

The construction equipment specification data⁸⁴ that was used in the evaluation was provided by the City of Chicago's consulting team (CCT) after review and acceptance by the FAA's Third Party Consultant (TPC). The construction data was segregated in to two categories: equipment requirements to implement the proposed development alternatives and equipment requirements to implement certain terminal elements (specifically terminal improvements included in the World Gateway Project that are included in the proposed Airport development). Two additional categories of equipment requirements were also evaluated -- requirements to implement previously approved airport development projects. Specific information regarding the scope and timing of each of these construction categories is provided in **Section J.2, Technical Memorandum, in Appendix J, Air Quality.**

I.9.2 Construction-Related Emissions

The construction-related HAP emissions were also evaluated considering both the estimated emission levels and the toxicity values of the individual HAPs.

These levels are provided in **Table I-62**. As shown, the construction-related HAPs emission rates would be the highest in the years 2005 and 2006 under the Original and Compressed Schedules and in the years 2006 and 2007 under the Delayed Schedule. Although construction emissions are expected to occur over a ten year period, the emissions related to this activity should be considered temporary in the context of potential health effects. A majority (over 99 percent) of the HAP emissions from construction activities are diesel particulate matter.

⁸⁴ Construction Logistics Equipment Plan based on the Airport Layout Plan, AOR/TOK, March 24, 2004.

TABLE I-62
HAP EMISSIONS – CONSTRUCTION ACTIVITY

Year	Tons(a)		
	Original Schedule	Compressed Schedule	Delayed Schedule
2004	16.04	--	--
2005	24.73	11.90	7.24
2006	18.63	30.41	24.38
2007	16.84	24.07	16.79
2008	7.05	7.05	13.67
2009	5.04	5.04	8.44
2010	10.07	10.07	3.97
2011	9.29	9.29	7.70
2012	5.65	5.65	9.47
2013	0.87	0.87	6.49
2014	0.01	0.01	1.68
2015	--	--	0.05
Total	114.22	104.36	99.88

Notes: -- = Not applicable.

(a) Representative of the 9.4 MCY Construction Scenario.

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

I.9.2.1 Potential Emission Reduction Measures

The City of Chicago and the City of Chicago's Department of Aviation have numerous best management practices⁸⁵ and other measures aimed at the reduction of pollutant emissions and pollutant precursors related to aircraft operations and construction activities at O'Hare (See **Section 5.6.5, Potential Emission Reduction Measures** for further details).

The emission inventories presented/discussed above, conservatively assume that 9.4 MCY of material would be removed from O'Hare property to construct the proposed improvements. Two potential additional scenarios, a 0.0 MCY scenario and a 5.4 MCY scenario are also being considered by the City. Each of these scenarios would reduce the level of construction-related HAP emissions (the majority of the reduction being diesel particulate matter) associated with the proposed improvements. The reduction in HAP emissions would be primarily due to a lesser need for haul trucks to remove the material from the Airport. The estimated range of construction-related emissions (from the 9.4 MCY to the 0.0 MCY scenario) is presented in **Table I-63**. Notably, the values are representative of those estimated to occur over the entire construction period for the proposed improvements. As shown, the level of HAP emissions could potentially be reduced from 11 to 32 percent of those presented in this EIS through the implementation of the 5.4 or 0.0 MCY scenarios, respectively.

⁸⁵ Best Management Practices Manual for Chicago O'Hare International Airport. Department of Aviation. Revised March 2003. (http://216.146.77.178/objGW/OMImages/9/000000GH/DOA_BM~1.PDF) Best Management Practices relate to the prevention and control of pollutants.

**TABLE I-63
TOTAL CONSTRUCTION-RELATED HAP EMISSIONS**

Scenario	Tons of HAP Pollutants
9.4 MCY	100
5.4 MCY	89
Percent Decrease (a)	11%
0.0 MCY	68
Percent Decrease (a)	32%

Note: (a) When compared to the 9.4 MCY Construction Scenario with the Delayed Construction Schedule.
Source: Environmental Science Associates, Inc. [TPC] analysis, 2005.

Based on existing programs, Best Management Practices⁸⁶ and implementation of the Sustainable Design Manual, several additional potential emission reduction measures were identified in the Draft EIS that would reduce pollutant emissions associated with both the operation and construction of the Airport. Certain measures (See **Section 5.6.5, Potential Emission Reduction Measures** for further details) would be implemented or would be considered for potential implementation by the City of Chicago for incorporation into the proposed improvements at O'Hare depending on potential benefit, cost, practicability and feasibility of use, impact to participation by Disadvantaged Business Enterprises (including Minority Business Enterprises and Women-Owned Business Enterprises), and potential impact to the construction schedule.

Notably, there are two measures that could substantially reduce construction-related air pollutant and pollutant precursor emissions:

- With certain limitations, requiring construction-related contractors to use ultra low sulfur diesel fuel in on- and off-road engines/vehicles, and
- With certain limitations, requiring construction-related contractors, in conjunction with the use of ultra low sulfur diesel fuel, to install and/or retrofit older off-road engines/vehicles with emission control devices prior to the equipment being used on the project site.

The limitations associated with the two measures above are related to the length of time certain contractors would use their equipment on the project (for which applying these requirements would be an undue burden). Taking these limitations into consideration, the potential for the two measures to reduce construction-related emissions was evaluated.

As shown in **Table I-64**, requirements to use ultra low sulfur diesel fuel would reduce emissions of HAPs (again, mostly in the form of diesel particulate matter) by approximately 4 percent, respectively. As also shown, the requirements to use ultra low sulfur diesel fuel and emission control device requirements are estimated to result in a minimum reduction in HAP emissions of 11 percent with a potential reduction as much as 24 percent. Notably, the

⁸⁶ Best Management Practices Manual for Chicago O'Hare International Airport. Department of Aviation. Revised March 2003. See **Attachment Q-1** in **Appendix Q, Construction**.

estimated ranges of emission reduction are appropriate because it is not known what types of devices an individual contractor would select and the level of emission reduction from individual devices varies.

**TABLE I-64
ESTIMATED REDUCTION IN EMISSIONS**

<u>Emission Reduction Measure</u>	<u>Estimated Reduction Range</u>	<u>Percent Reduction in Total Construction-Related Emissions</u>
Ultra low sulfur diesel fuel	NA	4%
Ultra low sulfur diesel fuel and emission control devices	Minimum	11%
	Average	17%
	Maximum	24%

Source: Environmental Science Associates, Inc. [TPC] analysis, 2005.

I.10 COMPARATIVE EVALUATION

One purpose of providing a comparative evaluation is to determine how the HAP concentrations in the vicinity of O'Hare and emission estimates for O'Hare compare to concentrations and emission estimates for other sources within Cook and DuPage counties. The results of these comparisons indicate whether HAP levels in the vicinity of the Airport are unique and/or notable within the two county area, or whether the concentrations of HAPs in the vicinity of O'Hare and the emission estimates for O'Hare are what could be considered "typical urban air."

Another purpose of the comparative evaluation is to determine how concentrations of HAPs in the vicinity of O'Hare and O'Hare-related HAP emission totals compare to concentrations and emission estimates for other airports with the same general level and type of aviation activity and other sources. The results of these comparisons indicate whether concentrations of HAPs in the vicinity of O'Hare and emission estimates for O'Hare are what could be considered "typical airport air" and whether O'Hare can be considered a "typical source".

I.10.1 Typical Urban Air Evaluation

The following provides a comparison of levels of HAPs measured in the vicinity of O'Hare to levels measured elsewhere within the region. A comparison of emission estimates for O'Hare and regional emission estimates is also provided.

I.10.1.1 Ambient Measurements

USEPA AirData was reviewed to determine if ambient (outdoor) HAP levels in the vicinity of O'Hare are different than HAP levels in other non-airport suburban and urban regions of Cook and DuPage counties. This goal is the same as one of the goals of the short-term monitoring program conducted by the IEPA in the year 2000 (see **Section I.6.1.3, IEPA Air Toxics Monitoring Program**).

To perform the evaluation, data from three ambient monitoring sites was extracted from the USEPA's AirData. The address of the sites, the distance and direction from O'Hare, and a description of the land uses surrounding each site are provided in **Table I-65**. The location of the three sites relative to O'Hare is illustrated on **Exhibit I-6**.

**TABLE I-65
AMBIENT AIR MONITORING SITES: O'HARE, NORTHBROOK, DOWNTOWN
CHICAGO**

Site Location	City	Distance/Direction from Airport	Area Land Uses
4743 N. Mannheim	Schiller Park	Adjacent to Airport/SE	Airport, Residential, Commercial
750 Dundee Road	Northbrook	20 miles/NNE	Suburban, Commercial
1000 E. Ohio Street	Chicago	20 miles/ESE	Central Business District

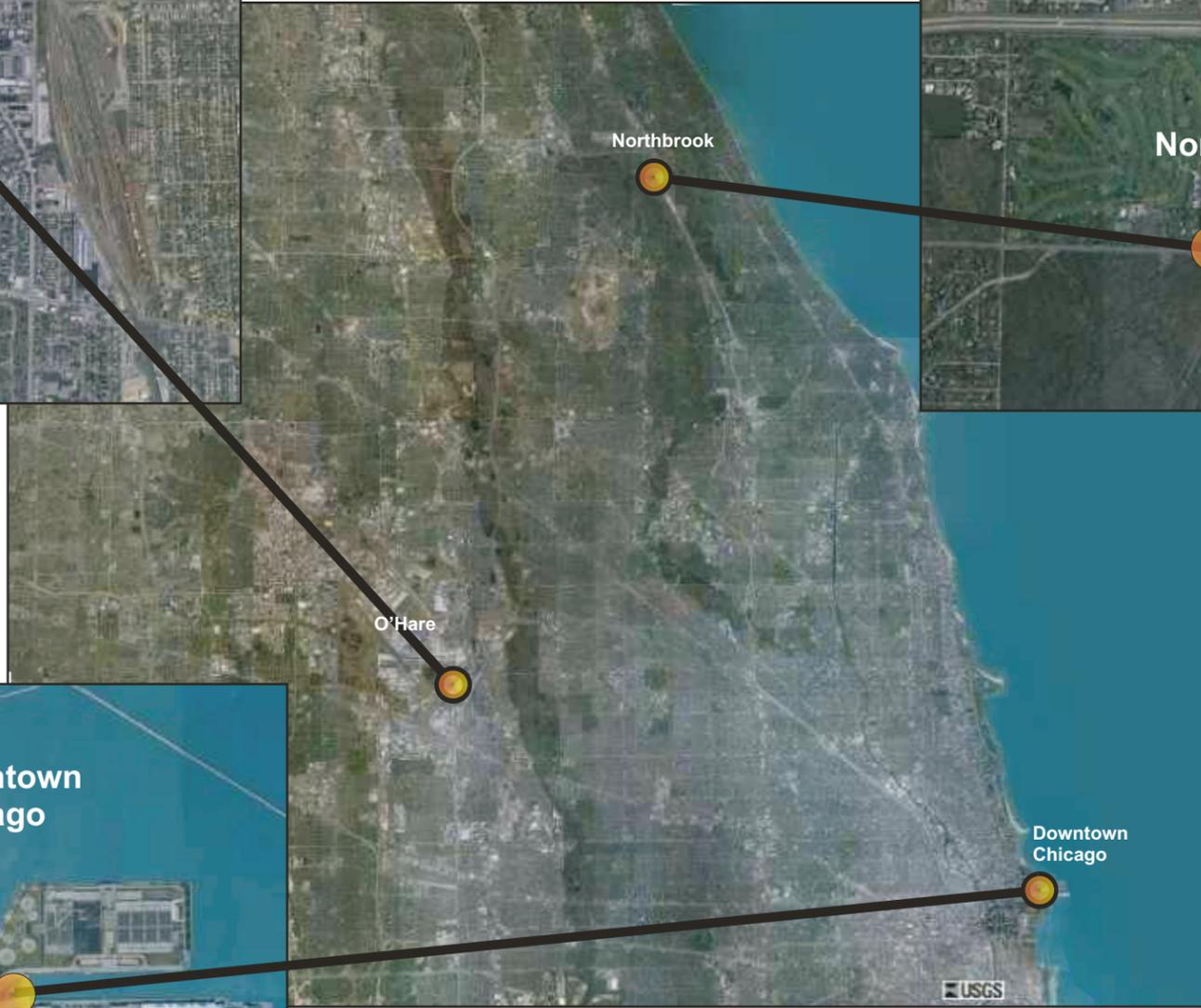
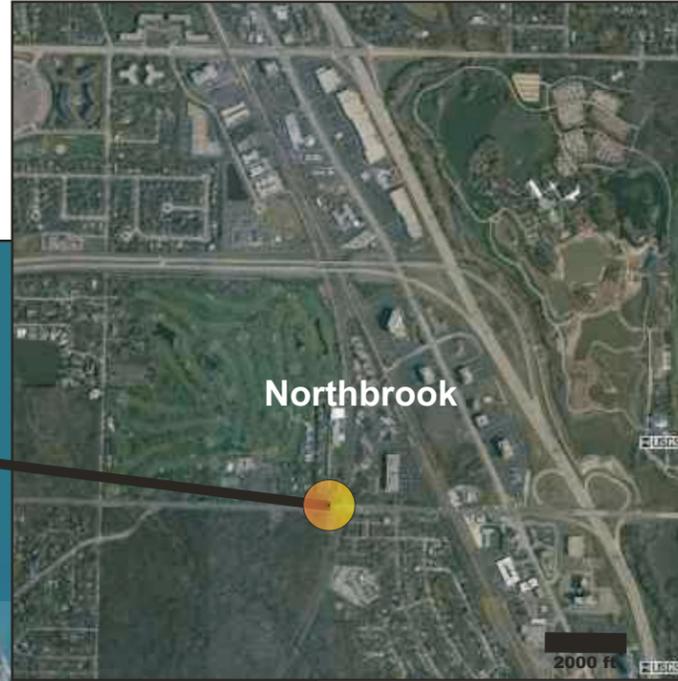
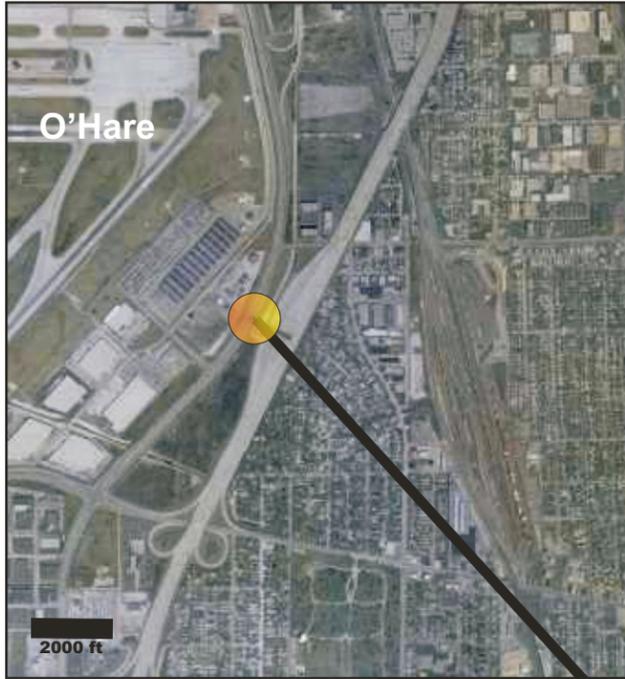
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004.

As shown on **Exhibit I-5**, the Schiller Park monitor is located between O'Hare's property line and an Interstate 294 toll facility. Sources that could affect measured levels at this station include the Airport-related sources, vehicles at the toll facility, and area sources such as dry cleaning facilities. The Northbrook monitor is located approximately 1 mile east of Interstate 94 and immediately west of a railroad track. Generally, this area is considered suburban residential with mixed commercial uses. Sources that could affect measured levels at this station include motor vehicles on roadways within the area (including Interstate 94), trains, and area sources. Finally, the monitor located in downtown Chicago is located due east of Chicago's Central Business District. Sources that could affect measured levels at this station include motor vehicles, and area sources.

Table I-66 provides the average annual mean concentrations of acetaldehyde, benzene, formaldehyde, and toluene for the years 2000, 2002, and 2003. Data is also available for acetaldehyde for the year 2004. As shown, the average measured levels of acetaldehyde and formaldehyde were higher in the vicinity of O'Hare than in Northbrook. Conversely, levels of these HAPs were lower in the vicinity of O'Hare than in downtown Chicago. As also shown, the average measured levels of benzene and toluene were higher in the vicinity of O'Hare than at either the Northbrook or downtown Chicago locations.

Notably, the proximity of a pollutant monitor to a specific source(s) has a direct effect on the level of measured pollutants. For example, one would expect pollutants emitted by motor vehicles to be higher at the Schiller Park (Airport) location than at the other two locations because the monitor is located in close proximity to a heavily traveled Interstate and toll facility (at which extensive motor vehicle queues can occur during peak travel times).

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Chicago

O'Hare

International

Airport

O'Hare Modernization Environmental Impact Statement

HAP Monitoring Sites:
O'Hare, Northbrook,
Downtown Chicago

► Exhibit I-5

**TABLE I-66
MEASURED HAP LEVELS – O'HARE, NORTHBROOK, DOWNTOWN CHICAGO**

Pollutant	Year	Mean Concentration (ppb)- Schiller Park (Airport)	Northbrook		Downtown Chicago	
			Mean Concentration (ppb)	% Higher or Lower than Schiller Park	Mean Concentration (ppb)	% Higher or Lower than Schiller Park
Acetaldehyde	2000	1.78	1.23	-31%	2.80	+ 57%
	2002	1.65	1.20	-27%	1.33	-19%
	2003	1.13	0.96	-15%	1.64	+45%
	2004	1.03	0.73	-29%	1.37	+33%
	Average	1.40	1.03	-26%	1.79	+29%
Benzene	2000	3.06	1.88	-38%	2.48	-19%
	2002	2.37	1.49	-37%	2.94	+24%
	2003	2.87	1.12	-61%	0.65	-77%
	Average	2.76	1.50	-46%	2.02	-24%
Formaldehyde	2000	3.54	1.82	-49%	4.95	+40%
	2002	2.15	1.40	-35%	2.83	+32%
	2003	1.89	1.36	-28%	2.93	+ 55%
	Average	2.53	1.53	-37%	3.57	+42%
Toluene	2000	7.13	4.58	-36%	3.44	-52%
	2002	6.25	3.10	-50%	4.27	-32%
	2003	5.39	6.23	+16%	2.50	-54%
	Average	6.25	4.64	-23%	3.40	-46%

Note: ppb = parts per billion
Source: EPA AirData

I.10.1.2 Emission Estimates

In support of the HAP evaluation, estimated O'Hare-related emission estimates were prepared for O'Hare for the year 2002. To provide an indication of the magnitude of O'Hare's emissions relative to regional totals of HAPs, the O'Hare estimates were compared to emission totals prepared by the Great Lakes Commission for the year 2001 (presented previously in **Section I.5.2, Emission Inventories**). It is recognized that the years of evaluation are not the same (2001 and 2002). However, because the level of aircraft operations at O'Hare was similar from 2001 to 2002, the O'Hare estimates for the year 2002 can be considered representative of year 2001 emissions. **Table I-67** presents the comparative data.

