CITY OF PARK RIDGE, ILLINOIS

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

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VOLUME II

PRELIMINARY MODELING EVALUATION OF RISKS ASSOCIATED WITH EMISSIONS FROM CHICAGO O'HARE AIRPORT

by

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Prepared for:

City of Park Ridge, Illinois
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City of Des Plaines, Illinois
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EXECUTIVE SUMMARY

ENVIRON is a nationally recognized consulting firm in the related fields of public health and environmental sciences. ENVIRON was asked by the community of Park Ridge, Illinois to prepare a preliminary modeling evaluation of the potential risks posed by hazardous chemicals being released as a result of operations at O'Hare International Airport. This type of emissions/dispersion/receptor risk analysis of air toxics is typical of similar analyses performed to evaluate the public health impact and risk associated with the operation of other major sources of hazardous chemical emissions such as incinerators, power plants, steel mills, and chemical facilities.

In conducting the analysis, ENVIRON used emission estimates prepared by KM Chng for the City of Chicago and then applied standard risk assessment techniques (e.g., dispersion models, exposure parameters and toxicity criteria) developed by the United States Environmental Protection Agency (USEPA). This approach was taken because KM Chng has developed emission estimates for specific air toxics from O'Hare Airport, but has not quantified the risks associated with those emissions. This evaluation was intentionally restricted to the use of emission estimates developed by KM Chng for the City of Chicago; these emission estimates have not been critically evaluated and may not be representative of actual emissions from O'Hare Airport.

The overall findings of ENVIRON's preliminary risk analysis are as follows:

- **Cancer Risk Associated with Operations of O'Hare Airport.** Based on estimated emissions of certain hazardous air pollutants, the individual cancer risks associated with operations of the O'Hare Airport exceed 1 in 100,000 (i.e., 1×10^{-5}) over an area of approximately 40 square miles, assuming 70 years of exposure. Cancer risks exceeding 1 in 1,000,000 (i.e., one in one million, or 1×10^{-6}) extend about 40 miles to the northeast, encompassing a total area of approximately 1,000 square miles, primarily to the east and northeast of the airport. The maximum hypothetical cancer risk at the airport property boundary is estimated to be approximately 1 in 10,000 (i.e., one in ten thousand, or 1×10^{-4}). These risk estimates do not include emissions from potential sources not associated with O'Hare Airport.

- **Public Health Goals for Cancer Risk.** Under its air toxics program, USEPA has adopted a tiered approach to evaluating the risks posed by air contaminants (USEPA 1999a). If a screening-level assessment indicates that cancer risks for the most highly exposed individual are greater that approximately $1x10^{-6}$, then a more refined analysis may be required. In a refined analysis, risks exceeding $1x10^{-4}$ are generally considered to be unacceptable, while the acceptability of risks between $1x10^{-6}$ and $1x10^{-4}$ are evaluated on a case-by-case basis considering various factors, including the size of the population exposed. The results of such assessments are used to help determine whether additional controls for sources of hazardous air pollutants are needed beyond the promulgated technology-based Maximum Achievable Control Technology (MACT) standards (USEPA 1999a). This preliminary risk assessment estimates that emissions of hazardous air pollutants from O'Hare Airport operations may result in a cancer risk exceeding 1×10^{-6} over a relatively large area, and exceeding 1×10^{-5} within a smaller area near the airport (especially to the northeast downwind of the prevailing winds from the southwest). The maximum hypothetical cancer risk at the airport property boundary is estimated to be approximately 1×10^{-4}.

- **Non-Cancer Health Risks.** Based on the emission estimates developed by KM Chng, emissions from the O'Hare airport during normal operations would not be expected to result in adverse noncancer health effects. However, monitoring data collected by Mostardi Platt (2000) suggest that exposures to compounds not considered by KM Chng (such as naphthalene) may pose a noncancer risk.

- **KM Chng (Chicago) may understate emissions and resultant health risks associated with O'Hare Airport operations.** The emission data developed by KM Chng and used in this analysis may underestimate actual emissions and risk associated with operations of O'Hare airport. For example, total volatile compound (VOC) emissions estimated by KM Chng are lower than would be derived from USEPA's National Emission Trends database. Furthermore, only a subset of all air toxics that have been identified with airport operations were included by KM Chng.