**TABLE I-67
COMPARATIVE EMISSIONS: O'HARE, REGIONAL**

Pollutant	Tons		Percent of O'Hare to Regional Total
	Regional Totals 2001	O'Hare 2002	
1,3-Butadiene	612.10	19.590	3
Acetaldehyde	1384.91	12.500	<1
Acrolein	168.42	2.120	1
Arsenic	0.71	0.013	2
Benzene	3946.73	66.330	2
Chromium	1.52	0.004	<1
Formaldehyde	2553.93	62.300	2
Naphthalene	302.42	3.190	1
Nickel	6.48	0.012	<1
Toluene	24051.98	136.920	1

Compiled by: Environmental Science Associates, Inc. [TPC], 2004.

The data indicate that, on a regional basis, the sources within the O'Hare study area emit approximately 3 percent of the regional emissions of 1,3-butadiene, approximately 2 percent of the regional emissions of arsenic, benzene, and formaldehyde, and from 1 to less than 1 percent of the remaining HAPs for which the Great Lakes Commission provides emission estimates. Notably, because the sources included in the O'Hare evaluation include both motor vehicle traffic related to the Airport and background traffic, these estimates can be considered conservative.

The Great Lakes Commission data does not include estimates of diesel particulate matter. To provide an indication of the magnitude of O'Hare-related emissions to this pollutant, the O'Hare-specific estimates for 2002 were compared to the USEPA estimates for Cook and DuPage counties for the year 1996. This comparison should also result in a conservatively high estimate of the magnitude of O'Hare's emissions to regional totals because it is expected that regional totals of this pollutant would have increased from the year 1996 through the year 2002. The comparative data is provided in **Table I-68**. As shown, sources included in the O'Hare evaluation emit approximately 1 percent of the regional totals of this pollutant.

**TABLE I-68
COMPARATIVE EMISSIONS: O'HARE, REGIONAL - DIESEL PARTICULATE
MATTER**

Pollutant	USEPA (1996)	O'Hare (2002)	Percent of O'Hare to Regional Total
Diesel Particulate	6390	40.01	1

Compiled by: Environmental Science Associates, Inc. [TPC], 2004.

I.10.2 Typical Airport Air Evaluation

The following provides a comparison of levels of HAPs measured in the vicinity of O'Hare to levels measured at other airports within the US. A comparison of emission estimates for O'Hare and regional emission estimates is also provided.

I.10.2.1 Ambient Measurements

The USEPA's AirData was also used to evaluate whether measured HAP levels in the vicinity of O'Hare are comparable to levels measured at, or in the vicinity of, other airports with similar levels and types of aviation activity.

O'Hare and Hartsfield-Jackson Atlanta International Airport are consistently the two airports with the greatest level of commercial aircraft activity in the US. The three airports with the next greatest levels of activity are Dallas-Fort Worth International, Los Angeles International (LAX), and Denver International. Based on a review of available AirData, the closest HAP monitors to Hartsfield-Jackson Atlanta International and Dallas-Fort Worth International are 16 miles from the airports. And, the closest HAP monitor is located 21 miles from Denver International. The only airport, of those with similar levels and types of aviation activity with a HAP monitor located within a reasonable distance is LAX. This HAP monitor is located approximately 3 miles south of the airport.

Additional airport/monitor locations were reviewed to determine if any other comparisons could be made and it was determined that the HAP monitor located at Minneapolis-St. Paul International (MSP) would be suitable for the purpose of the comparison. Until 2004, this monitor was located on airport property directly adjacent to the runways at the airport. No other airports were identified that had a HAP monitor(s) in close proximity.

Table I-69 provides year 2002-2003 average mean measured HAP levels from the monitors in the vicinity of O'Hare, LAX, and MSP. As shown, the average measured levels of benzene and toluene were lower in the vicinity of O'Hare than measured levels in the vicinity of LAX and the majority of the pollutants were higher at O'Hare than at MSP.

I.10.2.2 Emission Estimates

To compare emission estimates prepared for O'Hare to emission estimates for other airports, HAP emissions were compared using data from two recent airport development programs. The airports are LAX and Oakland International Airport (OAK). Based on the results of the evaluation, 11 of the 66 HAPs emitted from sources operating at and in the vicinity of O'Hare contributed approximately 99 percent to the total while accounting for emissions and toxicity levels of the evaluated scenarios. Thus, this comparison of LAX and OAK focused on the 11 HAPs which were analyzed for O'Hare.

**TABLE I-69
MEASURED HAP LEVELS: O'HARE, LAX, MSP**

Year	HAP	O'Hare Level	LAX		MSP	
			LAX Level	Percent Higher or Lower than O'Hare	MSP Level	Percent Higher or Lower than O'Hare
2002	1,3-Butadiene	0.80	-	-	0.22	-92
	Acetaldehyde	1.65	-	-	1.43	-10
	Benzene	2.37	3.5	+48	1.56	-37
	Formaldehyde	2.15	-	-	1.99	-5
	Toluene	6.25	11.5	+84	2.51	-60
	Number of Operations(a)	901,703	637,588	-29	506,808	-45
2003	1,3-Butadiene	0.41	-	-	0.22	-46
	Acetaldehyde	1.13	-	-	1.43	+27
	Benzene	2.87	2.82	-2	1.56	-46
	Formaldehyde	1.89	-	-	1.99	+5
	Toluene	5.39	9.53	+77	2.51	-53
	Number of Operations	923,578	630,755	-32	506,808	-45
Average	1,3-Butadiene	0.605	-	-	0.141	-77
	Acetaldehyde	2.78	-	-	1.46	-47
	Benzene	2.62	3.16	+21	1.53	-42
	Formaldehyde	2.02	-	-	2.02	0
	Toluene	5.82	10.52	+81	2.52	-57
	Number of Operations	912,641	623,172	-32	502,371	-45

Note: (a) Obtained from FAA's Terminal Area Forecast.

- = Not available or not applicable.

Source: USEPA AirData

Los Angeles International Airport

The analysis of HAP emissions for LAX was selected for comparison to O'Hare, because the airport, along with O'Hare, is one of the top four airports in the US with respect to the number of annual aircraft operations and an evaluation of HAPs was recently performed for the airport. The LAX HAP emission estimates were obtained from an EIS prepared for LAX for the year 2015 (Alternative B). The emission estimates for LAX were then compared to the Build Out (2013) and Build Out + 5 (2018) emission estimates for O'Hare. The comparative data for O'Hare and LAX is provided in **Tables I-70** and **I-71**.

**TABLE I-70
COMPARISON OF HAP EMISSIONS – NO ACTION: O'HARE, LAX**

Pollutants	Tons			Percent Difference	
	LAX (2015)	O'Hare		O'Hare	
		Build Out	Build Out + 5	Build Out	Build Out + 5
1,3-Butadiene	12.669	12.814	12.900	1%	2%
Acetaldehyde	18.130	6.277	6.327	-65%	-65%
Acrolein	7.875	1.273	1.283	-84%	-84%
Arsenic	0.012	0.026	0.036	119%	209%
Benzene	33.907	32.831	33.071	-3%	-2%
Chromium VI	0.001	0.008	0.012	1404%	2031%
Diesel Particulate Matter	NA	19.217	15.542	NA	NA
Formaldehyde	57.634	39.539	39.756	-31%	-31%
Naphthalene	13.532	2.021	2.048	-85%	-85%
Toluene	53.345	58.997	59.507	11%	12%
Nickel	2.565	0.018	0.025	-99%	-99%
Total	199.552	173.021	170.507	-13%	-14%

Note: NA=not available

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

**TABLE I-71
COMPARISON OF HAP EMISSIONS – PROPOSED PROJECT: O'HARE, LAX**

Pollutants	Tons			Percent Difference	
	LAX (2015)	O'Hare		O'Hare	
		Build Out	Build Out + 5	Build Out	Build Out + 5
1,3-Butadiene	18.237	16.697	17.523	-8%	-4%
Acetaldehyde	23.549	7.708	7.603	-73%	-72%
Acrolein	13.214	1.674	1.747	-87%	-87%
Arsenic	0.012	0.028	0.039	130%	228%
Benzene	27.282	40.297	39.299	48%	44%
Chromium VI	0.001	0.009	0.013	801%	1195%
Diesel Particulate Matter	6.196	20.851	17.312	237%	179%
Formaldehyde	93.080	52.188	55.231	-44%	-41%
Naphthalene	16.454	2.535	2.654	-85%	-84%
Toluene	44.833	71.971	68.338	61%	52%
Nickel	2.579	0.024	0.031	-99%	-99%
Total	251.437	213.981	209.790	-15%	-16%

Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The emissions estimates for 1,3-butadiene, acetaldehyde, acrolein, formaldehyde, naphthalene, and nickel for O'Hare alternatives in 2013 and 2018 would be less than those reported for LAX in 2015. The emissions estimates of arsenic, benzene, diesel particulate matter, toluene, and chromium VI for O'Hare alternatives in 2013 and 2018 would be greater than those reported for LAX in 2015. The significant difference in the O'Hare and LAX estimates for these pollutants may primarily be due to differences in the aircraft speciation profiles that are being/were used

for the O'Hare and LAX evaluations. For example, the speciation profile that was used for acrolein emissions from aircraft in the LAX evaluation is approximately eight times greater than the profile that was used for the O'Hare evaluation.

Oakland International Airport

A recent evaluation performed for OAK was selected for the comparison of HAP-related emissions because of the studies detailed evaluation. However, unlike O'Hare and LAX, emissions for each scenario were not reported in the OAK documentation. The only Build Alternative-related emissions that were reported are the incremental Build Alternative-related emission. Therefore, the OAK incremental emission estimates for 2010 were compared to the 2009 and 2013 incremental emission estimates for O'Hare. The incremental emissions equal the emissions increase when comparing a build alternative to a no-action alternative. The comparative incremental emission estimates are provided in **Table I-72**.

**TABLE I-72
COMPARISON OF INCREMENTAL HAP EMISSIONS: O'HARE, OAK**

Pollutants	Tons			Percent Difference	
	OAK (2010)	O'Hare		O'Hare	
		Construction Phase II	Build Out	Construction Phase II	Build Out
1,3-Butadiene	1.330	2.720	3.880	105%	192%
Acetaldehyde	1.400	0.632	1.430	-55%	2%
Acrolein	0.660	0.274	0.401	-58%	-39%
Arsenic	NA	0.001	0.002	NA	NA
Benzene	2.950	2.990	7.470	1%	153%
Chromium VI	0.001	<0.001	0.001	-92%	-53%
Diesel Particulate Matter	1.580	3.770	1.630	139%	3%
Formaldehyde	7.600	9.220	12.600	21%	66%
Naphthalene	0.326	0.325	0.514	0%	58%
Toluene	4.500	3.730	13.000	-17%	189%
Nickel	<0.001	0.003	0.006	2960%	6555%

Note: NA= not available
Source: Environmental Science Associates, Inc. [TPC] analysis, 2004

The incremental emissions estimates of 1,3-butadiene, benzene, formaldehyde, naphthalene, toluene, and nickel for O'Hare alternatives in Construction Phase I and Build Out would be greater than those reported for OAK in 2010. The emissions estimates of acrolein and chromium IV for O'Hare alternatives in Construction Phase I and Build Out would be less than those reported for OAK in 2010. A portion of the difference in emissions-toxicity values for the two airports is attributable to the greater size and operational scope proposed for O'Hare. However, differences are also due to differences in the HAP speciation profiles used in the evaluations. For example, the speciation profile that was used for acrolein emissions from aircraft in the OAK evaluation is approximately three times greater than the profile that was used for the O'Hare evaluation.

Factors to Consider

In reviewing the comparison of emission estimates associated with the development programs at O'Hare, LAX⁸⁷ and OAK,⁸⁸ it is important to note that several factors could affect calculated emission levels for the airports. The factors affect emissions of HAPs, which are a subset of volatile organic compounds.⁸⁹ The following provides a discussion of reasons why the emission estimates for O'Hare, LAX, and OAK are different.

Aircraft Operations - The difference in aircraft operations among the airports affects the emission estimates. Since emissions of volatile organic compounds increase with aircraft activity, HAP emissions will also increase. Total operations at LAX for the 2015 no action and project alternative are 782,970 and 933,922, respectively (a 19 percent increase with the project alternative). Total operations at OAK for the 2010 no action and project alternative are 420,480 and 527,790, respectively (a 26 percent increase in operations with the project alternative). The forecast number of aircraft operations for O'Hare with Alternative A (No Action) in the year 2009 and the number of operations with Alternative C are 974,000 and 1,057,200, respectively (a 9 percent increase). The forecast number of operations for O'Hare with Alternative A (No Action) in the year 2010 and the number of operations with Alternative C are 974,000 and 1,194,000, respectively (a 23 percent increase). Because O'Hare has/will have a larger number of operations than either LAX or OAK, the Airport-related HAP emissions resulting from activities at O'Hare would likely result in greater HAP emissions than either LAX or OAK.

Aviation Activity Types - Air carrier airports differ considerably in terms of the mix of aircraft activity types. This variance will have an effect on emission estimates of HAPs. At some airports, the large majority of the operations are performed by jet aircraft. At others, turboprop aircraft (commuter aircraft) and general aviation aircraft dominate the fleet. The aircraft in each of these aircraft groups have different HAP emission characteristics. O'Hare and LAX have a similar mix of aircraft activity, with about 98 and 94 percent of the total operations being passenger aircraft, respectively. By comparison, only 83 percent of the total operations at OAK are in this category with the remaining operations resulting from cargo activity. A review of the existing (2002) fleet mix for O'Hare indicates that cargo aircraft emit a greater amount of HAP emissions per operation than the air carrier passenger aircraft.

Fleet Mix - Differences in aircraft fleet mixes can also affect the level of HAPs associated with an airport. For example, approximately 50 percent of the aircraft operations at OAK are performed by commuter type aircraft while the majority of the operations at O'Hare and LAX are transcontinental and intercontinental routes. Therefore, the aircraft fleet mixes at these airports will tend to have a higher proportion of larger aircraft in the fleet. Again, a review of

⁸⁷ LAWA, 2004, LAX Master Plan Final EIS/EIR, Human Health Risk Assessment, Technical Report 14a., prepared for the Los Angeles World Airports Authority.

⁸⁸ CDM, 2003. Ambient Air Quality Human Health Risk Assessment for the Oakland International Airport Draft Report, prepared for the Port of Oakland Environmental Planning Department.

⁸⁹ The relationship between volatile organic compounds and HAPs emissions is itself subject to variation, depending on the particular speciation profile used.

the existing (2002) fleet for O'Hare indicates that commuter aircraft produce the least level HAP emissions per operation.

Airport Layout – The configuration of airport facilities, both airside and landside, can also affect the level of HAP emissions. As previously noted, HAP emissions are greatest when aircraft are operating on the ground in taxi/idle mode. If the design of an airport's taxiway system requires longer taxi times for departing aircraft to reach a runway or for arriving aircraft to reach passenger terminals or cargo ramps, HAP emissions increase. Similarly, delays due to congestion caused by inadequate airfield capacity may increase idle times, again resulting in increases in HAP emissions. Exact taxi time estimates were not available for LAX and OAK, however, general information suggests that the taxi times used in the LAX evaluation are similar to those used in the evaluation of O'Hare and taxi times at OAK are approximately 75 percent of those for LAX and O'Hare.

Ground Support Equipment – The number, types, and duration of use of ground support equipment also affects the level of HAP emissions. Ground support equipment is a function of both the number of aircraft operations and types of aircraft. Cargo aircraft tend to operate more ground support equipment over longer durations than would occur for general aviation aircraft. Both the LAX and OAK evaluations assumed a greater number of alternatively fueled ground support equipment than was assumed in the evaluation for O'Hare.

On-Road Vehicle Traffic - Air carrier airports exhibit major differences in terms of the on-road vehicle activity associated with their airport operations. On-road vehicle activity may vary considerably not only in terms of traffic volume and trip length but also the types of on-road vehicles. At airports where air cargo operations constitute a significant percentage of total aviation activity, trips by trucks serving the cargo carriers may represent a significant percentage of total on-road vehicle trips. Many such truck trips will involve vehicles with diesel engines, and particulate matter emissions will be a large component of the pollutant mix for these engines.

Although the O'Hare, LAX, and OAK airport evaluations used different emission factor estimation models, a review of the volatile organic compound emission factors used for each indicates that the factors are similar. Secondly, although the vehicle fleet mix is not known for LAX and OAK, it is expected that vehicle fleet mixes would be similar to O'Hare. Based on available data, the study area roadway network within the O'Hare analysis would appear to be larger than the network within the OAK and LAX (i.e., a larger number of vehicle miles traveled within the study area). Therefore, it is reasonable to expect HAP emissions from LAX and OAK to be lower than those for O'Hare.

Additional Factors

There are several other factors that will affect the level of HAP emissions reported for a particular airport. These factors include the assumed atmospheric mixing height. Logically, a lower mixing height would result in lower aircraft emissions. Both the LAX and OAK evaluations used a lower mixing height than was used for O'Hare.

One final factor that can affect the level of reported HAP emissions is the model used to estimate emission levels. For the O'Hare evaluation, the FAA's Emissions and Dispersion Modeling System (EDMS) Version 4.12 was used. The LAX and OAK evaluations were performed with EDMS Version 4.1. Differences in the model versions may also result in differences in emission estimations (due to updates in aircraft emission rates, times in operational mode, etc.)

I.10.3 Typical Source Evaluation

The USEPA maintains a National Emissions Inventory database⁹⁰ of air emission data with input from numerous State and local air agencies and industry for all permitted sources. Facility-level emissions are provided for each major point source that emits or has the potential to emit at least 10 tons per year of a single HAP, or at least 25 tons per year of a combination of HAPs. Data from this source was used to compare levels of individual HAPs for O'Hare to levels from individual sources with Cook and DuPage counties. **Table I-73** provides a summary of the available data for the facilities considered to be the highest emitters in the DuPage and Cook county region in 1999 (the most recent data available). Notably, the National Emissions Inventory does not include data for diesel particulate matter.