The estimated cancer risks calculated in this preliminary modeling evaluation (i.e., risks exceeding $1x10^{-5}$ in off-site areas near the airport) are consistent with cancer risks estimated by ENVIRON (2000) based on short-term sampling performed by Mostardi-Platt (2000). However, the risk driver in this modeling analysis (1,3-butadiene) was not included in the Mostardi-Platt analytical results. Furthermore, the Mostardi-Platt (2000) analytical results indicate a higher

potential noncancer risk, associated with chemicals (such as acetaldehyde and naphthalene) that were not evaluated by KM Chng and thus were not included in this risk evaluation. It should also be recognized that the analytical results of the Mostardi-Platt (2000) sampling may not be representative of long-term conditions.

The findings of this analysis should be considered preliminary, and could be refined through additional air monitoring or more sophisticated emission, dispersion, and exposure modeling.

I. REVIEW OF RECENT EMISSIONS ESTIMATES

A. Airport Emissions

KM Chng Environmental Inc. (KM Chng) prepared estimates of emissions associated with operations at Chicago O'Hare International Airport (O'Hare) in 1995 and 1999 (KM Chng 1995, 1999a). The 1995 KM Chng report provides emissions estimates and dispersion modeling results for criteria pollutants (under 1994 conditions), but does not include any individual air toxics. The 1999 KM Chng report provides revised emission estimates for volatile organic compounds (VOCs), along with speciated information for certain air toxics (i.e., benzene, 1,3-butadiene, formaldehyde, and polycyclic aromatic hydrocarbons [PAHs]). No dispersion modeling results for individual air toxics are provided in KM Chng's 1999 report. KM Chng also prepared a separate report evaluating the contribution of airport operations to soot deposition in the airport vicinity (KM Chng 1999b).

In the report *Findings Regarding Aircraft Emissions, O'Hare International Airport and Surrounding Communities* (KM Chng 1999a), five separate on-airport sources of volatile organic compound (VOC) emissions are described:

- Aircraft;
- Ground support service vehicles;
- Motor vehicles on roadways – includes traffic on airport roadways, queuing at the terminal curbsides, and traffic in parking facilities;
- Fuel storage and handling; and
- Heating and refrigeration plant.

Emissions of total VOCs and ten air toxics are provided by KM Chng (1999a) for three categories of emissions: aircraft, on-airport motor vehicles, and other airport sources. Based on descriptions of the emissions sources from an earlier report by KM Chng (1995), it appears that the "other airport sources" category includes ground support service vehicles, fuel storage/handling, and the heating/refrigeration plant. The specific air toxics for which emissions estimates were developed by KM Chng (1999a) are benzene, 1,3-butadiene, formaldehyde, and seven polycyclic aromatic hydrocarbons (7-PAH): benz(a)anthrocene, benzo(a)pyrene,

benzo(b)fluoranthrene, benzo(k)fluoranthrene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. These air toxics are included among a more extensive group of hazardous air pollutants (HAPs) being regulated by USEPA under the 1990 Clean Air Act Amendments (CAAA). The emission estimates provided by KM Chng (1999a) correspond to airport operations in 1998, and are summarized in Table I-1.

Based on ENVIRON's review of the KM Chng (1999a) emissions report, the following observations were made:

- **KM Chng may have underestimated VOC emissions from O'Hare by a factor of two to three.** The KM Chng estimate of 4.03 tons per day of VOCs from aircraft for 1998 is slightly lower than the estimate of 4.12 tons per day provided by KM Chng (1995) for 1994. ENVIRON compared the VOC emission estimates provided by KM Chng (1995, 1999a) to USEPA's National Emission Trends database for 1996 (NET96). The NET database consists of emissions data for criteria pollutants compiled and maintained by USEPA's Emission Factors and Inventory Group (EFIG). In the NET96 database, aircraft in Cook County are estimated to emit 4,178 tons of VOCs per year, which is equivalent to approximately 11 tons per day. Giving a credit for Midway Airport emissions, which are relatively small in relation to O'Hare, according to USEPA estimates, it appears that KM Chng's VOC emissions estimates for O'Hare may be underestimated by a factor of two to three. Since the emissions individual air toxics were calculated by KM Chng from the total VOC emissions using speciation profiles, the emissions of benzene, 1,3-butadiene, formaldehyde, and 7-PAH may also be underestimated by a factor of two to three.