**TABLE I-73
COMPARATIVE EMISSIONS: O'HARE, INDIVIDUAL SOURCES**

Pollutant	O'Hare (Tons - 2002)	Tons (1999)					Percent O'Hare Higher/ Lower
		Chemical Petroleum Exchange, Inc.	Midwest Generation	Midland Industries	Northeastern Illinois University	Reliable Asphalt	
1,3-Butadiene	19.56	28.4	-	-	-	-	-31%
Arsenic	0.0130	-	0.063	-	-	-	-79%
Chromium VI	0.0043	-	-	2.4735	-	-	-99%
Formaldehyde	62.2	-	-	-	67.77	-	-8%
Naphthalene	3.19	-	-	--	-	45.8	-93%
Nickel	0.0121	-	-	-	-	7.9	-99%

Note: (a) A negative number indicates that emissions at O'Hare were lower than the indicated source.
 "--" = not available or not applicable

Source: USEPA National Emissions Inventory Database. Facility HAP Emissions for Cook and DuPage County CY1999
 (<http://www.epa.gov/air/data/geosel.html>)

When comparing the existing (2002) estimated levels of HAPs for O'Hare to the sources in the two county region, the results of the evaluation indicate that there are sources within Cook and DuPage counties that emit more tons per year of the following: 1,3 butadiene, arsenic, chromium VI, formaldehyde, naphthalene, and nickel. No individual sources were identified

⁹⁰ Source: USEPA National Emissions Inventory Database. Facility HAP Emissions for airports in the US.
 Information provided to ESA by USEPA - April 2004.

that emit higher levels of acetaldehyde, acrolein, benzene, or toluene. However, as presented previously, the Great Lakes Commission emission inventories indicate that stationary sources, area sources, on-road and off-road vehicles all contribute to regional totals of the HAPs emissions evaluated in this report.. Therefore, it is reasonable to assume that the types of HAP emissions associated with O'Hare are not unique within the air shed and the sources operating at or in the vicinity of O'Hare can be considered "typical sources".

**ATTACHMENT I-1
DETAILED SUMMARY OF HAPS
AND HEALTH EFFECTS**

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HAPs are gaseous organic and inorganic chemicals and particulate matter that are either known or suspected to cause cancer (to be carcinogenic) or known or suspected to cause other health effects (non-carcinogenic). The USEPA has identified 188 air pollutants as HAPs. Based on a review of available data, the O'Hare evaluation concluded that 65 of the 188 HAPs have the potential to be emitted by sources at or using O'Hare. One additional HAP, diesel particulate matter, was also identified as being emitted by O'Hare-related sources.

Based on the results of the evaluation, 11 of the 66 HAPs were identified as the HAPs of most interest. These HAPs are 1,3-butadiene, acetaldehyde, acrolein, arsenic, benzene, chromium VI, diesel particulate matter, formaldehyde, naphthalene, nickel, and toluene.

1,3-Butadiene⁹¹

1,3-Butadiene is a colorless gas with a gasoline-like odor at room temperature. It is usually produced as a byproduct of petroleum processing. 1,3-Butadiene is primarily used in the production of synthetic rubber and plastics. Additionally, butadiene is found in automobile exhaust, gasoline vapor, fossil fuel incineration products, and cigarette smoke.

Potential for Human Exposure - 1,3-Butadiene may be released to the environment as fugitive emissions during production, use, storage, transport, or disposal. The majority of 1,3-butadiene is released to air. 1,3-Butadiene is highly volatile; therefore, it is expected to partition primarily to air and evaporate quickly from water and soil. In air, 1,3-butadiene is broken down rapidly (half-life of about 2 hours) by sunlight. 1,3-Butadiene is also removed by the gas-phase reaction with ozone and by reaction at night with nitrate radicals in urban areas. Humans are typically exposed to 1,3-butadiene via inhalation of polluted urban, suburban, or workplace (where 1,3-butadiene is manufactured or used) air.

Qualitative Description of Health Effects – Breathing very high levels of 1,3-butadiene for a short time can cause central nervous system damage, blurred vision, nausea, fatigue, headache, decreased blood pressure and pulse rate, and unconsciousness. There are no recorded cases of accidental exposures at high levels that caused death in humans, but this could occur. Breathing lower levels may cause irritation of the eyes, nose, and throat. Studies on workers who had longer exposures with lower levels have shown an increase in heart and lung damage, but these workers were also exposed to other chemicals and it is unclear which chemical (or chemicals) caused the effects.

Animal studies show that breathing 1,3-butadiene during pregnancy can increase the number of birth defects. Other effects seen in animals that breathed low levels of this compound for one year include kidney and liver disease, damaged lungs, increased tumor incidence, and death.

Quantitative Description of Health Effects – USEPA has assigned 1,3-butadiene classification A; known human carcinogen. This classification was based on sufficient human epidemiological data, as well as rodent (rat and mouse) studies in which exposure to airborne concentrations of 1,3-butadiene caused multiple tumors and tumor types. The USEPA has assigned an inhalation

⁹¹ Summary based on the Agency for Toxic Substances and Disease Registry *ToxFAQ for 1,3-butadiene*, <http://www.atsdr.cdc.gov/tfacts28.html>, September 1995.

carcinogenic unit risk factor of 0.00003 cancers per microgram of 1,3-butadiene per cubic meter of air. The chronic inhalation reference concentration for non-carcinogenic effects is 0.002 milligrams per cubic meter of air.⁹²

Acetaldehyde⁹³

Acetaldehyde is a colorless, volatile liquid with a characteristic pungent, fruity odor. It is a highly flammable and reactive compound that is miscible in water and most common solvents. Acetaldehyde is used primarily as a chemical intermediate in the production of acetic acid, as well as a synthetic flavoring agent. It is also used in the manufacture of disinfectants, dyes, explosives, rubber accelerators, and varnishes. Acetaldehyde is a metabolic intermediate in humans and higher plants and is a product of alcohol fermentation.

Potential for Human Exposure –Acetaldehyde is released into air or wastewater from facilities producing or using this chemical. Acetaldehyde is also released to the environment in vehicle exhaust and as a product of open burning of gas, fuel oil, and coal. Degradation of hydrocarbons, sewage, and solid biological wastes produces acetaldehyde. Other sources of acetaldehyde include roasted coffee, tobacco smoke, forest fires, and volcanoes.

The majority of direct releases of acetaldehyde are to air and underground sites. In air, acetaldehyde reacts with other chemicals in air or gets broken down by sunlight. Acetaldehyde can contribute to the formation of photochemical smog when it reacts with other volatile organic carbon substances in air. Acetaldehyde is highly volatile and will evaporate from soil and water. Acetaldehyde in soil and water can also undergo microbial degradation. Acetaldehyde may leach into the ground and can enter groundwater. Bioaccumulation and bioconcentration of acetaldehyde in plants and animals is unlikely to occur.

Qualitative Description of Health Effects –Acute exposure to acetaldehyde can cause eye, nose, and throat irritation and subsequent conjunctivitis and coughing. This compound can also cause central nervous system depression, delayed pulmonary edema, and moderate narcosis. Chronic dermal exposure can lead to skin burns and dermatitis. Chronic inhalation exposure at high concentrations causes adverse respiratory tract effects in animals. Carcinogenicity studies in rats have shown that acetaldehyde causes respiratory tract tumors.

Quantitative Description of Health Effects – USEPA has assigned acetaldehyde classification B2; probable human carcinogen. This classification was based on sufficient animal study data in which exposure to airborne concentrations of acetaldehyde resulted in increased nasal tumors in male and female rats and caused tumors of the larynx in male and female hamsters. The USEPA has assigned an inhalation carcinogenic unit risk factor of 0.0022 cancers per microgram of acetaldehyde per cubic meter of air. The chronic inhalation reference concentration for non-carcinogenic effects is 0.009 milligrams per cubic meter of air.⁹⁴

⁹² USEPA, USEPA's Risk Screening Environmental Indicators (RSEI) Chronic Human Health Methodology, Technical Appendix A, Version 2.1, OPPT, Washington DC, January 2004.

⁹³ Summary based on the Hazardous Substances Database – Acetaldehyde, <http://toxnet.nlm.nih.gov>, August 2003.

⁹⁴ USEPA, *Risk Screening Environmental Indicators (RSEI) Chronic Human Health Methodology*, Technical Appendix A, RSEI Version 2.1, OPPT, Washington DC, January 2004.

Acrolein⁹⁵

Acrolein is a clear or yellow liquid with a disagreeable odor. It readily dissolves in water and quickly changes to a vapor when heated. It also burns easily. Acrolein is used as an intermediate in the production of acrylic acid, as well as a pesticide to control algae, weeds, bacteria, and mollusks. Small amounts of acrolein can be formed and emitted into the air when trees, tobacco, other plants, gasoline, and oil are burned.

Potential for Human Exposure – Acrolein may be released to the environment in emissions and effluents from its manufacturing and use facilities and in emissions from combustion processes. Acrolein evaporates rapidly from soil and water. Acrolein is an unstable compound and is removed from air primarily by reaction with sunlight or hydroxyl radicals. In soil and water, acrolein can be broken down by micro-organisms. This compound does not accumulate up the food chain.

Qualitative Description of Health Effects – The only known effects of acrolein exposure in humans are that breathing large amounts damages the lungs and could cause death. Breathing lower amounts may cause eye watering and burning of the nose and throat and a decreased breathing rate.

Animal studies show that breathing acrolein causes irritation to the nasal cavity, lowered breathing rate, and damage to the lining of the lungs.

Quantitative Description of Health Effects – USEPA has assigned acrolein classification D; not classifiable as to human carcinogenicity. This classification was based on insufficient human epidemiological data and insufficient animal studies in which exposure to airborne concentrations of acrolein increased the number of benign tumors in organ surfaces of exposed male and female rats. The USEPA has assigned a chronic inhalation reference concentration for non-carcinogenic effects of 0.00002 per milligram of acrolein per cubic meter of air.⁹⁶

Arsenic⁹⁷

Arsenic (As) is a naturally occurring element that is widely distributed in the earth's crust. Arsenic combines with oxygen, chlorine, and sulfur in the environment to form inorganic arsenic compounds and combines with carbon and hydrogen in animals and plants to form organic arsenic compounds. Elemental arsenic is used as an alloying agent for heavy metals and in special solders. Inorganic arsenic compounds are mainly used to preserve wood, whereas organic arsenic compounds are used as pesticides.

Potential for Human Exposure – Sources of arsenic include forest fires, volcanic eruptions, and human activities, such as metal smelting, chemical production and use, coal combustion, motor

⁹⁵ Summary based on the Agency for Toxic Substances and Disease Registry *ToxFAQ for Acrolein*, <http://www.atsdr.cdc.gov/tfacts124.html>, July 1999.

⁹⁶ USEPA, *Risk Screening Environmental Indicators (RSEI) Chronic Human Health Methodology*, Technical Appendix A, Version 2.1, OPPT, Washington DC, January 2004.

⁹⁷ Summary based on the Agency for Toxic Substances and Disease Registry *ToxFAQ for Arsenic*, <http://www.atsdr.cdc.gov/tfacts2.html>, December 2003.

vehicle exhaust, and waste disposal, release considerable amounts of arsenic to the environment. Most human releases are to land, but substantial amounts are also released to air and water. Arsenic in air will settle to the ground or is washed out of the air by rain. Many arsenic compounds can dissolve in water. Also, fish and shellfish can accumulate arsenic, but mostly in a harmless form. Human exposure can occur through food ingestion, drinking water, or breathing air containing arsenic.

Qualitative Description of Health Effects – Breathing high levels of inorganic arsenic can give you a sore throat or irritated lungs. Ingesting high levels of inorganic arsenic can result in death. Lower levels of arsenic can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of “pins and needles” in hands and feet. Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small “corns” or “warts” on the palms, soles, and torso. Skin contact with inorganic arsenic may cause redness and swelling. Organic arsenic compounds are less toxic than inorganic arsenic compounds. Exposure to high levels of some organic arsenic compounds may cause similar effects as inorganic arsenic.

Quantitative Description of Health Effects – USEPA has assigned arsenic classification A; known human carcinogen. This classification was based on sufficient human epidemiological data, where inhalation or oral ingestion caused multiple tumors and tumor types in multiple human populations. The USEPA has assigned an inhalation carcinogenic unit risk factor of 0.0043 cancers per microgram of arsenic per cubic meter of air. The chronic inhalation reference concentration for non-carcinogenic effects is 0.00003 milligrams per cubic meter of air.⁹⁸

Benzene⁹⁹

Benzene is a volatile, colorless, flammable liquid that has a sweet odor. It is a chemical intermediate in the synthesis of compounds such as plastics, resins, nylon, synthetic fibers, synthetic rubbers, lubricants, dyes, detergents, drugs, and pesticides.

Potential for Human Exposure – Benzene is released to the environment by both natural and man-made sources. Major sources of atmospheric releases include vehicle exhaust emissions, evaporative gasoline fumes, emissions from vehicle service stations, and industrial emissions. Other sources of atmospheric benzene include cigarette smoke and landfill emissions. Benzene is released to soils and water from industrial discharges, landfill leachate, and gasoline leaks from underground storage tanks.

Benzene is water-soluble and highly volatile. Atmospheric benzene is removed primarily through chemical degradation. Due to its water-solubility, some benzene is removed from the atmosphere in rainwater or snow. Benzene in soil and water breaks down more slowly, primarily through evaporation and microbial degradation. This compound does not accumulate in plants or animals.

⁹⁸ USEPA, USEPA's Risk Screening Environmental Indicators (RSEI) Chronic Human Health Methodology, Technical Appendix A, Version 2.1, OPPT, Washington DC, January 2004.

⁹⁹ Summary based on the Agency for Toxic Substances and Disease Registry *ToxFAQ for Benzene*, <http://www.atsdr.cdc.gov/tfacts3.html>, September 1997.

Qualitative Description of Health Effects – Acute inhalation exposure to benzene can result in death, while high levels can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. Eating or drinking foods containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, and death.

The major effect of benzene from long-term (365 days or longer) exposure is on the blood. Benzene causes harmful effects on the bone marrow and can cause a decrease in red blood cells leading to anemia. It can also cause excessive bleeding and can depress the immune system, increasing the susceptibility to infection. Some women who breathed high levels of benzene for many months had irregular menstrual periods and a decrease in the size of their ovaries. It is not known whether benzene affects the developing fetus in pregnant women or fertility in men.

Quantitative Description of Health Effects – USEPA has assigned benzene classification A; known human carcinogen. This classification was based on sufficient human epidemiological data, where exposure has resulted in leukemia and Hodgkin's disease, as well as sufficient animal studies in which benzene increased the risk of cancer in multiple species and multiple organs. The USEPA has assigned an inhalation carcinogenic unit risk factor of 0.0000078 cancers per microgram of benzene per cubic meter of air. The chronic inhalation reference concentration for non-carcinogenic effects is 0.03 milligrams per cubic meter of air.¹⁰⁰

Chromium VI¹⁰¹

Chromium is a naturally occurring element found in rocks, animals, plants, soil, and in volcanic dust and gases. Chromium occurs in several oxidation states, the most common forms of which are chromium (0), chromium (III), and chromium (VI). Chromium (III) occurs naturally in the environment and is an essential nutrient, whereas chromium (VI) and chromium (0) are typically produced in industrial processes. Chemical, physical, and toxicological properties of chromium vary by form; chromium (VI) is profiled in this report. Chromium (VI) is the second most stable chromium compound, after chromium (III). Chromium (VI) is used for chrome plating, dyes and pigments, leather tanning, and wood preservation.

Potential for Human Exposure – Human activities including driving and using motor vehicles are responsible for the majority of chromium (VI) environmental releases into air. In air, chromium is present mostly as fine dust particles which eventually settle out of the atmosphere. This compound can adsorb in to soils and has minimal volatilization and water solubility. Human exposure can occur via inhalation of contaminated air or ingestion of contaminated food and water.

Qualitative Description of Health Effects – Acute inhalation of high levels of chromium (VI) primarily causes irritation to the nose, including nosebleeds, ulcers and holes in the nasal septum. Ingesting large amounts of chromium (VI) can cause stomach upsets and ulcers,

¹⁰⁰ USEPA, USEPA's Risk Screening Environmental Indicators (RSEI) Chronic Human Health Methodology, Technical Appendix A, Version 2.1, OPPT, Washington DC, January 2004.

¹⁰¹ Summary based on the Agency for Toxic Substances and Disease Registry *ToxFAQ for Chromium*, <http://www.atsdr.cdc.gov/tfacts7.html>, February 2001.

convulsions, kidney and liver damage, and even death. Dermal exposure with chromium (VI) can cause skin ulcers and dermatitis.

For chronic inhalation exposure, epidemiological and animal studies have shown an increased risk of lung tumors.

Quantitative Description of Health Effects – USEPA has assigned chromium VI classification A; known human carcinogen. This classification was based on sufficient human epidemiological data, as well as animal studies in which exposure to airborne concentrations of chromium VI caused implant and injection site tumors in rats and mice. The USEPA has assigned an inhalation carcinogenic unit risk factor of 0.012 cancers per microgram of chromium VI per cubic meter of air. The chronic inhalation reference concentration for non-carcinogenic effects is 0.0001 milligrams per cubic meter of air.¹⁰²

Diesel Particulate Matter¹⁰³

Diesel exhaust is a complex mixture of thousands of individual gaseous and particulate compounds emitted from diesel-fueled combustion engines. Many researchers have used the particles in diesel exhaust to quantify exposure to whole diesel exhaust. Diesel particulate matter is formed primarily through the incomplete combustion of diesel fuel. Particulate matter in diesel exhaust can be emitted from on- and off-road vehicles, stationary area sources, and stationary point sources. Typical diesel exhaust particles have diameters ranging from 0.1 to 0.25 micrometers. The particles are mainly aggregates of spherical elemental carbon particles coated with organic and inorganic substances.

Potential for Human Exposure – Diesel exhaust particulate matter is removed from the atmosphere through physical processes including atmospheric fall-out and washout by rain. Humans can be exposed to airborne diesel particulate matter or via deposited diesel particulates on water, soil, and vegetation.

Qualitative Description of Health Effects – Acute inhalation exposure to diesel particulates has shown increased symptoms of irritation, cough, phlegm, chronic bronchitis, and inhibited pulmonary function. In animals, inhalation of diesel particulates induced lung inflammation, fibrosis, and increased susceptibility to lung infection.

Quantitative Description of Health Effects – CARB has assigned diesel particulate matter classification B1; probable human carcinogen. This classification was based on strong but insufficient human epidemiological data, as well as supportive animal study evidence of carcinogenicity in rats and mice via various routes of exposure. The CARB has assigned an inhalation carcinogenic unit risk factor of 0.0003 cancers per microgram of diesel particulate matter per cubic meter of air.¹⁰⁴ The chronic inhalation reference concentration for non-

¹⁰² USEPA, USEPA's Risk Screening Environmental Indicators (RSEI) Chronic Human Health Methodology, Technical Appendix A, Version 2.1, OPPT, Washington DC, January 2004.

¹⁰³ Summary based on the California Air Resources Board and Office of Environmental Health Hazard Assessment. *Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant*, approved by the Scientific Review Panel in April 1998, and USEPA, *Health Assessment Document for Diesel Engine Exhaust*, EPA/600/8-90/057F, May 2002.

¹⁰⁴ California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, 2003.

carcinogenic effects is 0.005 milligrams per cubic meter of air.¹⁰⁵ Although the USEPA has not identified diesel exhaust as a HAP, the agency has concluded that it is a probable human carcinogen.¹⁰⁶

Formaldehyde¹⁰⁷

At room temperature, formaldehyde is a colorless, flammable gas that has a distinct, pungent smell. Formaldehyde is produced both by natural processes and human activities. It is used in the production of fertilizer, paper, plywood, and urea-formaldehyde resins. It is also used as a preservative in some foods, antiseptics, medicines, and cosmetics.

Potential for Human Exposure – Formaldehyde is a product of incomplete combustion and is emitted into the air by burning wood, coal, kerosene, and natural gas, by automobiles, and by cigarettes; it is also a naturally occurring substance. Formaldehyde can be released to soil, water, and air by industrial sources and can off-gas from materials made with it. Humans can be exposed to formaldehyde primarily through inhalation of contaminated air and smog.

Most formaldehyde in air is broken down during the day by photochemical processes. The breakdown products are formic acid and carbon monoxide.

Qualitative Description of Health Effects – Low levels of formaldehyde can cause irritation of the eyes, nose, throat, and skin. It is also possible that individuals with asthma may be more sensitive to the effects of inhaled formaldehyde. Drinking large amounts of formaldehyde can cause severe pain, vomiting coma, and possible death.

Some epidemiological studies found an increased incidence of nose and throat cancer in exposed individuals, whereas other studies could not confirm this finding. In animal studies, rats exposed to high levels of formaldehyde in air developed nose cancer.

Quantitative Description of Health Effects – USEPA has assigned formaldehyde classification B1; probable human carcinogen. This classification was based on strong but insufficient human epidemiological data, as well as sufficient animal data in which inhalation exposure of rats and mice resulted in increased risk of nasal cancer. The USEPA has assigned an inhalation carcinogenic unit risk factor of 0.000000055 cancers per microgram of formaldehyde per cubic meter of air. The chronic inhalation reference concentration for non-carcinogenic effects is 0.0098 milligrams per cubic meter of air.¹⁰⁸

¹⁰⁵ USEPA, Risk Screening Environmental Indicators Chronic Human Health Methodology, Technical Appendix A, Version 2.1, Washington DC, January 2004.

¹⁰⁶ <http://www.epa.gov/ttn/atw/nata/natsafaq.html#B7>

¹⁰⁷ Summary based on the Agency for Toxic Substances and Disease Registry *ToxFAQ for Formaldehyde*, <http://www.atsdr.cdc.gov/tfacts111.html>, July 1999.

¹⁰⁸ USEPA, *Risk Screening Environmental Indicators (RSEI) Chronic Human Health Methodology*, Technical Appendix A, Version 2.1, OPPT, Washington DC, January 2004.

Naphthalene¹⁰⁹

Naphthalene is a white solid with the odor of mothballs or tar, and is found naturally in fuels when they are burned. Burning tobacco or wood also produces naphthalene. The major commercial use of naphthalene is in the manufacture of polyvinyl chloride (PVC) plastics. Its major consumer use is in moth repellents and toilet deodorant blocks.

Potential for Human Exposure – Naphthalene is released into the air predominantly through volatilization from mothballs and through the burning of tobacco, wood, oil and coal. Naphthalene is not persistent in the environment. In air, moisture and sunlight break it down within 1 day. In water and soil, naphthalene can be removed via evaporation or bacterial decomposition.

Qualitative Description of Health Effects – Exposure to large amounts of naphthalene may damage or destroy some of your red blood cells. This could cause you to have too few red blood cells until your body replaces the destroyed cells. This condition is called hemolytic anemia, with symptoms including fatigue, lack of appetite, restlessness, and pale skin. Exposure to large amounts of naphthalene may also cause nausea, vomiting, diarrhea, blood in the urine, and a yellow color to the skin.

Rodents that breathed naphthalene daily for a lifetime developed irritation and inflammation of their nose and lungs. Some mice and rats exposed to naphthalene developed lung and nose tumors, respectively.

Quantitative Description of Health Effects – USEPA has assigned naphthalene classification C; possible human carcinogen. This classification was based on inadequate human epidemiological data, as well as limited evidence of carcinogenicity in animals. The USEPA has assigned a chronic inhalation reference concentration for non-carcinogenic effects of 0.003 milligrams of naphthalene per cubic meter of air.¹¹⁰

Nickel¹¹¹

Nickel is an abundant silvery-white metal, which can be found in soil and expelled from volcanoes. Airport-related sources of nickel include ground support equipment, motor vehicles, and heating plants. Nickel can be combined with other metals such as iron, copper, chromium, and zinc to form alloys that can be used to make coins, jewelry, valves, and stainless steel. Nickel can also be combined with other elements such as chlorine, sulfur, and oxygen to form nickel compounds.

Potential for Human Exposure – Nickel is a commonly found element in nature, as well as in many alloys that humans are exposed to. Small nickel particles in the air settle to the ground or

¹⁰⁹ Summary based on the Agency for Toxic Substances and Disease Registry *ToxFAQ for Naphthalene*, <http://www.atsdr.cdc.gov/tfacts67.html>, September 2003.

¹¹⁰ USEPA, *Risk Screening Environmental Indicators (RSEI) Chronic Human Health Methodology*, Technical Appendix A, Version 2.1, OPPT, Washington DC, January 2004.

¹¹¹ Summary based on the Agency for Toxic Substances and Disease Registry *ToxFAQ for Nickel*, <http://www.atsdr.cdc.gov/tfacts15.html>, September 2003.

are taken out of the air in rain. The major source of human exposure to nickel is through ingestion of food that contains nickel. Alternate routes of exposure include dermal contact with soil, bath or shower water, or metals containing nickel, as well as by handling coins or touching jewelry containing nickel. Drinking nickel-contaminated water or breathing air or smoking tobacco containing nickel can also expose humans to this compound.

Qualitative Description of Health Effects – The most common harmful effect of nickel in humans is an allergic reaction. People can become sensitized to nickel through dermal contact with nickel-containing jewelry or other items. Sensitized individuals can then have an allergic reaction to subsequent dermal, inhalation, or ingestion exposure to nickel.

Individuals working in nickel refineries or processing plants have experienced chronic bronchitis and reduced lung function. Workers who drank water containing high amounts of nickel had stomachaches and suffered adverse effects to their blood and kidneys. Cancers of the lung and nasal sinus have resulted when workers breathed dust containing high levels of nickel compounds. Damage to the lung and nasal cavity has been observed in rats and mice breathing nickel compounds.

Quantitative Description of Health Effects – USEPA has assigned nickel classification A; known human carcinogen. This classification was based on sufficient human epidemiological data, as well as animal studies in which exposure to airborne concentrations of nickel caused inhalation and injection carcinomas in rats. Nickel has a calculated carcinogenic toxicity weight of 3500.¹¹² The chronic inhalation reference concentration for non-carcinogenic effects is 0.0002 milligrams of nickel per cubic meter of air.¹¹³

Toluene¹¹⁴

Toluene is a colorless, clear liquid that occurs naturally in crude oil and in tolu trees. It is also produced in the process of making gasoline and other fuels from crude oil and making coke from coal. Toluene is used in making paints, paint thinners, fingernail polish, lacquers, adhesives, and rubber, as well as in some printing and leather tanning processes. Airport-related sources of toluene include aircraft, ground support equipment, motor vehicles, heating plants, and gasoline fuel storage tanks.

Potential for Human Exposure – Toluene can be released to air, water, and soil through the manufacture and use of the various products described above. Also, it can enter surface and groundwater from spills of solvents and petroleum products and from leaking underground storage tanks. However, toluene is not very persistent in the environment. Humans can be exposed to naphthalene via inhalation of contaminated workplace air or automobile exhaust,

¹¹² Argonne National Laboratory, Environmental Assessment Division and Decision and Information Sciences Division, United States Department of Energy, *Air Screening Assessment for Cook County, Illinois, and Lake County, Indiana*, March 2004.

¹¹³ USEPA, *Risk Screening Environmental Indicators (RSEI) Chronic Human Health Methodology*, Technical Appendix A, Version 2.1, OPPT, Washington DC, January 2004.

¹¹⁴ Summary based on the Agency for Toxic Substances and Disease Registry *ToxFAQ for Toluene*, <http://www.atsdr.cdc.gov/tfacts56.html>, February 2001.

drinking contaminated water, or working with gasoline, kerosene, heating oil, paints, and lacquers.

Qualitative Description of Health Effects – Low to moderate levels of toluene can affect the nervous system and cause tiredness, confusion, weakness, memory loss, nausea, loss of appetite, and hearing and color vision loss. Inhaling high levels of toluene in a short time can make you feel light-headed, dizzy, or sleepy, and can cause unconsciousness and death.

Quantitative Description of Health Effects – USEPA has assigned toluene classification D; not classifiable as to human carcinogenicity. This classification was based on insufficient human epidemiological data and insufficient animal studies to classify toluene. The USEPA has assigned a chronic inhalation reference concentration for non-carcinogenic effects of 0.4 milligrams of toluene per cubic meter of air.¹¹⁵

¹¹⁵ USEPA, *Risk Screening Environmental Indicators (RSEI) Chronic Human Health Methodology*, Technical Appendix A, Version 2.1, OPPT, Washington DC, January 2004.

**ATTACHMENT I-2
ANALYSIS PROTOCOL FOR HAZARDOUS AIR
POLLUTANTS**

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Chicago O'Hare International Airport

NOTE: This document is a suggested guideline for conducting the O'Hare Modernization Program (OMP) air quality analyses. It is provided for deliberative purposes only and is based on previously approved air quality methodologies and assumptions used in the preparation of the air quality analysis for O'Hare's World Gateway Program Environmental Assessment. This Hazardous Air Pollutant Analysis Protocol is being developed through close coordination with the Federal Aviation Administration (FAA) and associated contractors, the City of Chicago Department of Aviation, the US Environmental Protection Agency (USEPA) Region V, and the Illinois EPA (IEPA). This Protocol is based on information that the City of Chicago has provided to the FAA to date. If major components of the OMP are changed and/or phasing is altered, this Protocol will be adjusted by FAA as necessary, in consultation with USEPA and IEPA.

Draft

Analysis Protocol for– Hazardous Air Pollutants

O'Hare Modernization Program
Environmental Impact Statement

February 25, 2003

CHICAGO O'HARE INTERNATIONAL AIRPORT

O'HARE MODERNIZATION PROGRAM EIS

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Chapter

1

Introduction

The City of Chicago Department of Aviation (City) is proposing a program to modernize O'Hare International Airport (Airport). Known as the O'Hare Modernization Program (OMP), the program includes the addition of one new runway and the relocation of three existing runways into an east-west configuration. The future airport, as currently envisioned by the City, would consist of eight runways (six east-west parallel runways and two northeast-southwest parallel runways). The OMP could also involve relocation of some or all of the existing navigation aids, placement of new navigation aids, provision for a new western access to the Airport, construction of additional terminal facilities, and relocation of various roadways and rail lines. Based on the potential impacts associated with the proposed improvements, the Federal Aviation Administration (FAA) has determined that the environmental review process will be in the form of an Environmental Impact Statement (EIS).

As part of the air quality analysis for the EIS, an evaluation will be performed to assess the effect of the OMP on hazardous air pollutant (HAP) levels. HAPs are pollutants that do not have established NAAQS but present potential adverse human health risks from short-term (acute) or long-term (chronic) exposures. Although the analysis of HAPs is not a Federal or state requirement, the analysis described herein is fully consistent with current recommended government guidelines.

It should be noted that currently there is very little testing, modeling or other supporting information available that affirmatively identifies and quantifies the types of HAPs associated with airports, in general, and aircraft, in particular. This situation is no more apparent than when dealing with HAP emission factors for aircraft. For example, the basis for most of the HAP emission factors for commercial aircraft is from data derived from the testing of only two aircraft types conducted over 15 years ago. These published emission factors were intended for the development of state- and region-wide emission inventories and not envisioned for use in atmospheric dispersion modeling of HAPs from individual airports. Moreover, the combined human health and environmental effects of airport-related HAPs with HAPs from other sources are also not well documented.

For these and other reasons, the results of the HAPs analysis discussed below is based on the best data, information and modeling techniques currently available but still potentially subject to a high degree of imprecision and uncertainty. The sources and magnitudes of these uncertainties will be discussed further in the EIS.

This Protocol identifies the technical assumptions, methodologies, and databases that will be used to conduct the OMP HAPs evaluation. The purpose of the Protocol is to document, in advance of any data collection or data analysis, the approach to the evaluation. The Protocol will be circulated to the US Environmental Protection Agency (USEPA) and the Illinois Environmental Protection Agency (IEPA) to ensure that the approach meets regulatory needs and requirements.

For the purpose of reviewing the Analysis Protocol for HAPs (this Protocol), a matrix indicating the years of planned HAP emission inventories and OMP project elements is provided in **Table 1**. Additional details regarding the OMP and graphics illustrating the airfield development concept and airfield evolution can be viewed at http://modernization.ohare.com/program_pages/configuration.htm.

1.1 Airport-related HAPs

For the purpose of this Protocol, aircraft-related HAPs are defined to be those identified as such in FAA's "Selected Resource Materials and Annotated Bibliography on the Topic of HAPs Associated with

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Aircraft, Airports, and Aviation¹ and included in USEPA's National Toxics Inventory. **Table 2** (from FAA's referenced document) provides the list of these aircraft-related HAPs. The emissions are shown in descending order by total annual emissions, nationwide. Notably, the lead emissions shown in Table 2 (ranked 8th in the list) are likely a result of general aviation aircraft, as these emissions are not considered a byproduct of commercial aircraft engine combustion.

¹ Table 2 of FAA's Selected Resource Materials and Annotated Bibliography on the Top of HAPs Associated with Aircraft, Airports, and Aviation lists the HAPs that USEPA has determined are related to aircraft and airports. It is anticipated that FAA's document will be published in March, 2003.

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Table 1. OMP Elements by Calendar Year – HAP Evaluation

Air Quality Element	Existing (2001)	Future												
		2003	2004	2005	2006	2007 ^a	2008	2009	2010	2011	2012	2013	2018	
Existing Conditions and Future No-Action Alternative ^b	*					*		*					*	*
OMP (Action) Alternative ^b	New Rwy 9L-27R					*		*					*	*
	Rwy 18-36 Relocated							*					*	*
	Rwy 10L-28R Extended							*					*	*
	Rwy 9R-27L Extended												*	*
	Rwy 14L-32R Relocated												*	*
	Rwy 14R-32L Relocated												*	*
	Western Access												*	*
	On-Airport public roadways												*	*
	On-Airport service roads						*		*				*	*
	Inving Park Road relocated								*				*	*
Construction Emissions						*		*				*	*	

^a Required year for conformity demonstration for one-hour O3 SIP.

^b The airport-related sources to be included in the evaluation will be determined after reviewing available speciation factors and evaluating the reliability of the factors. The sources could include aircraft, ground service vehicles, point sources, motor vehicles (on and off airport), parking facilities, auxiliary power units, and training fires.

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Table 2. Aircraft-Related HAPs Included in the USEPA National Toxics Inventory Ranked in Order

Pollutant	Total Emissions (Tons/Year)	Ranking	Percent of Total	Cumulative Percent
Formaldehyde	6,408	1	42.3	42.3
Acetaldehyde	1,969	2	13.0	55.3
Benzene	1,184	3	7.8	63.1
Toluene	1,174	4	7.7	70.8
Acrolein	938	5	6.2	77.0
1,3-Butadiene	824	6	5.4	82.5
Xylene	702	7	4.6	87.1
Lead	541	8	3.6	90.7
Naphthalene	454	9	3.0	93.7
Propionaldehyde	396	10	2.6	96.3
Ethylbenzene	211	11	1.4	97.7
Styrene	195	12	1.3	99.0
n-Hexane	71	13	0.5	99.4
2,2,4-Trimethylpentane	30	14	0.2	99.6
Acenaphthylene	17	15	0.1	99.7
Phenanthrene	10	16	0.1	99.8
Fluorene	8	17	0.1	99.9
Fluoranthene	5	18	<0.1	99.9
Pyrene	5	19	<0.1	99.9
Anthracene	4	20	<0.1	100
Acenaphthene	3	21	<0.1	100
Benzo(ghi)perylene	1	22	<0.1	100
Benzo(b)fluoranthene	0.5	23	<0.1	100
Benzo(k)fluoranthene	0.5	24	<0.1	100
Benzo(a)anthracene	0.4	25	<0.1	100
Benzo(a)pyrene	0.4	26	<0.1	100
Chrysene	0.4	27	<0.1	100
Indeno(1,2,3-cd)pyrene	0.3	28	<0.1	100
Dibenz(a,h)anthracene	0	29	<0.1	100

Source: Draft Selected Resource Materials and Annotated Bibliography on the Topic of HAPs Associated with Aircraft, Airports, and Aviation, FAA.

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Motor vehicle-related HAPs are defined as those listed in USEPA's Final Rule on controlling emissions from mobile sources (66FR17230, March 29, 2001).

Comments received from IEPA and USEPA expressed interest in including diesel exhaust emissions as an air toxic concern. The USEPA released the final version of the Health Assessment Document for Diesel Engine Exhaust (EPA/600/8-90/057F) in May 2002. This document will be used to quantify diesel exhaust emissions from diesel sources.