- **Emissions of only a limited number of air toxics were evaluated.** KM Chng (1999a) provided speciated emission estimates for only four individual air toxics, plus a group of PAH. In contrast, USEPA (1999b) identified 33 air toxics that present the greatest threat to public health in the largest number of urban areas. With respect to aircraft emissions, ERG (1999) identified and quantified the emissions of 14 air toxics from aircraft (Table I-2). The four air toxics quantified by KM Chng accounted for only 60 percent of the total air toxics emissions identified by ERG. Key air toxics omitted by KM Chng include acetaldehyde, which had the second highest emissions among the 14 (second only to formaldehyde), and naphthalene. Naphthalene was identified as a risk driver in the ENVIRON (2000) analysis of air monitoring data collected by Mostardi-Platt (2000).

TABLE I-1
Summary of KM Chng (1999a) Emission Estimates for 1998 (tons/day)

Pollutant	Source		
	Aircraft	On-Airport Motor Vehicles	Other Airport Sources
Total VOCs	4.03	1.01	1.50
Benzene	0.09	0.03	0.02
1,3-Butadiene	0.08	0.00	0.01
Formaldehyde	0.67	0.01	0.04
7-PAH*	0.0000072	0.0000018	NA
Benzo(a)Pyrene	0.0000018	0.00000045	NA

Notes:

* = 7-PAH refers to the sum of seven polycyclic aromatic hydrocarbons: benz(a)anthrocene, benzo(a)pyrene, benzo(b)fluoranthrene, benzo(k)fluoranthrene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

NA = not available.

TABLE I-2 ERG (1999) Emissions of Air Toxics from Aircraft		
Air Toxic	**Included in KM Chng (1999a)**	**Not Evaluated by KM Chng (1999a)**
1,3-Butadiene	□	
Acetaldehyde		□
Acrolein		□
Benzene	□	
Ethylbenzene		□
Formaldehyde	□	
Lead Compounds		□
n-Hexane		□
POM as 7-PAH	□	
POM as 16-PAH		□
Propionaldehyde		□
Styrene		□
Toluene		□
Xylene		□

- **KM Chng does not quantify the risks posed by emissions from O'Hare Airport.** In its reports, KM Chng does not estimate concentrations of individual air toxics in offsite areas, or the risks associated with exposure to theses air toxics. Instead, for the individual air toxics, KM Chng compares mass emissions from O'Hare airport to mass emissions from other potential sources within a 10-mile radius (or a circle 20 miles in diameter). Such a comparison does not provide an indication of the relative risk of emissions from O'Hare Airport on surrounding communities, particularly for those locations closest to the airport. It also does not account for the different extent of dispersion that might be expected from different source types.

B. Soot Deposition

In the report *Findings Regarding Source Contributions to Soot Deposition, O'Hare International Airport and Surrounding Communities* (KM Chng 1999b), dry deposition samples collected in the airport vicinity were analyzed for hydrocarbon constituents. These data were compared with deposition samples collected from various sources, and the contribution from these sources apportioned using a technique called Advanced Chemical Fingerprinting (ACF), which was developed by Arthur D. Little (ADL).

Based on ENVIRON's review of the KM Chng (1999b) emissions report and other reports on the ACF method, ENVIRON believes ACF may not be appropriate for evaluating sources of soot deposition at O'Hare Airport. The ACF procedure was developed as a tool to allocate the proportional contributions from multiple sources of soil or water contamination. The ACF method is based on the assumption that the chemical composition of the source does not change as it is transported from the source to the receptor. This assumption is reasonable for soil or water contamination, but may not be appropriate for air.

In discussions with the developers of the ACF method (i.e., ADL), ENVIRON learned that the only applications to air have been for evaluating soot deposition from three airports. The results for the other two airports reportedly were similar to those found by KM Chng for O'Hare Airport. Due to the dynamic nature of the atmospheric aerosol, airborne particles may undergo significant changes in particle size distribution. This is particularly true for particles that are emitted in the smaller size range (e.g., submicron). Dry deposition rate is highly dependent on particle size, thus the chemical signature will vary as the particle size distribution changes with distance from the source. Furthermore, the semivolatile nature of PAHs may cause some species to volatilize from the particle phase to the vapor phase during atmospheric transport, affecting the ability to match a dry deposition sample collected at a distance from the source with the source's chemical fingerprint.

II. DISPERSION MODELING AND RISK ANALYSIS

A. Airport Emissions

In this study, ENVIRON modeled atmospheric dispersion from six separate emission sources, as described in Table II-1. Emissions from the heating/refrigeration plant were considered insignificant (< 1% of total VOC and 7-PAH emissions) based on estimates presented by KM Chng (1999a), and were not considered in this assessment. Figure 1 shows a site plan of the airport and the location of the emission sources.

To develop emission rates for these six separate sources from the estimates provided by KM Chng (1999a) for three emission source categories (Table I-1), ENVIRON assumed the relative proportions of emissions from each of the individual sources are the same as those identified in an earlier KM Chng (1995) report. For example, KM Chng (1995) estimated that parking facilities account for 11 percent of the total VOC emissions from motor vehicles. Therefore, for each of the air toxics in Table II-2, the emissions from parking facilities represent 11 percent of the total for the three sources within the motor vehicles category (i.e., roadway motor vehicles, terminal curbsides, and parking facilities). Based on the relative VOC emissions for the six sources presented in KM Chng (1995), the distribution of each source was determined. Table II-2 presents the emissions used for this assessment. The data provided in KM Chng (1995) for respirable particulate matter (PM10) were not adequate for partitioning the PAH emissions among the sources within the motor vehicles category; however, it was estimated that the distribution for PM10 would be similar to that of VOCs, and the VOC distribution was used for this purpose.

KM Chng (1999a) provided emission rates for the seven PAHs as a group (7-PAH), as well as a separate emission rate for one of these seven (benzo(a)pyrene). Because the seven PAHs have different toxicity values, separate emission rates are necessary for each individual PAH. To divide the 7-PAH emission rate among the seven PAHs, emission factors from USEPA's *Locating and Estimating Air Emissions from Sources of Polycyclic Organic Matter* (USEPA 1998) were used to determine the relative amount of each PAH being emitted from aircraft and motor vehicles. Based on USEPA (1998), it was determined that three of the PAH (i.e., benzo(b)fluoranthrene, benzo(k)fluoranthrene, and dibenz(a,h)pyrene) are not present in significant amounts in emissions from either aircraft or motor vehicles, and were thus not

INSERT FIGURE 1 HERE

TABLE II-1
Description of Emission Sources Modeled by ENVIRON

Source Category	Source	Location
Aircraft	Aircraft	Seven Airport Runways
On-Airport Motor Vehicles	Roadway motor vehicles	Roadway leading to main terminal
	Terminal curbsides	Adjacent to terminals
	Parking facilities	Parking garage (6 levels) and four open lots (Lots B,C,D,E)
Other Airport Sources	Service vehicles	Adjacent to concourses
	Fuel storage/handling	Truck fuel stand and superfuel satellite (one source) and fuel farm

TABLE II-2
Emissions of Air Toxics from Individual Sources (g/s)

Source	Benzene	1,3-Butadiene	Formalde-hyde	Benzo(a) pyrene	Benz(a) anthracene	Chrysene	Indeno (1,2,3-cd) pyrene
Aircraft	9.47E-01	8.42E-01	7.05E+00	1.89E-05	9.87E-06	4.67E-05	0
Roadway motor vehicles	1.56E-01	0	5.19E-02	2.33E-06	2.35E-06	3.52E-06	1.17E-06
Parking facilities	3.46E-02	0	1.15E-02	5.19E-07	5.22E-07	7.83E-07	2.61E-07
Terminal curbsides	1.25E-01	0	4.18E-02	1.88E-06	1.89E-06	2.84E-06	9.46E-07
Service vehicles	1.85E-01	1.20E-01	4.78E-01	0	0	0	0
Fuel storage/handling	2.53E-02	1.26E-02	5.05E-02	0	0	0	0

included in this evaluation.

It should be noted that KM Chng has estimated emissions for only a limited number of air toxics that may be associated with airport operations. ERG (1999) identified and quantified emissions of 14 air toxics from aircraft; the air toxics quantified by KM Chng account for only 60 percent of the total air toxics emissions identified for by ERG. Key air toxics omitted by KM Chng include acetaldehyde and naphthalene, which was identified as a risk driver in the ENVIRON (2000) analysis of air monitoring data collected by Mostardi-Platt (2000). As a result, the risk for total airport emissions may tend to be underestimated.

As previously discussed, KM Chng may have underestimated VOC emissions from O'Hare by a factor of two to three, based on data from USEPA's National Emission Trends data base for 1996 (NET96). On the other hand, however, the KM Chng emission estimates for aircraft include emissions from altitude during takeoffs and landings, which would have less impact on ground level concentrations than predicted using the dispersion approach applied in this modeling evaluation. Given these and other uncertainties in the emission and dispersion methodologies, ENVIRON used the KM Chng emission estimates for the preliminary modeling and risk evaluation.