1.2 Availability of Local HAPs Data

Regional estimates of HAP emissions within Cook and DuPage counties can be obtained from USEPA's National Toxics Inventory (NTI) Database (<http://www.epa.gov/air/data/index.html>). The database is an inventory of stationary and mobile sources that emit HAPs. The NTI Database includes estimates of emissions from stationary, major, area, and mobile sources, as defined in Section 112 of the CAA. Currently, the Database provides data from 1996.

1.2.1 IEPA's Chicago O'Hare Airport Air Toxic Monitoring Program

In the year 2000, the IEPA conducted a short-term measurement program to assess levels of various air contaminants in the vicinity of Chicago O'Hare International Airport as well as other locations within the Chicago area². The IEPA's monitoring program focused on the urban air toxic compounds identified in USEPA's National Strategy (The National Strategy is discussed in Section 1.2) and on mobile source emissions associated with airport operations. The compounds sampled included volatile organics, semi-volatile organics, carbonyls and trace metals. Two monitoring sites were located near the Airport (Bensenville and Schiller Park). Three monitoring sites were located in non-airport-related areas (Northbrook (just north of the urban core), Washington School (a highly industrialized area in Southeast Chicago), and Lemont (just downwind of major refineries and chemical complexes and on the southwestern edge of the metropolitan area).

The monitoring program focused on the urban air toxic compounds identified in USEPA's National Strategy and on mobile source emissions associated with airport operations. The compounds sampled included volatile organics, semi-volatile organics, carbonyls and trace metals.

The Chicago area toxics monitoring program was designed to provide data to meet four objectives:

- To measure the concentrations of specific compounds of concern;
- To assess the geographic variability of various compounds in the Chicago area and perform a comparison of levels measured at the two O'Hare sites to those recorded at the remaining three Chicago area locations;
- To compare Chicago area results to data collected for other large U.S. cities; and
- To determine if the emissions associated with O'Hare Airport have a measurable impact on air quality in areas adjacent to the airport.

The HAPs measured included such compounds as ethyl benzene, styrene, toluene, xylenes and various polycyclic aromatics such as naphthalene and phenanthrene. The program's sampling sites were located to provide air toxic measurements at different points across the Chicago metropolitan area, thereby allowing for a comparison of the levels found at the Airport to those found in different parts of the metropolitan area.

A review and analysis of the accumulated monitoring results obtained from the monitoring network provided the following findings:

² Chicago O'Hare Airport Air Toxic Monitoring Program June – December, 2000, IEPA Bureau of Air, May 2002.

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- The average concentrations measured at O'Hare Airport for many of the target compounds were found to be comparable with the concentrations found at the other Chicago area sites;
- The highest concentrations of several target urban air toxic compounds were found to be spread between several sites but generally the highest levels for many of the air toxics were found to occur in Southeast Chicago;

A comparison of measured levels of urban air toxics in Chicago to those found in other large cities served as a point of reference to what would be considered "typical urban" concentrations. Based upon a comparison of the results from the Chicago area monitoring program to that collected for other large U.S. cities data, it was found that:

- Concentrations of several of the principal urban air toxics, such as acetaldehyde, benzene, and formaldehyde, compared to the metropolitan areas of Atlanta, Detroit, Houston and Milwaukee, were found to be comparable or lower in the Chicago metropolitan area.
- The acetaldehyde and formaldehyde levels measured near the Airport were comparable or lower than levels measured in Atlanta, Detroit and Houston.

In order to assess the possible impact of emissions from the Airport on adjacent areas, two monitoring sites were deployed on different sides of the airport. This configuration allowed for the collection of sampling data on wind persistent days that would align one site to be upwind, unaffected by the airport, and the other to be downwind and subject to airport emissions. Based upon IEPA's review of the air toxics monitoring data collected near the Airport, from other Chicago area sites, and from USEPA's databases, the following conclusions were reached:

- The levels of air toxic compounds found near O'Hare and other sites in the Chicago metropolitan area were comparable or lower than those found in other large U.S. cities.
- The highest levels of most air toxic compounds measured in the Chicago area were found in Southeast Chicago.
- An analysis of data collected from the sites at O'Hare found that emissions from the Airport have an impact on the air quality in adjacent communities, but that impact did not result in levels higher than those found in a typical urban environment.

The data collected through the IEPA's study indicated that the toxics air quality in the vicinity of the Airport is comparable to the air quality in other parts of Chicago and comparable to the air quality in other major urban areas.

1.3 Applicable Regulations

Currently, there are no ambient emission standards for HAPs.

1.3.1 Aircraft Engine Exhaust Emission Regulations

The Clean Air Act (CAA) of 1970 directed the USEPA to establish standards applicable to emissions of any air pollutant, from any class or classes of aircraft or aircraft engines that cause or contribute to air pollution which may reasonably be anticipated to endanger the public health and welfare. Under section 231 of the CAA the EPA has established the emissions standards, which are codified in 40 CFR part 87. In 1997 EPA aligned the United States' emissions standards with those engine emissions standards and recommended practices prescribed by the International Civil Aviation Organization (ICAO). The United States is an active member of ICAO's Committee on Aviation Environmental Protection, which is responsible for the further development of internationally agreed engine emissions standards.

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In establishing the United States emissions standards, the EPA is responsible (in consultation with the Department of Transportation) for ensuring that the effective date of such regulations will permit the development and application of requisite technology, giving appropriate consideration to the cost of compliance. The EPA is also responsible for consulting with the Department of Transportation before promulgation of emissions standards concerning aircraft safety.

Under section 232 of the CAA the Department of Transportation is responsible for enforcing the standards established by the EPA under section 231. The Secretary of the Department of Transportation delegated the responsibility for enforcement to the Federal Aviation Administration (FAA). Under the authority of CAA, the FAA has promulgated 14 CFR part 34, which administers and enforces the standards of 40 CFR part 87. The FAA ensures compliance with these regulations by reviewing and approving certification test plans, procedures, test reports, and the engine emissions certification levels.

The primary exhaust emissions from jet airplane engines are oxides of nitrogen (NO_x), hydrocarbons (HC), carbon monoxide (CO), and smoke, all of which are measured during the FAA's engine certification process. Engine exhaust emission levels are measured and regulated as prescribed in 14 CFR part 34. These regulations apply to all civil airplanes that are powered by gas turbine engines including turboprop, turbofan and turbojet engines. There are limitations to these regulations based on minimum engine thrust (rated output).

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Chapter

2

Methodology

This evaluation will assess the effect of the OMP on HAP levels using results from the VOC and PM emission inventories that will be prepared in support of the criteria air pollutant assessment. The same emission sources that will be evaluated for the EPA "criteria pollutants" will be assessed for HAPs. These sources include aircraft, GSE, stationary sources, and motor vehicles associated with the airport. The following list describes the basic methodology and proposed tasks for the OMP HAPs evaluation.

- A literature search will be conducted to identify available airport-related HAP measurement studies. It is assumed that these studies will contain information for equipment/engines similar to the type of equipment/engines that will be evaluated for the OMP.
- The criteria air pollutant VOC and non-aircraft PM emissions inventory by source type will be speciated to individual HAPs on a quantitative basis.
- The speciated HAP emissions will be ranked relative to each pollutant's toxicity value.
- A comparative analysis will be performed between the OMP-related HAP levels and HAP levels reported for other airports/sources and to regional (area wide) source totals.
- A qualitative health risk assessment (HRA) will be performed by comparing the operational levels and health risks reported in other HAP studies to the forecast operational levels with the OMP.

Sections 2.1 through 2.3 provide additional detail regarding the proposed methodology, the preparation of the HAP emission inventory, potential sources of the HAP speciation factors, the assignment of toxicity factors, and the comparative analysis.

2.1 Prepare HAP Emission Inventory

The results of the VOC and PM emission inventories from the criteria air pollutant assessment will be segregated according to source category (e.g., aircraft, motor vehicles). Speciation factors that are specific to each source category will be applied to the results to obtain source-specific inventories of HAPs. For example, aircraft-specific speciation factors will be applied to the aircraft-specific VOC emissions. Speciation factors specific to diesel construction equipment will be applied to diesel-specific VOC and PM emissions. With the exception of lead, which is not a byproduct of commercial jet aircraft, all of the aircraft-related HAPs in the USEPA National Toxics Inventory are VOC-based. Therefore, the VOC results from the emissions inventory will form the analytical basis for the HAPs assessment. This approach avoids the current problem of sparse data for aircraft PM and a methodology that would compound the uncertainty in the speciation of individual HAPs.

The actual sources that will be included in the evaluation will be determined after reviewing available speciation factors and evaluating the reliability of the factors. The final determination of airport-related sources/factors will be made in consultation with the USEPA and IEPA. The airport-related sources could include aircraft, ground service vehicles, point sources, motor vehicles (on and off airport), parking facilities, auxiliary power units, and construction equipment.

2.1.1 Potential Sources of HAP Speciation Factors

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It is recognized that HAP speciation factors are available for some of the airport-related emission sources. The sources of this information include:

- SPECIATE3.2 -USEPA's repository of VOC and PM speciated profiles for a variety of sources (<http://www.epa.gov/ttn/chieff/software/speciate/>).
- The California Air Resources Board (CARB) maintains and updates estimates of the chemical composition and size fractions of PM and the chemical composition and reactive fractions of VOC (<http://www.arb.ca.gov/emisinv/catef/catef.htm>).
- Diesel exhaust emissions can be obtained from the USEPA's Compilation of Air Pollutant Emission Factors - AP-42 (<http://www.epa.gov/ttn/chieff/ap42/index.html>).³

A data search will be performed of the sources listed above and other sources to obtain speciation factors for the sources applicable to the OMP. It is recognized that these data may be very limited. In support of the data search, a detailed commentary will also be prepared concerning the adequacy of the data (such as the number of engines/aircraft types for which data are available or the type of fuel used in the testing). Sources of conflicting data will also be documented.

2.2 Assign Toxicity Values

The speciated HAP emissions will be prioritized according to their toxicity values. Toxicity levels for the individual species will be obtained from USEPA's Integrated Risk Information System (IRIS). IRIS is a database of human health effects that may result from exposure to various substances found in the environment. Notably, USEPA makes the following statement regarding the use of the values obtained from IRIS:

- "In general IRIS values cannot be validly used to accurately predict the incidence of human disease or the type of effects that chemical exposures have on humans. This is due to the numerous uncertainties involved in risk assessment, including those associated with extrapolations from animal data to humans and from high experimental doses to lower environmental exposures. The organs affected and the type of adverse effect resulting from chemical exposure may differ between study animals and humans. In addition, many factors besides exposure to a chemical influence the occurrence and extent of human disease."⁴

2.3 Perform Comparative Analysis

The effects of the OMP HAP emissions will be determined by evaluating the relationship of the OMP HAP emission levels to regional levels and to the emission burdens of similar projects/regions for which impacts have already been determined. The comparison will not be performed using HAP emission studies for other airports and facilities that do not have and/or indicate that the levels were based on the same types of emission sources as will be included in the OMP assessment.

Studies that may be used to perform the comparative analysis could include the Environmental Impact Report (EIR) for the proposed Master Plan Update at Los Angeles International Airport and the Supplemental EIR for the Oakland International Airport's Development Program (the Oakland document is currently being prepared). Other studies may include the Analysis of Air Toxic Emissions and Health Risks Near Santa Monica Airport in California (prepared in 1999), a Screening Health Risk Assessment in the Vicinity of Teterboro Airport in New Jersey (prepared in 2001), and studies prepared for the Seattle Tacoma International Airport (2000).

³ *Compilation of Air Pollutant Emission Factors*. AP-42. U.S. Environmental Protection Agency, Fifth Edition (with Supplements), Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.

⁴ <http://www.epa.gov/iris/limits.htm>

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ATTACHMENT I-3
TURBINE ENGINE AIRCRAFT HAZARDOUS AIR
POLLUTANT SPECIATION PROFILES MEMO

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Chicago O'Hare International Airport

O'Hare Modernization Program

DRAFT

MEMORANDUM

To: Laura Kramer, Crawford, Murphy, and Tilly (CMT)

Cc: Bruce Jacobson – CMT
Amy Hanson, Mike MacMullen – Federal Aviation Administration (FAA)

From: Carrol Bryant, Bob Vranka, Mike Ratte - Environmental Science Associates (ESA)

Date: June 2, 2004

Subject: Turbine Engine Aircraft Hazardous Air Pollutant (HAP) Speciation Profiles

Environmental Science Associates (ESA) has prepared documentation for the hazardous air pollutant (HAP) speciation profiles that will be used to provide a supplemental air quality assessment of HAP emissions with and without the proposed O'Hare Modernization Program (OMP). The document is submitted separately. The document presents profiles for airport-related emission sources including aircraft, ground support equipment (GSE), and motor vehicles. As a result of ESA's literature search on available HAP data (including a review of the Federal Aviation Administration's (FAA's) recent documentation¹); four HAP speciation profile datasets were evaluated for use in estimating emissions from commercial turbine engine aircraft. Because the O'Hare Environmental Impact Statement (EIS) will be the first FAA EIS presenting project-related HAPS emissions and the selection of the dataset could be subjective, we request that the information in this Memorandum be submitted to the United States Environmental Protection Agency (USEPA) and the Illinois Environmental Protection Agency (IEPA), along with the speciation profile document, for their review and comment.

The following briefly summarizes the methodology that will be used to perform the OMP HAP assessment²:

- A literature search will be conducted to identify available HAP measurement studies for airports within the United States (U.S.) and studies for sources the same as those operating at airports (i.e., diesel construction equipment).
- The criteria air pollutant precursor volatile organic compound (VOC) and non-aircraft particulate matter (PM) emissions inventory by source type will be speciated to individual HAPs on a quantitative basis using speciation profiles obtained from the literature search.
- The speciated HAP emissions will be ranked relative to each pollutant's toxicity value.
- A comparative analysis will be performed between the OMP-related HAP levels and HAP levels reported for other U.S. airports/sources and to regional (area wide) source totals.

¹ Federal Aviation Administration, 2003, *Select Resource Materials and Annotated Bibliography on the Topic of Hazardous Air Pollutants (HAPs) Associated with Aircraft, Airports, and Aviation*, Office of Environment and Energy.

² Environmental Science Associates, 2003, *Analysis Protocol for Hazardous Air Pollutant Speciation Profiles – O'Hare Modernization Program EIS*, February.

- A *qualitative* assessment will be performed by comparing the operational levels and health risks reported in other HAP studies to the forecast operational levels with the OMP.

It should be noted that there is limited testing, modeling, or other documentation available that identifies and quantifies HAPs associated with airport sources. In fact, recent publications question the accuracy of available HAP emission profiles to appropriately represent emissions resulting from a key source at airports, the operation of the current (or future) commercial aircraft fleet.³ Additionally, the speciation profiles obtained from available research or regulatory agencies are intended to be used to develop *gross* estimates of HAP emissions on a state- and region-wide basis. As such, the profiles may not be appropriate to assess the site-specific impact analyses of HAP levels at the project level (for an individual airport). Moreover, the human health and environmental effects of airport-related HAPs combined with HAPs from other sources are not well documented. Therefore, although the recommended HAP speciation profiles are based on the best data, information, and techniques currently available, *ESA considers that all of the profiles include a high degree of uncertainty.*

To assist in the review of the speciation datasets, this Memorandum 1) provides summary information for each dataset, 2) reviews and compares the datasets, and 3) provides ESA's recommendation on the data to be used in the OMP analysis. Referenced sources should be consulted if additional detail/information is desired.

Quality of Available Data

The following describes the four aircraft-related HAPs datasets:

- *USEPA Dataset*

The USEPA dataset uses as a base, results of tests performed by C.W. Spicer for the USAF during the mid-1980's.^{4,5,6} Only one of the engines tested could be considered representative of today's commercial aircraft engines (the CFM56-3). The testing was performed using JP-5 jet fuel, a fuel that is not in current use by commercial aircraft.

- *CARB Dataset*

The CARB dataset also uses, as its base, the testing performed by C.W. Spicer for the USAF (described above) with one exception. The CARB removed silicon-containing material from the test data and renormalized the remaining profiles. Therefore, the CARB dataset is also based on testing that was performed in the mid-1980's on only one engine using fuel that is not in current use.

³ Vanderbilt, Pamela, 2003, *Health Risk Assessment of Air Toxics from Airports; The State of the Science, May 2002*, CH2M Hill with John Lowe, presented to the Air & Waste Management Association; Hayes, Stanley, 2003, *Characterizing Air Toxics Composition of Jet Exhaust for Airport Health Risk Assessments*, presented at an Air & Waste Management Association conference; Pehrson, John, 2003, *Toxic Air Contaminant Emissions from Aircraft – A Literature Review of Aircraft Engine Measurements*, (other contributors include Wei Guo, Teresa Raine, Vincent Tino, and Roger Johnson – Los Angeles World Airports), presented at an Air & Waste Management Association conference; and CDM, 2003, *A Preliminary Study and Analysis of Hazardous Air Pollutant Emissions from a Commercial Airport using Modeled and source Speciation Profiles*, by Wei Guo, John Pehrson, Teresa Raine, James LaVelle, and Vincent Tino, presented at an Air & Waste Management conference.

⁴ Spicer, C.W.; Holdren, M.W.; Lyon, T.F.; Riggan, R.M., *Composition and Photochemical Reactivity of Turbine Engine Exhaust*, U.S. Air Force Engineering and Services Center, 1984.

⁵ Spicer, C.W.; Holdren, M.W.; Miller, S.E.; Smith, D.L.; Smith, R.N.; Kuhlman, M.R.; Hughes, D.P., *Aircraft Emissions Characterization: TF41-A2, TF30-P103, and TF30-P109 Engines*, U.S. Air Force Engineering and Services Center, 1987.

⁶ Spicer, C.W.; Holdren, M.W.; Miller, S.E.; Smith, D.L.; Smith, R.N.; Kuhlman, M.R.; Hughes, D.P., *Aircraft Emissions Characterization*, U.S. Air Force Engineering and Services Center, 1988.

- *USAF Dataset*

In 1999, T. Gerstle, working for the USAF, tested, characterized, and evaluated the exhaust emissions (including HAPs) of eighteen military aircraft engines. Twelve of the engines are representative of current turbofan engine technology. Ten of the twelve engines were subject to HAP testing. One engine, the F108-CF-100, is the military version of the CFM56 engine, a newer model of the engine tested by Spicer in 1983. The testing was performed using JP-8 fuel, a fuel similar to today's commercial grade Jet A fuel. HAP emissions from JP-8 fuel are closer to those from Jet-A fuel because the molecular formulations of the two fuels are closer to each other than the molecular formulations of the JP-8 versus JP-5 fuel.

- *Oakland Dataset*

The Port of Oakland recently completed an air quality analysis that included a health risk assessment. The analysis was performed to support a State Environmental Impact Report (SEIR) for the Airport Development Program at Oakland International Airport. The CARB requested that the HAP profiles be developed using all available test data. Therefore, the Oakland speciation profiles represent composite data of the older USEPA data, the CARB data, and the more recent USAF data. The data were calculated using simple averages (no weighting). Notably, because the average included values from both the USEPA and CARB values (results from testing for the same engine), the earlier test data was essentially counted "twice". The reason for the "double counting" is not known.

Table 1 provides the speciation profiles for 9 of the 26 most prevalent HAPs emitted from turbine engine aircraft⁷. These 9 compounds represent 91 and 96 percent of the speciated HAP emission totals using the USEPA and USAF data, respectively (the remaining 17 HAP profiles account for 9 and 4 percent of the HAP emission totals, respectively). The profiles provided in Table 1 are representative of those which would occur during one landing (arrival) and takeoff (departure) cycle (an LTO). The USEPA and CARB data were available per LTO. For comparative purposes, ESA developed the USAF and Oakland speciation profiles using USEPA default times in mode for commercial aircraft.

Table 1 – HAP Speciation Profiles (Per LTO)

Pollutant	Speciation Profiles			
	USEPA ^a	CARB ^b	USAF ^c	Oakland ^d
Acetaldehyde	0.052	0.053	0.005	0.017
Acrolein	0.025	0.026	0.003	0.009
Benzene	0.019	0.022	0.021	0.019
Ethylbenzene	0.002	0.002	0.002	0.003
Formaldehyde	0.150	0.173	0.118	0.114
Naphthalene	0.006	0.007	0.003	0.004
Toluene	0.005	0.006	0.009	0.017
Styrene	0.004	0.005	0.002	0.004
Xylenes	0.005	0.005	0.004	0.012

^a Source: USEPA's Speciate database
^b Source: California Air Resource Board, Air Toxics Emission Factors II (CATEF Version 1.2), 2001.
^c Average speciation factors for relevant aircraft. Calculated using USEPA default times in mode.
^d Calculated using USEPA default times in mode.

⁷ USEPA 2002 National Toxics Inventory, 2003.

As shown in Table 1, when comparing the USEPA and USAF datasets, the speciation profiles for ethylbenzene are the same. For formaldehyde and xylenes, the profiles are within 25 percent of each other. For naphthalene and styrene, the data differ by approximately 50 percent. Finally, for acetaldehyde, acrolein, and toluene, the data differ by as much as 90 percent. Similar comparisons were not performed for the CARB and Oakland datasets as these data are based on the USEPA and USAF datasets (the CARB values are renormalized USEPA data after extracting silicon containing materials from the USEPA values and the Oakland values are a composite of the USEPA, CARB, and USAF dataset values).

Base Data and Applicability to O'Hare

The values from the USEPA and USAF datasets are the base values for the CARB and Oakland datasets. As such, this section of the Memorandum provides additional information regarding the USEPA and USAF datasets. As previously stated, the USEPA values are representative of testing from one commercial aircraft engine and the USAF dataset is based on testing of ten military aircraft engines. The following presents the results of research conducted to identify civilian engine counterparts and/or designations for the USAF military engines and to evaluate the applicability of either dataset to the existing (2002) and forecast future (2018) aircraft fleet mix at O'Hare.

Table 2 presents a summary of information for the USEPA engine (CFM56-3). Because the testing was performed in 1983, the engine that was tested was likely a CFM56-3B1. Based on information provided in JP-Airline Fleets (2003/2004 Edition), there are currently 313 US registered cargo and commercial passenger aircraft operating with this engine. Using information from the FAA regarding the fleet of aircraft operating in 2003, the 313 aircraft represent approximately 4.1 percent of the national aircraft fleet (air carrier, cargo, and commuter aircraft). Based on the current (2002) aircraft fleet mix, aircraft with this engine represent approximately 7.0 percent of the total aircraft operating at O'Hare (Boeing 737s). Finally, using forecast of the future fleet mix, by the design year for the OMP (2018), no aircraft will be operating at O'Hare with this engine type.

Table 3 presents a summary of information for the ten USAF engines. To determine the closest civilian engine counterpart and/or civilian designation, the specifications for each of the military engines were reviewed. Based on the results of the review, three of the military engines do not have civilian counterparts or designations (F110-GE-100, F188-GE-100, and F404-GE-F1D2/400). Again, using FAA data regarding the fleet of aircraft operating in 2003, the aircraft with civilian counterparts/designations represent approximately 5.3 percent of the national aircraft fleet. Based on the current (2002) aircraft fleet mix for O'Hare, aircraft with these engines represent approximately 8.5 percent of the fleet operating at the Airport. Finally, using the forecast future fleet mix, approximately 0.6 percent of the aircraft will be operating at the Airport in 2018 (Boeing 757's and Challenger 601/604 or Canadair Regional Jets (CRJs)).

Table 2 - Aircraft Engine Information – USEPA Database

Civilian					
Engine	Aircraft	Category	Notes ^e	% of National Fleet (2003)	% of OMP Fleet (2002/2018)
CFM56-3 ^c	B737-300 ^d 	Large Commercial Jet	Because the testing on this engine was performed in 1983, the engine was likely a CFM56-3B1. Currently, there are 313 US registered aircraft operating with this engine (air carrier and cargo).	4.1	7.0/0.0

^a McGraw-Hill Companies - Aviation Weeks World Aviation Directory and Aerospace Database – 2004 Sourcebook (<http://www.aviationnow.com/content/reference/sourcebook/sourcebook.htm>)
^b General Electric Company (<http://www.geae.com/engines/commercial/cf6.history.html>)
^c General Electric Company (<http://www.geae.com/engines/military/T101/index.html>)
^d General Electric Company (<http://www.geae.com/aboutgeae/history.html>)
^e JP-Airline Fleets – International, Edition 2003/04.
Note: Engines in bold and italic text indicates tested engine.
Compiled by Environmental Science Associates, 2004.

Table 3 - Aircraft Engine Information – USAF Database

Military			Civilian				% National Fleet (2003) ^g	% OMP Fleet (2002/2018)
Engine	Representative Aircraft	Category	Engine	Representative Aircraft	Category	Notes ^h		
TF39-GE-1C (GE)	C-5A (Galaxy) ^f 	Cargo/Transport/Refueling ^a	CF6-6 ^g	DC-10, L1011 ^h 	Heavy Commercial Jet	Closest in specification to the CF6-6K/K2 models. 17 US registered cargo aircraft	0.2	0.2/0.0
F110-GE-100 (GE)	F-16C/D (Fighting Falcon) ^b 	Fighter ^a	None	--	--	--	--	--
F101-GE-102 (First GE-produced turbofan with an augmentor)^b	B-1B (Lancer) ^a 	Bomber ^a	CFM56 ^c	A-340-200/300 ^g 	Large Commercial Jet	Closest in specification to the CFM56-SC2 model. Not in current use on any US registered commercial aircraft.	0.0	0.0/0.0
TF33-P-102 (Pratt Whitney)	C-135b (Stratolifter) ^d 	Cargo/Transport/Refueling ^a	JT3 ^e	Boeing 707-138 ^{d,f} 	Large Commercial Jet	JT3D-1/3B/7 models in current use - 55 US registered government and cargo 707, 720, DC-8-61/62/63 aircraft	0.7	0.8/0.0
F108-CF-100 (CFM)	KC135R (Stratotanker) ^a 	Cargo/Transport/Refueling ^a	CFM56-2 ^c	DC-8 ^e 	Heavy Commercial Jet	CFM56-2c model in limited current use - 71 US registered government and cargo DC-8-71/72/73 aircraft	0.9	0.2/0.0
TF33-P-77A (Pratt Whitney)	C141B/C (Starlifter) ^a 	Cargo/Transport/Refueling ^a	JT3D-5 ^f	DC-8-50, Boeing 707-120B ^f (see representative photos above)	Heavy Commercial Jet	Not in current use on any US registered commercial aircraft.	0.0	0.0/0.0
F117-PW-100 (Pratt Whitney)	C-17A (Globemaster 3) ^a 	Cargo/Transport/Refueling ^a	PW2000 ^g	Boeing 757 ^h 	Large Commercial Jet	Closest in specification to PW2040 model. 45 US registered 757 carrier, cargo, and government/corporate aircraft.	0.6	7.0/0.1
F-118-GE-100 (GE)	B2 (Spirit) ^a 	Bomber ^a	None	--	--	--	--	--
F404-GE-F1D2.400 (GE - no afterburner)^g	F-117 (Nighthawk) ^a 	Attack ^a	None	--	--	--	--	--
TF34-GE-100A (GE)	A-10A (Thunderbolt 2) ^a 	Attack ^a	CF-34 ^g	Challenger 601/604 ^m 	Large General Aviation Jet	Closest in specification to CF34-3A/3A1 models. 225 US registered CL601-3A/3R and CRJ100ER commuter and cargo aircraft	2.9	0.3/0.5

^a McGraw-Hill Companies - Aviation Weeks World Aviation Directory and Aerospace Database - 2004 Sourcebook (<http://www.aviationnow.com/content/reference/sourcebook/sourcebook.htm>)
^b General Electric Company (<http://www.ge.com/engines/military/f110/f110-100-400.html>)
^c General Electric Company (<http://www.ge.com/engines/military/f108/index.html>)
^d Designations of U.S. Air Force Projects, Andreas Parsch, January 24, 2004 (<http://www.designation-systems.net/usmilav/projects.html>)
^e The Global Aircraft Organization (http://www.globalaircraft.org/planes/f-117_nighthawk.pl)
^f Federation of American Scientists, Washington DC 2004 (<http://www.fas.org/irp/military/101/sv/ac/c-135.html>)
^g General Electric Company (<http://www.ge.com/engines/commercial/cf6/history.html>)
^h General Electric Company (<http://www.ge.com/engines/military/f101/index.html>)
ⁱ Aerospace Web Organization, May 12, 2001 (<http://aerospacweb.org/aircraft/transport-m/c135/>)
^j General Electric Company (<http://www.ge.com/engines/military/f14/>)
^k Defense Aerospace.com (http://www.defense-aerospace.com/cgi-bin/client/modele.pl?prod=25346&session=die_2834298.1085169215.QK4908C99DUAABWPLTE&modele=jdc_11)
^l Pratt & Whitney, 2004 (http://www.pw.com/about_history/classic_fm.asp)
^m General Electric Company (<http://www.ge.com/engines/corporate/cf34-3.html>)
ⁿ Boeing (<http://www.boeing.com/commercial/707/family/>) and Aerofiles (<http://www.aerofiles.com/boe.html>)
^o General Electric Company (<http://www.ge.com/aboutge/history.html>)
^p JP-Airline Fleets - International, Edition 2003/04.
^q FAA Aerospace Forecast Book, 2004-2015, March 2004; Percentages based on 4,090 air carrier aircraft, 942 air carrier cargo aircraft, and 2,672 regional commuter aircraft. Values were not available for general aviation cargo aircraft. Therefore, percentages presented in this table should be considered conservative.
Note: Engines in bold and italic text are the tested engines
 Compiled by Environmental Science Associates, 2004.

Considerations/Recommendations for the O'Hare Speciation Profile Dataset

ESA does not recommend using the USEPA, CARB, or Oakland datasets for the OMP analysis. The reasons for this recommendation are as follows:

- The USEPA and CARB datasets are based on tests that included only one engine that could be considered representative of those in the current aircraft fleet. The tested engine was manufactured at least 20 years ago. Newer models of this engine have been redesigned to operate at higher pressures and temperatures. With the higher temperatures, combustion is more complete. Modern engines are more fuel-efficient, emit lower levels of HAPs, and the mix of HAPs is different than the engine that was tested in 1983. Notably, there have been at least four new models of the CFM56, with considerable design changes, since the CFM56-3 was introduced. The latest model being the CFM56-7.
- The USEPA/CARB testing was performed with a fuel that is not comparable to the fuel used by today's commercial aircraft fleet.
- The Oakland dataset includes both the USEPA and CARB values. Because the CARB data is modified USEPA data, use of the Oakland data sets essentially "double counts" values from testing of the older engine.

Based on the information provided above, *ESA recommends that the values from the USAF dataset be used to assess HAP emission levels associated with the proposed OMP.* The reasons for this recommendation are as follows:

- The USAF dataset is based on the most recent tests, the tests were performed on more than one engine, and the majority of the engines are representative of aircraft in the current commercial aircraft fleet.
- The USAF testing was performed with JP-8 fuel, a fuel that is considered comparable to the fuel used for today's commercial aircraft fleet (Jet-A).

As previously stated, three of the engines within the USAF dataset do not have civilian counterparts or designations (F110-GE-100, F188-GE-100, and F404-GE-F1D2/400). These military engines are used on F-16, B2, and F-177 aircraft (fighter, bomber, and attack aircraft, respectively). Because these aircraft would not use O'Hare, *ESA proposes that the results of the testing for engines used on the F-16, B2, and F-177 aircraft be excluded from the O'Hare dataset.*

As also previously stated, ESA recognizes that the selection of the database could be considered subjective. As such, the following provides alternatives that could be considered (Option 1 is the the recommended alternative).

- Option 1 – Average values for the seven engines within the USAF dataset with civilian counterparts/designations (the recommended option).
- Option 2 – Average values for all ten aircraft within the USAF dataset.
- Option 3 – Average values for the USEPA dataset plus the values for the seven USAF engines.
- Option 4 – Average values for the USEPA dataset plus values for all ten of the USAF engines.

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The calculated speciation profiles for each alternative are provided in Table 4. Notably, the USAF dataset does not include profiles for propionaldehyde or 1,3-Butadiene. As such, the data from the USEPA would be used for these compounds regardless of alternative.

Table 4 – Speciation Profiles

Pollutant	Fraction of Total Organic Gases or Volatile Organic Compounds			
	Option 1	Option 2	Option 3	Option 4
	USAF seven engines	USAF – ten engines	USEPA/USAF seven engines	USEPA/USAF ten engines
Acetaldehyde	0.004	0.005	0.010	0.009
Acrolein	0.003	0.003	0.006	0.005
Benzene	0.016	0.021	0.016	0.021
Ethylbenzene	0.002	0.002	0.002	0.002
Formaldehyde	0.096	0.118	0.103	0.121
Naphthalene	0.003	0.003	0.003	0.003
Toluene	0.008	0.009	0.007	0.009
Styrene	0.002	0.002	0.002	0.003
Xylenes	0.003	0.004	0.004	0.005
Isobutyraldehyde	0.004	0.004	0.004	0.004
Acenaphthylene	0.0002	0.0002	0.0002	0.0002
Phenanthrene	0.0002	0.0002	0.0002	0.0002
Fluorene	0.0002	0.0002	0.0002	0.0002
Fluoranthene	0.0002	0.0002	0.0001	0.0001
Pyrene	0.0002	0.0002	0.0001	0.0001
Anthracene	0.0002	0.0002	0.0001	0.0001
Acenaphthene	0.0002	0.0002	0.0001	0.0001
Benzo(ghi)perylene	0.0002	0.0002	0.0001	0.0001
Benzo(b)fluoranthene	0.0002	0.0002	0.0001	0.0001
Benzo(k)fluoranthene	0.0002	0.0002	0.0001	0.0001
Benzo(a)anthracene	0.0002	0.0002	0.0001	0.0001
Benzo(a)pyrene	0.0002	0.0002	0.0001	0.0001
Chrysene	0.0002	0.0002	0.0001	0.0001
Indeno(123cd)pyrene	0.0002	0.0002	0.0001	0.0001
Propionaldehyde ^a	0.0095	0.0095	0.0095	0.0095
1,3-Butadiene ^a	0.0180	0.0180	0.0180	0.0180

Values reflect rounding.

^a Values for these pollutants are only available in the USEPA dataset. These values would be assumed regardless of dataset selection.

ATTACHMENT I-4 HAZARDOUS AIR POLLUTANT SPECIATION PROFILES

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Chicago O'Hare
International Airport

This document presents recommended HAP speciation profiles for air emission sources associated with the O'Hare Modernization Program. Based on an extensive literature search and gathering of data, speciation profiles are reported for aircraft, nonroad equipment, onroad vehicles, and stationary sources.

Draft

**Hazardous Air Pollutant
Speciation Profiles**

O'Hare Modernization Program
Environmental Impact Statement

June 29, 2004

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Chapter

1

Introduction

1.1 Background and Purpose

The City of Chicago Department of Aviation (City) is proposing a program to modernize O'Hare International Airport (Airport or O'Hare). Known as the O'Hare Modernization Program (OMP), the program includes the addition of one new runway and the relocation of three existing runways into an east-west configuration. The future Airport, as currently envisioned by the City, would consist of eight runways (six east-west parallel runways and two northeast-southwest parallel runways). The OMP could also involve relocation of some or all of the existing navigation aids, placement of new navigation aids, provision of a new western access to the Airport, construction of additional terminal facilities, and relocation of various roadways and rail lines. Based on the potential impacts associated with the proposed improvements, the Federal Aviation Administration (FAA) has determined that preparation of an Environmental Impact Statement (EIS) will be required. Additional details regarding the OMP and graphics illustrating the proposed airfield development concept can be viewed at <http://modernization.ohare.com/>. The emission sources associated with the OMP include aircraft, nonroad equipment, stationary sources, and motor vehicles.

This document identifies the hazardous air pollutant (HAP) speciation profiles¹ that will be used to provide an estimate of OMP-related HAP emissions. This document supplements the February 2003 *Analysis Protocol for Hazardous Air Pollutants*, as presented and accepted by the Illinois Environmental Protection Agency (IEPA) and FAA. The HAP speciation profiles will be applied to the project-related emissions of hydrocarbons (HC) (or volatile organic compounds (VOC)) and particulate matter (PM) to assess the potential increase/decrease in HAP levels with the OMP.

It should be noted that limited testing has been performed that affirmatively identifies and quantifies HAP levels associated with airports (in general) and aircraft (in particular). As such, although the HAP speciation factors presented in this document are based on the best data, information, and techniques currently available, the factors are subject to a high degree of imprecision and uncertainty.