B. Air Dispersion Modeling and Exposure Assessment

1. Air Dispersion Model Selection

The USEPA Industrial Source Complex Short-Term (ISCST3) model was used to perform atmospheric dispersion modeling in this evaluation. ISCST3 is an advanced steady-state Gaussian plume model that predicts chemical concentrations at specific locations as a function of wind speed, atmospheric stability, temperature gradient, mixing height, and downwind distance. USEPA lists ISCST3 as a Preferred Air Quality Model in its *Guideline on Air Quality Models* (40 CFR Part 51, Appendix W) for the following applications: (1) industrial source complexes; (2) rural or urban areas; (3) flat or rolling terrain; (4) transport distances less than 50 kilometers; and (5) 1-hour to annual averaging times.

The emissions and dispersion modeling performed by KM Chng (1999a) utilized a combination of three models – the FAA's Emissions and Dispersion Modeling System (EDMS) for aircraft, service vehicles, parking facilities, and the heating/refrigeration plant; USEPA's MOBILE5b model for motor vehicles; and USEPA's TANKS model for fuel storage and handling. ISCST3 was selected for this preliminary evaluation because the emissions estimation and dispersion modeling functions of EDMS cannot be readily separated. ISCST3 was identified as the most appropriate model for performing a stand-alone dispersion modeling study using the emission rates developed based on KM Chng (1995, 1999a) and USEPA (1998).

Emission/dispersion modeling for individual air toxics could be performed using the EDMS model as input to a refined risk evaluation. The EDMS model contains a database of aircraft engines, ground support equipment, aerospace ground equipment, auxiliary power units, vehicular and stationary source emission factor data. Using detailed input data (e.g., type of aircraft, number of landings and take-offs per aircraft type, aircraft taxiing and idling times, runway configuration, vehicular traffic), EDMS performs both an emissions inventory for airport-related sources and dispersion modeling to estimate ambient air concentrations. The dispersion modeling is based on USEPA-validated dispersion models (PAL2 and CALINE3) for various emissions source types. These two model components interact with the emissions database when used to perform air quality assessments. By taking detailed aircraft- and other source-specific data into consideration to develop an improved relationship between the emissions and dispersion modeling components, the EDMS model provides a more detailed approach to evaluating the impact of airport emissions.

2. Meteorological Data

ISCST3 utilizes hourly meteorological data records to define the conditions for dispersion. The principal meteorological data required include hourly surface wind speed, wind direction, temperature, atmospheric stability, and mixing height. The model estimates the concentration associated with each combination of source and receptor for each hour of input meteorological data, and can calculate average concentrations over specified time intervals (e.g., quarterly or annual averages).

To generate the required input meteorological data files required for the ISCST3 model, surface meteorological, and upper air files were downloaded from USEPA's SCRAM electronic bulletin board for 1987-91, the most recent five-year period for which a complete set of data are readily available. The surface meteorological data were collected by the National Weather Service (NWS) at the O'Hare Airport. A wind rose diagram of these meteorological data is shown in Figure 2. For upper air data, the closest NWS station for which the appropriate data are available is in Peoria, Illinois. Precipitation scavenging and plume depletion due to dry and wet deposition were not considered in this assessment. The potential impact of dry deposition was evaluated separately.

ISCST3 selects the appropriate dispersion coefficients and wind-profile exponents for an indicated atmospheric stability base on the urban/rural classification of the modeled area. Based on the land use of the site vicinity, the site was modeled as an urban area. Regulatory defaults values were used for all other modeling options.

INSERT FIGURE 2 HERE

3. Source and Receptor Configuration

Given its configuration, the parking garage was modeled as a volume source. Each of the other five individual sources was modeled as an area source. Aircraft area sources were assumed to have a release height of 15 feet to account for the elevated release from the aircraft engines when taxiing or idling, while all other area sources were assumed to have a release height of one foot, which accounts for the height of a motor vehicle exhaust.

Fenceline concentrations were estimated at approximately 200-meter intervals along the property line. The fenceline concentrations represent the maximum off-site air concentrations. In addition, a 50×50 Cartesian receptor grid was established at 1.2-kilometer intervals to estimate concentrations and corresponding risks of the surrounding area.

4. Estimation of Exposure Concentrations

Using a unit emission rate of 1 $g/s/m^2$ for all area sources, dispersion factors were calculated in units of $(ug/m^3)/(g/s/m^2)$ from the ISCST3 model. This dispersion factor represents the average annual air concentration that would result at a given location from a unit emission rate of 1 $g/s/m^2$. By multiplying this dispersion factor by the emission rate for a chemical (g/s) and dividing by the total area of the source (m^2), the air concentration associated with the emissions of that chemical from that source can be determined. Using this methodology, it is assumed that the emissions from each parking lot are proportional to the area of the parking lot. The relative emission rate from the parking garage (volume source) is based on the sum of the areas for each of the six levels.