1.2 HAP Regulations and Airport-Related Guidelines/Guidance

Under the federal Clean Air Act (CAA) and its amendments, the U.S. Environmental Protection Agency (USEPA) identified 188 air pollutants as HAPs that are subject to the requirements of Section 112 (National Emission Standards for Hazardous Air Pollutants) of the Act. These requirements apply to emissions from both major and area stationary sources. The major and area stationary sources include pulp and paper facilities, surface coating activities, gasoline distribution centers, and iron and steel foundries. Aircraft engine test cells are also regulated when they are located at a major stationary source of HAP emissions². Other activities at an airport that may also be regulated by Section 112 of the Act include aircraft repair/maintenance facilities and central heating plants.

The USEPA prepares a nationwide assessment of aircraft-related HAPs as part of the National Toxics Inventory (NTI). The NTI is a comprehensive database for all stationary and mobile HAP emission sources

¹ Speciation profiles are the percentage of HAPs in particulate matter (PM) or hydrocarbons (HC) in the exhaust.

² Federal Register, Volume 68, May 27, 2003.

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on a state and county basis. Using 1993 as the baseline for the NTI and updating it every three years (i.e., 1996, 1999, etc.), the USEPA (2000, 2001) tracks changes in gross HAP emissions, including those associated with aircraft and airports. To support the NTI, the USEPA's Office of Transportation and Air Quality (OTAQ) developed a list of HAPs emitted from the operation of aircraft and their ground support equipment (GSE). The initial list of 14 HAPs consists primarily of VOCs – 12 individual substances and two groups of complex polycyclic organic materials (POMs).

The USEPA also designated 21 HAPs as mobile source air toxics (MSATs), or HAPS that are emitted by motor vehicles and nonroad engines. These MSATs include VOCs and heavy metals that are more commonly associated with the combustion of gasoline and diesel fuels, including diesel exhaust particulates. Included in the nonroad category of HAP sources are construction equipment and airport GSE, both diesel- and gasoline-powered. For diesel-powered equipment, significant reductions in VOCs, particulate matter (PM), and other pollutants are in place or planned due to what are known as Tier 1, Tier 2, and Tier 3 standards. For gasoline-powered equipment, effective exhaust control programs have been in place for many years. The existing or planned nonroad emission control programs are expected to result in significant reductions in HAPs from these sources.

The FAA's *Selected Resource Materials and Annotated Bibliography on the Topic of HAPs Associated with Aircraft, Airports, and Aviation*³ provides a comprehensive discussion of publicly available information pertaining to HAP emissions associated with airports. The publication provides information regarding the common HAP emissions associated with aircraft engines and airport operations, HAP monitoring data collected on, and in the vicinity of, several major metropolitan airports (including O'Hare), and a discussion of the limited availability and accuracy of airport-related HAP emission factors (speciation profiles).

³ Select Resource Materials and Annotated Bibliography on the Topic of Hazardous Air Pollutants (HAPS) Associated with Aircraft, Airports, and Aviation, Federal Aviation Administration, July 1, 2003.

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Chapter

2

Data Review/Speciation Profiles

This Chapter provides the basis for the selected HAP speciation profiles that will be used to evaluate the emission sources associated with the OMP. The profiles will be applied, as applicable, to the HC and PM emission inventories prepared in support of the criteria air pollutant analysis. Essentially, the results of the HC and PM criteria pollutant emission inventories will be segregated according to source category (i.e., aircraft, ground service vehicles (GSE), stationary sources, motor vehicles, etc.). The speciation profiles for each source category will then be applied to the source-specific information to obtain source-specific inventories of HAPs. Additional details regarding the assessment methodology are provided in the *Analysis Protocol for Hazardous Air Pollutants* (published separately). The document was also prepared in support of OMP evaluation.

The following discusses the available information and recommended speciation profiles for each of the airport-related sources that will be evaluated.

2.1 Aircraft

The level of HAP emissions from aircraft varies depending on the age and model of an engine, the number of engines, and the type of fuel. The level of emissions also depends on the aircraft operating mode (approach, climbout, takeoff, and taxi/idle) and the time spent in each mode. By definition, approach emissions are those that occur from the point where aircraft drop below the local inversion height⁴ to the runway threshold. Takeoff mode emissions occur along the runway and continue until the aircraft reaches an altitude of 500 feet. Climbout emissions are those that occur between 500 feet in altitude and the inversion height. Taxi/idle emissions occur as aircraft taxi in to and out of terminal gates and cargo facilities. Excess delay (or idle) can be a significant contributor to the total aircraft-related HAP emissions at an airport.

The relevant sources of information for aircraft HAP speciation profiles include:

- Spicer, C.W. et al., 1984. *Composition and Photochemical Reactivity of Turbine Engine Exhaust*, March.
- Spicer, C.W. et al., 1988. *Aircraft Emissions Characterization*, March.
- Spicer, C.W. et al., 1990. *Aircraft Emissions Characterization of F101 and F110 Engines*.
- The California Air Resources Board (CARB) maintains and updates estimates of the chemical composition and size fractions of PM and the chemical composition and reactive fractions of VOC.
- USEPA, 2000. *Documentation for the 1996 Base Year National Toxics Inventory for Aircraft Sources*, June 2.
- USAF, 1999. *Aircraft Engine and Auxiliary Power Unit Emissions Testing: Volumes 1–3*, March.
- USAF, 2002. *Aircraft/Auxiliary Power/Aerospace Ground Support Equipment Emissions Factors*, October.
- USEPA, 2002. *Documentation for the 1999 Base Year Aircraft, Commercial Marine Vessel, and Locomotive National Emission Inventory for Criteria and Hazardous Air Pollutants*, November.
- Hayes, Stanley R., 2003. *Characterizing Air Toxics Composition of Jet Exhaust for Airport Health Risk Assessments*, June.
- SPECIATE3.2 – USEPA's repository of VOC and PM speciated profiles.

⁴ The local inversion height is the height at which significant mixing of pollutants occurs within the atmosphere.

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2.1.1 Turbine Engines

As previously stated, limited testing has been performed that identifies and quantifies HAP levels associated with airports (in general) and aircraft (in particular). This is especially true with respect to the level and composition of turbine engine HAP emissions. In coordination with the FAA and USEPA, it was determined that the most appropriate turbine engine HAP speciation profiles would be data from testing performed by the USAF in 1999. The following provides a brief summary of the testing effort by the USAF and the applicability of the data to both the current and future turbine engine aircraft operating at O'Hare.

USAF HAP Emission Testing

In 1999, T. Gerstle, working for the USAF, tested, characterized, and evaluated the exhaust emissions (including HAPs) of eighteen military aircraft engines. Twelve of the engines are considered representative of current turbofan engine technology. Ten of the twelve engines were subject to HAP testing. A listing of the ten engines and representative military aircraft on which these engines are/were used is provided in Table 1. The military aircraft are categorized as cargo/transport refuelers, fighters, bombers, and attack aircraft.

In some cases, although an engine has the same specifications, the military uses its own engine identifiers. As such, additional research was conducted to determine if the USAF tested military engines have civilian designations/counterparts. The results of this research are provided in Table 1. As shown, it was determined that seven of the ten military engines have specifications similar to civilian aircraft engines. Representative civilian aircraft on which these engines are/were used is also provide in Table 1. As shown, the engines are/were used aircraft such as DC-10s, A-340-200/300s, 707s, DC-8s, 757s, and Challenger 601/604s. It was determined that the testing data for the seven aircraft would be used to evaluate OMP-related HAP emissions.

To evaluate the applicability of the USAF engine testing to the current turbine engine aircraft operating nationally, and to the current/future fleet mix at O'Hare, an aviation fleet database (JP-Airline Fleets – International Edition 2003/2004) and the current/forecast data prepared in support of the OMP evaluation were consulted. Results of this effort indicate that aircraft operating with the evaluated types of engines comprise slightly more than 5 percent of the national fleet and only 8.5 percent of the current fleet operating at O'Hare. Further, by the year 2018, less than one percent of these aircraft will be operating at the Airport. Therefore, it should be noted that even the USAF data has limited applicability to the actual aircraft that will be evaluated.

It should also be noted that the USAF testing was performed using JP-8 fuel. JP-8 fuel is the military equivalent of Jet A-1 fuel—a fuel not used within the U.S. Currently, aircraft operating within the US use Jet A fuel. Although differences between Jet A-1 and Jet A are considered minimal, the level of tested/predicted HAP emissions could be affected by the differences.

The HAP speciation profiles for turbine engine aircraft are provided in Table 2.

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Table 1 – Turbine Engine Information – USAF Database

Military			Civilian					
Engine	Representative Aircraft	Category	Engine	Representative Aircraft	Category	Notes ^p	% National Fleet (2003) ^q	% OMP Fleet (2002/2018)
TF39-GE-1C (GE)	C-5A (Galaxy) ^a 	Cargo/Transport / Refueling ^a	CF6-6 ^b	DC-10, L1011 ^b 	Heavy Commercial Jet	Closest in specification to the CF6-6K/K2 models. 17 US registered cargo aircraft	0.2	0.2/0.0
F110-GE-100 (GE)	F-16C/D (Fighting Falcon) ^c 	Fighter ^d	None	--	--	--	--	--
F101-GE-102 (First GE-produced turbofan with an augmentor)^h	B-1B (Lancer) ^a 	Bomber ^a	CFM56 ^o	A-340-200/300 ^g 	Large Commercial Jet	Closest in specification to the CFM56-5C2 model. Not in current use on any US registered commercial aircraft.	0.0	0.0/0.0
TF33-P-102 (Pratt Whitney)	C-135b (Stratolifter) ^d 	Cargo/Transport / Refueling ^a	JT3 ^e	Boeing 707-138 ^f 	Large Commercial Jet	JT3D-1/3B/7 models in current use - 55 US registered government and cargo 707, 720, DC-8-61/62/63 aircraft	0.7	0.8/0.0
F108-CF-100 (CFM)	KC135R (Stratotanker) ^a 	Cargo/Transport / Refueling ^a	CFM56-2 ^e	DC-8 ^e 	Heavy Commercial Jet	CFM56-2c model in limited current use - 71 US registered government and cargo DC-8-71/72/73 aircraft	0.9	0.2/0.0
TF33-P-77A (Pratt Whitney)	C141B/C (Starlifter) ^h 	Cargo/Transport / Refueling ^a	JT3D-5 ^e	DC-8-50, Boeing 707-120B ^f (see representative photos above)	Heavy Commercial Jet	Not in current use on any US registered commercial aircraft.	0.0	0.0/0.0
F117-PW-100 (Pratt Whitney)	C-17A (Globemaster 3) ^a 	Cargo/Transport / Refueling ^a	PW2000 ^e	Boeing 757 ^g 	Large Commercial Jet	Closest in specification to PW2040 model. 45 US registered 757 carrier, cargo, and government/corporate aircraft.	0.6	7.0/0.1
F-118-GE-100 (GE)	B2 (Spirit) ^a 	Bomber ^a	None	--	--	--	--	--
F404-GE-F1D2/400 (GE - no afterburner)^g	F-117 (Nighthawk) ^h 	Attack ^g	None	--	--	--	--	--
TF34-GE-100A (GE)	A-10A (Thunderbolt 2) ^a 	Attack ^g	CF-34 ⁱ	Challenger 601/604 ^m 	Large General Aviation Jet	Closest in specification to CF34-3A/3A1 models. 225 US registered CL601-3A/3R and CRJ100ER commuter and cargo aircraft	2.9	0.3/0.5

^a McGraw-Hill Companies - Aviation Weeks World Aviation Directory and Aerospace Database – 2004 Sourcebook (<http://www.aviationnow.com/content/reference/sourcebook/sourcebook.htm>)
^b General Electric Company (<http://www.geae.com/enines/military/f101/f101-100-400.html>)
^c General Electric Company (<http://www.geae.com/enines/military/f108/index.html>)
^d Designations of U.S. Air Force Projects, Andreas Parsch, January 24, 2004 (<http://www.designation-systems.net/usmilav/projects.html>)
^e The Global Aircraft Organization (http://www.globalaircraft.org/planes/f-117_nighthawk.pj)
^f Federation of American Scientists, Washington DC 2004 (<http://www.fas.org/man/dod-101/sys/acrc-135.htm>)
^g General Electric Company (<http://www.geae.com/enines/commercial/history.html>)
^h General Electric Company (<http://www.geae.com/enines/military/f101/index.html>)
ⁱ Aerospace Web Organization, May 12, 2001 (<http://aerospacweb.org/aircraft/transport-m/c135/>)
^j General Electric Company (<http://www.geae.com/enines/military/f34/>)
^k Defense Aerospace.com (<http://www.defense-aerospace.com/cgi-bin/client/modele.p?prod=25346&session=dae3834268.1085160015.QK4908Oa9tJAARvPI,TE&modele=jdc.1>)
^l Pratt & Whitney, 2004 (http://www.pw.com/about/history/classic_r34.asp)
^m General Electric Company (<http://www.geae.com/enines/commercial/cf34-3.htm>)
ⁿ Boeing (<http://www.boeing.com/commercial/707/family/>) and Aerofiles (<http://www.aerofiles.com/boe.html>)
^o General Electric Company (<http://www.geae.com/about/geae/history.html>)
^p JP-Airline Fleets – International, Edition 2003/04.
^q FAA Aerospace Forecast Book 2004-2015, March 2004. Percentages based on 4,000 air carrier aircraft, 642 air carrier cargo aircraft, and 2,872 regional commuter aircraft. Values were not available for general aviation cargo aircraft. Therefore, percentages presented in this table should be considered conservative.
Note: Engines in bold and italic text are the tested engines
 Compiled by Environmental Science Associates, 2004.

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Table 2. Speciation Profiles for Turbine Engine Aircraft-

Pollutant	Fraction of Total Organic Gases or Volatile Organic Compounds
Acetaldehyde	0.004
Acrolein	0.003
Benzene	0.016
Ethylbenzene	0.002
Formaldehyde	0.096
Naphthalene	0.003
Toluene	0.008
Styrene	0.002
Xylenes	0.003
Isobutyraldehyde	0.004
Acenaphthylene	0.0002
Phenanthrene	0.0002
Fluorene	0.0002
Fluoranthene	0.0002
Pyrene	0.0002
Anthracene	0.0002
Acenaphthene	0.0002
Benzo(ghi)perylene	0.0002
Benzo(b)fluoranthene	0.0002
Benzo(k)fluoranthene	0.0002
Benzo(a)anthracene	0.0002
Benzo(a)pyrene	0.0002
Chrysene	0.0002
Indeno(123cd)pyrene	0.0002
Propionaldehyde ^a	0.0095
1,3-Butadiene ^a	0.0180
Values reflect rounding.	
^a Values obtained from the USEPA HAP speciation profile dataset.	

The level of metals emissions related to turbine engine aircraft will be estimated using the elemental analysis of Jet A fuel conducted by the US Navy (Shumway, 2000) and the Jet A consumption rate provided in the Emission Dispersion and Modeling System (EDMS) for the OMP specific engines. Table 3 presents the concentration of metals found in Jet A fuel.

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Table 3. Elemental Mass Fractions in Jet A for Turbine Aircraft

Pollutant	Mass Fractions (ppb)
Barium	3
Calcium	555
Chromium (Total)	26
Copper	5
Iron	210
Lead	11
Manganese	6
Mercury	Not detected
Nickel	Not detected
Scandium	11
Strontium	12
Sulfur	1220
Tin	10
Titanium	100
Vanadium	Not detected
Zirconium	16

ppb = parts per billion (by weight)

SOURCE: Shumway, 2000. *Trace Element and Polycyclic Aromatic Hydrocarbon Analysis of Jet Engine Fuels: Jet A, JP-5, JP-8*. December.

2.1.2 Piston Engines

Piston aircraft also emit HAPs, although such aircraft constitute a small percentage of the O'Hare operations. The recommended piston aircraft HC speciation profiles are identified as Profile 413 in the CARB's speciation database. Table 4 presents mass fractions, relative to total organic gases, from piston aircraft. These mass fractions will be applied to all piston aircraft operating modes.

Table 4. Total Organic Gases Speciation Profiles for Piston Aircraft

Pollutant	Speciation Profiles (wt%)
Formaldehyde	0.92
Acetaldehyde	0.56
Acrolein	0.13
Naphthalene	0.12
Benzene	3.76
Toluene	7.37
Ethylbenzene	1.47
Xylenes	5.60
Styrene	0.28
1,3-Butadiene	0.72

SOURCE: CARB, 2000. *Speciation Profiles and Size Fractions*. December.

Lead is the only major metal pollutant from piston aircraft engines (due to the continued use of leaded aviation gas). The lead speciation will be based on the existing (2002) throughput volume for primary aviation gasoline used at O'Hare. The lead speciation for 100 octane low-lead (100LL) is 0.56 grams per gallon. Future levels will be based on projected throughput volumes using the number of forecast piston engine aircraft within the aircraft fleet.

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2.2 Nonroad Equipment

Nonroad equipment include GSE, construction equipment (e.g., backhoes, bulldozers, asphalt pavers, etc.), industrial equipment (e.g., forklifts, sweepers, etc.), and commercial equipment (e.g., portable generators, air compressors, etc.). The estimates of HAPs will be prepared using VOC estimates from the USEPA's NONROAD (Version 2.2.0) emissions model. Notably, estimates of HAPs resulting from construction equipment-related PM will not be calculated as speciation profile data is not currently available.

2.2.1 Construction and GSE

Nonroad equipment is typically powered by two primary types of internal combustion engines: reciprocating and gas turbine. The majority of the equipment is powered by reciprocating engines (compression and spark ignition). Diesel-fueled engines are compression-ignited and gasoline engines are spark-ignited. Spark ignition (gasoline) engines are separated into two different design classes: 2-stroke and 4-stroke.

The VOC and PM emission factors are specific to the type and size of the nonroad equipment. The HAP speciation profiles take into account the different fuel types typically used by nonroad equipment and the fact that various regions use different gasoline blends (baseline, reformulated, and oxygenated).

Sources of the speciation profile data for nonroad equipment included:

- USEPA, 1998. *Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources*, September.
- USAF, 1999. *Aircraft Engine and Auxiliary Power Unit Emissions Testing: Volumes 1–3*, March.
- USEPA, 2000. *Documentation for the 1996 Base Year National Toxics Inventory for Aircraft Sources*, June 2.
- USAF, 2002. *Air Emission Inventory Guidance Document for Mobile Sources at Air Force Installations*, January.
- USEPA, 2002. *Documentation for the 1999 Base Year Aircraft, Commercial Marine Vessel, and Locomotive and Other Nonroad Components of the National Emission Inventory for Criteria and Hazardous Air Pollutants*, November.

The default HAP speciation profiles from the USEPA's 1999 NTI are recommended for use in the OMP evaluation. Table 5 presents the speciation profiles for diesel- and gasoline-fueled construction equipment and for gasoline-powered GSE.

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Table 5. Speciation Profiles for Diesel Construction Equipment and Gasoline Construction Equipment/GSE^{a,b}

Pollutant	Diesel	2-Stroke	4-Stroke
1,3-Butadiene	0.0019	0.0022	0.0095
Formaldehyde	0.1180	0.0035	0.0159
Benzene	0.0203	0.0226	0.0472
Acetaldehyde	0.0531	0.0033	0.0082
Ethylbenzene	0.0031	0.0218	0.0180
Styrene	0.0006	0.0012	0.0007
Acrolein	0.0030	0.0003	0.0007
Toluene	0.0150	0.0890	0.0654
Hexane	0.0016	0.0140	0.0098
Propionaldehyde	0.1180	0.0002	0.0019
2,2,4-Trimethylpentane	0.0007	0.0372	0.0193
Xylenes	0.0106	0.0978	0.0617
Naphthalene	0.0005	0.000004	0.0907

^a Default equipment and values (in most cases, rounded to four significant digits).^b Based on reformulated gasoline (oxygenated with ethanol). Some pollutants include both exhaust and evaporative emissions.SOURCE: USEPA, 2002e. *Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory.*

For diesel-powered GSE, USEPA's AP-42 emission factors for reciprocating and turbine engines are recommended. Table 6 presents these emission factors (in pounds per 1,000 gallons of fuel).

Table 6. Emission Factors for Diesel GSE (lbs/gallon of fuel)

Pollutant	Diesel Reciprocating Engines	Diesel Turbine Engines ^a
1,3-Butadiene	0.005	0.0022
Formaldehyde	0.162	0.0389
Benzene	0.128	0.0077
Acetaldehyde	0.105	-
Acrolein	0.013	-
Toluene	0.056	-
Xylenes	0.039	-
PAHs	0.023	0.0056
Naphthalene	0.012	0.0049
Arsenic	-	0.0015
Beryllium	-	0.00004
Cadmium	-	0.0007
Chromium	-	0.0015
Lead	-	0.0020
Manganese	-	0.1100
Mercury	-	0.0002
Nickel	-	0.0006
Selenium	-	0.0035

^a In most cases, rounded to four significant digits.SOURCE: USAF, 2002. *Air Emission Inventory Guidance Document for Mobile Sources at Air Force Installations.* January.

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2.2.2 Auxiliary Power Units

Auxiliary power units (APUs) are essentially small turbine engines that are used on larger aircraft to generate both electricity and compressed air. The electricity and compressed air operate an aircraft's instruments, lights, ventilation and other equipment when the main engines are not running. An APU also provides power to restart the aircraft's main engines after shutdown.

APU's may be activated when an aircraft is on approach and kept on during the taxi-in portion of the operation. The APU may also be activated once the aircraft is taxiing from the runway to the gate or when the pilot reaches an assigned gate. If a ground power system (115/200V, 400 Hz) and a source of pre-conditioned air (PCA) are available, use of the APU is not necessary once the aircraft is docked. In this situation, the aircraft is connected to the ground power system once the aircraft comes to a complete stop. In situations where the APU is not used at the gate, the APU will typically be restarted while the pilot performs departure checks.

It is recommended that the speciation profiles for APUs be the profiles for turbine engine aircraft (see separate memorandum discussing these types of aircraft engines).

2.3 Motor Vehicles

HAP speciation profiles for onroad (motor) vehicles are available from a number of sources. These speciation profiles are periodically revised by regulatory agencies. The MOBILE6.2 model provides the current tool for developing HAP speciation profiles for motor vehicles.

Vehicles traveling to and from the OMP will be considered in the EIS, including privately owned vehicles and commercial vehicles (rental cars, shuttles, buses, taxicabs, and delivery trucks). The evaluation will include the HAPs contribution from these vehicles both on-and off-airport property as well as within airport parking facilities.

The sources of speciation profile data for motor vehicles included:

- USEPA, 1997. *User's Guide to MOBILE6 (Mobile Source Emission Factor Model)*, April.
- USEPA, 2000. *Documentation for the 1999 Base Year National Toxics Inventory for Onroad Sources*, June 2.
- USAF, 2002. *Air Emission Inventory Guidance Document for Mobile Sources at Air Force Installations*, January.
- USEPA, 2002. *Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory, Volumes I and II*, November 11.

MOBILE6.2 is a modeling tool used to estimate emission factors for onroad mobile sources. Within the MOBILE6.2 model (USEPA, 1997b), six HAPs (benzene, formaldehyde, acetaldehyde, 1,3-butadiene, acrolein, and methyl tertiary butyl ether) can be calculated directly by including detailed fuel parameters and model scenario descriptions.

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MOBILE6.2 also allows the user to enter emission factors or air toxic ratios for additional air toxic pollutants. Within MOBILE6.2, the ratios must be expressed as milligrams of HAP per gram of VOC or PM. The USEPA's 1999 NTI provides emission factors for 29 additional motor vehicle-related HAPs. These emission factors will be included in the MOBILE6.2 model analysis to determine HAP speciation profiles for onroad vehicles. The resulting HAP speciation profiles for motor vehicle exhaust will correspond to the following vehicle types and fuel: gasoline, light-duty diesel, and heavy-duty diesel. Diesel PM emission factors will be developed based on PM emissions from diesel-powered motor vehicles.

Because the motor-vehicle speciation profiles will vary by year, vehicle speed, and fleet mix, the resultant number of profiles are too numerous to present in this document.

2.4 Stationary Sources

The stationary sources associated with the OMP that emit HAPs include heating plants, fire training facilities, storage tanks, painting operations, and generators.

The sources of speciation profile data for stationary sources included:

- USAF, 1998. *Emissions Testing of Fire Fighter Training Facility – Goodfellow Air Force Base, Texas*, January.
- USEPA, 2000. *Compilation of Air Pollutant Emission Factors – AP-42*.
- SPECIATE3.2
- CARB

2.4.1 Heating Plants

During the operation of heating plants, a small amount of organic compounds are emitted due to combustion. The rate at which organic compounds are emitted depends, to some extent, on the combustion efficiency of the boiler. Total organic compounds include VOCs, semivolatile organic compounds, and condensable organic compounds. The HAP speciation profiles for fuel oil and natural gas combustion will be the information contained in USEPA's *Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources*. Tables 7 and 8 present the HAP speciation profiles for fuel oil and natural gas combustion, respectively, from AP-42. Other databases (such as USEPA's SPECIATE) also provide speciation profiles for heating plants, but most often default to the values in AP-42.

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Table 7. Speciation Profiles for Fuel Oil Combustion Units

Pollutant	Emission Factor (lb/1,000 gallons)	Fraction of VOC ^a	Pollutant	Emission Factor (lb/1,000 gallons)	Fraction of PM ^b
Benzene	2.14E-04	1.33E-04	Antimony	5.25E-03	5.25E-04
Ethylbenzene	6.36E-05	3.96E-05	Arsenic	1.32E-03	1.32E-04
Formaldehyde	3.30E-02	2.06E-02	Barium	2.57E-03	2.57E-04
Naphthalene	1.13E-03	7.04E-04	Beryllium	2.78E-05	2.78E-06
1,1,1-Trichloroethane	2.36E-04	1.47E-04	Cadmium	3.98E-04	3.98E-05
Toluene	6.20E-03	3.86E-03	Chloride	3.47E-01	3.47E-02
o-Xylene	1.09E-04	6.79E-05	Chromium	8.45E-04	8.45E-05
Acenaphthene	2.11E-05	1.31E-05	Chromium VI	2.48E-04	2.48E-05
Acenaphthylene	2.53E-07	1.58E-07	Cobalt	6.02E-03	6.02E-04
Anthracene	1.22E-06	7.60E-07	Copper	1.76E-03	1.76E-04
Benzo(a)anthracene	4.01E-06	2.50E-06	Fluoride	3.73E-02	3.73E-03
Benzo(b,k)fluoranthene	1.48E-06	9.22E-07	Lead	1.51E-03	1.51E-04
Benzo(g,h,i)perylene	2.26E-06	1.41E-06	Manganese	3.00E-03	3.00E-04
Chrysene	2.38E-06	1.48E-06	Mercury	1.13E-04	1.13E-05
Dibenzo(a,h)anthracene	1.67E-06	1.04E-06	Molybdenum	7.87E-04	7.87E-05
Fluoranthene	4.84E-06	3.02E-06	Nickel	8.45E-02	8.45E-03
Fluorene	4.47E-06	2.79E-06	Phosphorous	9.46E-03	9.46E-04
Indo(123-cd)pyrene	2.14E-06	1.33E-06	Selenium	6.83E-04	6.83E-05
Phenanthrene	1.05E-05	6.54E-06	Vanadium	3.18E-02	3.18E-03
Pyrene	4.25E-06	2.65E-06	Zinc	2.91E-02	2.91E-03
Octachlorodioxin	3.10E-09	1.93E-09			

^a Based on a VOC emission factor of 1.605 lb/1,000 gallons (AP-42: Section 1.3, Table 1.3-3)^b Based on a PM emission factor of 10 lb/1,000 gallons (AP-42: Section 1.3, Table 1.3-1)SOURCE: USEPA, 1998. *Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume 1: Stationary Point and Area Sources*, September.

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Table 8. Speciation Profiles for Natural Gas Combustion Units

Pollutant	Emission Factor (lb/10 ⁶ scf) ^c	Fraction of VOC ^a	Pollutant	Emission Factor (lb/10 ⁶ scf)	Fraction of PM ^b
2-Methylnaphthalene	2.4E-05	2.18E-06	Arsenic	2.0E-04	1.05E-04
3-Methylchloranthrene	1.8E-06	1.64E-07	Barium	4.4E-03	0.00232
7,12-Dimethylchloranthrene	1.6E-05	1.45E-06	Beryllium	1.2E-05	6.32E-06
Acenaphthene	1.8E-06	1.64E-07	Cadmium	1.1E-03	5.79E-04
Acenaphthylene	1.8E-06	1.64E-07	Chromium	1.4E-03	7.37E-04
Anthracene	2.4E-06	2.18E-07	Cobalt	8.4E-05	4.42E-05
Benzo(a)anthracene	1.8E-06	1.64E-07	Copper	8.5E-04	4.47E-04
Benzene	2.1E-03	1.91E-04	Manganese	3.8E-04	2.00E-04
Benzo(a)pyrene	1.2E-06	1.09E-07	Mercury	2.6E-04	1.37E-04
Benzo(b)fluoranthene	1.8E-06	1.64E-07	Molybdenum	1.1E-03	5.79E-04
Benzo(ghi)fluoranthene	1.2E-06	1.09E-07	Nickel	2.1E-03	0.00111
Benzo(k)fluoranthene	1.8E-06	1.64E-07	Selenium	2.4E-05	1.26E-05
Butane	2.1	0.191	Vanadium	2.3E-03	0.00121
Chrysene	1.8E-06	1.64E-07	Zinc	2.9E-02	0.0153
Dibenzo(ah)anthracene	1.2E-06	1.09E-07			
Dichlorobenzene	1.2E-03	1.09E-04			
Ethane	3.1	0.282			
Fluoranthene	3.0E-06	2.73E-07			
Fluorene	2.8E-06	2.55E-07			
Formaldehyde	7.5E-02	0.00682			
Hexane	1.8	0.164			
Indeno(123-cd)pyrene	1.8E-06	1.64E-07			
Naphthalene	6.1E-04	5.55E-05			
Pentane	2.6	0.236			
Phenanthrene	1.7E-05	1.55E-06			
Propane	1.6	0.145			
Pyrene	5.0E-06	4.55E-07			
Toluene	3.4E-03	3.09E-04			

^a Based on a VOC emission factor of 11 lb/10⁶ scf (AP-42: Section 1.4, Table 1.4-6)^b Based on a PM emission factor of 1.9 lb/10⁶ scf (AP-42: Section 1.4, Table 1.4-6)^c scf = standard cubic footSOURCE: USEPA, 1998. *Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources*, September.

2.4.2 Airport Rescue and Firefighting Facilities

Airport Rescue and Firefighting Facilities (ARFFs) are used to train personnel for fuel fire suppression. The types of fires simulated include engine fires; exterior pool fires involving the fuselage, the left wing, or the right wing; interior fires on the flight deck, cargo, or passenger areas; and other miscellaneous fires. Based on information provided in a January 1998 document (*Environmental Quality Management, Emissions Testing of Fire Fighter Training Facility – Goodfellow Air Force Base, Texas*), the only HAP emission sampled during fuel fires was formaldehyde at a fraction of 0.011976 of the VOC. This factor will be used to assess HAP emissions associated with the ARFF at O'Hare.

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Chapter

3

Summary

A literature search was conducted to determine the availability of HAP speciation data and related emission factors for the aircraft, nonroad engines, onroad vehicles, and stationary sources associated with the OMP. Table 9 lists the emission sources associated with the OMP and provides a reference to the recommended speciation profiles discussed within this document.

Table 9. Summary of Recommended Speciation Profile Data

Emission Source	Speciation Data	Source of Data
Speciation Profiles for Turbine Aircraft	Table 2	USAF, 1999. Aircraft Engine and Auxiliary Power Unit Emissions Testing: Volumes 1–3, March.
Elemental Mass Fractions for Turbine Aircraft	Table 3	Shumway, 2000. <i>Trace Element and Polycyclic Aromatic Hydrogen Analysis of Jet Engine Fuels: Jet A, JP-5, JP-8</i> , December.
Speciation Profiles for Piston Aircraft	Table 4	CARB, 2000. <i>Speciation Profiles and Size Fractions</i> , December.
Diesel Construction Equipment and Gasoline Construction Equipment/GSE	Table 5	USEPA, 2002. <i>Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory</i> .
Diesel GSE	Table 6	USAF, 2002. <i>Air Emission Inventory Guidance Document for Mobile Sources at Air Force Installations</i> , January.
Motor Vehicles	Varies by Fleet Mix and Year of Analysis (see Section 3.3)	MOBILE6.2
Heating Plant (Oil-Fired)	Table 7	USEPA, 1998. <i>Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources</i> , September.
Heating Plant (Gas-Fired)	Table 8	USEPA, 1998. <i>Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources</i> , September.
Airport Rescue and Firefighting Facilities	0.011976 (Fraction of VOC)	Environmental Quality Management, Emissions Testing of Fire Fighter Training Facility – Goodfellow Air Force Base, Texas.

The type (number) of individual HAPs emitted will vary from each OMP-related source. Table 10 summarizes the individual HAPs that will be evaluated from each of the source types. The HAPs include VOC's, individual PAHs, and particulate/metals.

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Table 10. List of HAPS and OMP Emission Sources

Category	Pollutant	Turbine Aircraft	Piston Aircraft	Nonroad Equipment (Diesel)	Nonroad Equipment (Gasoline)	Ground Support Equipment (Diesel)	Onroad Vehicles (Diesel)	Onroad Vehicles (Gasoline)	Heating Plants (Oil)	Heating Plants (Gas)	AR
VOCs and Aldehydes	Acetaldehyde	√	√	√	√	√					
	Acrolein	√	√	√	√	√	√	√			
	Benzene	√	√	√	√	√			√		
	1,3-Butadiene	√	√	√	√	√					
	Butane									√	
	Dichlorobenzene									√	
	7,12-Dimethylchloranthrene									√	
	Ethane									√	
	Ethylbenzene	√	√	√	√		√	√	√		
	Formaldehyde	√	√	√	√	√			√	√	√
	Isobutyraldehyde	√									
	n-Hexane			√	√		√	√		√	
	2-Methylnaphthalene									√	
	3-Methylchloranthrene									√	
	Naphthalene	√	√	√	√	√	√	√	√	√	
	Octachlorodioxin								√		
	Pentane									√	
	Phenol					√					
	Propionaldehyde	√		√	√		√	√			
	Propane									√	
1,1,1-Trichloroethane								√			
Toluene	√	√	√	√	√	√	√	√	√		
Styrene	√	√	√	√	√	√	√	√			
Xylenes	√	√	√	√	√	√	√	√			
Individual PAHs	Acenaphthene	√		√	√	√	√	√	√	√	
	Acenaphthylene	√		√	√	√	√	√	√	√	
	Anthracene	√		√	√	√	√	√	√	√	
	Benzo(a)anthracene	√		√	√	√	√	√	√	√	
	Benzo(b)fluoranthene	√		√	√	√	√	√	√	√	
	Benzo(g,h,i)perylene	√		√	√	√	√	√	√	√	
	Benzo(k)fluoranthene	√		√	√	√	√	√	√	√	
	Benzo(a)pyrene	√		√	√	√	√	√	√	√	
	Chrysene	√		√	√	√	√	√	√	√	
	Dibenzo(a,h)anthracene			√	√	√	√	√	√	√	
	Fluoranthene	√		√	√	√	√	√	√	√	
	Fluorene	√		√	√	√	√	√	√	√	
	Indeno(1,2,3-c,d)pyrene	√		√	√	√	√	√	√	√	
	Phenanthrene	√		√	√	√	√	√	√	√	
	Pyrene	√		√	√	√	√	√	√	√	
	2,2,4-Trimethylpentane			√	√		√	√			
Particulate and Metal	Antimony								√		
	Arsenic					√	√	√	√	√	
	Barium	√							√	√	
	Beryllium					√			√	√	
	Cadmium					√			√	√	
	Calcium	√									
	Chloride								√		
	Chromium	√				√	√	√	√	√	
	Cobalt								√	√	
	Copper	√							√	√	
	Fluoride								√		
	Iron	√									
	Lead	√	√			√			√		
	Manganese	√				√	√	√	√	√	
	Mercury	√				√	√	√	√	√	
	Molybdenum								√	√	

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Category	Pollutant	Turbine Aircraft	Piston Aircraft	Nonroad Equipment (Diesel)	Nonroad Equipment (Gasoline)	Ground Support Equipment (Diesel)	Onroad Vehicles (Diesel)	Onroad Vehicles (Gasoline)	Heating Plants (Oil)	Heating Plants (Gas)	AR
	Nickel	√				√	√	√	√	√	
	Phosphorous								√		
	Scandium	√									
	Selenium					√			√	√	
	Strontium	√									
	Sulfur	√									
	Tin	√									
	Titanium	√									
	Vanadium	√							√	√	
	Zinc								√	√	
	Zirconium	√									
	Diesel Particulate			√		√	√		√		

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Chapter

4

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