C. Toxicity Evaluation

Toxicity values have been developed by USEPA for the evaluation of hazards posed by different types of chemical exposures. In this risk assessment, inhalation is considered to be the primary route of potential exposure for the off-site community.

1. Toxicity Values for Evaluating Potential Cancer Risk

There are two steps involved in assessing carcinogenic potential; first, the evaluation of the likelihood that the substance is a human carcinogen (i.e., a weight-of-evidence assessment), and second, definition of the quantitative relationship between dose and carcinogenic response.

USEPA classifies a chemical into one of five groups, based on the weight of evidence of carcinogenicity from human and animal investigations. These groups are as follows (USEPA 1989, 1997):

- Group A: Human Carcinogen (sufficient evidence of carcinogenicity in humans)

- Group B: Probable Human Carcinogen (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)
- Group C: Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data)
- Group D: Not Classifiable as to Human Carcinogenicity (inadequate or no evidence)
- Group E: Evidence of Noncarcinogenicity for Humans (no evidence of carcinogenicity in adequate studies).

The outcome of the second part of the evaluation for assessing carcinogenic risk is the derivation of a unit risk factor (URF) for each chemical in Groups A, B1 and B2. (USEPA estimates URFs for chemicals in Group C on a case-by-case basis.) The inhalation URF is an estimate of the upper-bound probability of an individual developing cancer from a lifetime of exposure to a unit concentration of a given chemical in air (USEPA 1989). Table III-3 presents URFs for the ten air toxic compounds considered in this evaluation. Where available, inhalation URFs for the chemicals at the site were obtained directly from the USEPA Integrated Risk Information System (IRIS) database and USEPA's Health Effects Assessment Summary Tables (HEAST). For some chemicals of potential concern, toxicity values published by USEPA Region III were used, due to a lack of toxicity values in IRIS and HEAST. For benzene, USEPA provides a range of URF values (2.2×10^{-6} ug/m^3 to 7.8×10^{-6} ug/m^3). Given the preliminary nature of this evaluation, the high end of this range was used.

It is noted that USEPA has developed a URF value for benzo(a)pyrene, but not the other potentially carcinogenic PAHs because of the limitations of the cancer studies performed on these compounds. Until individual toxicity values are assigned, a relative potency approach to determining carcinogenic potential based upon results in a group of carcinogenicity studies in animals. The toxicity of each carcinogenic PAH is evaluated relative to the toxicity of benzo(a)pyrene by multiplying the toxicity equivalency factor (TEF) of the PAH by the URF for benzo(a)pyrene (USEPA 1993b).

2. Toxicity Values for Evaluating the Potential for Non-Cancer Health Effects

The inhalation reference concentration (RfC) is an estimate of the chemical concentration in air to which an individual in the general population may be exposed over a substantial portion of a lifetime without experiencing adverse noncarcinogenic effects. The

TABLE II-3
Toxicity Values for Air Toxics

Chemical	URF $(ug/m^3)^{-1}$	TEF	RfC (ug/m^3)
Benzene	7.8E-06	--	5.99
1,3-Butadiene	2.80E-04	--	NA
Formaldehyde	1.30E-05	--	NA
Benzo(a)Pyrene	8.90E-04	1	NA
Benz(a)anthrancene	8.90E-05	0.1	NA
Chrysene	8.90E-07	0.001	NA
Indo(1,2,3-cd)pyrene	8.90E-05	0.1	NA

RfC values used in this assessment are presented in Table II-3. Chronic inhalation RfC values were taken directly from IRIS and HEAST where available.

D. Risk Characterization

Based on concentrations in air resulting from the air toxic emissions at Chicago O'Hare Airport, risks to human health associated with these emissions were estimated. For potential carcinogens, public health risk estimates are based on the incremental individual risk of developing cancer over a lifetime:

$$\text{Incremental Risk} = C \times URF$$

where:

C = annual average ambient air concentration (ug/m^3)
URF = chemical-specific inhalation unit risk factor $(ug/m^3)^{-1}$

An exposure duration of 70 years was used in quantifying potential exposures, as recommended by USEPA (2000) for conducting screening-level assessments for air contaminants. This exposure duration is also consistent with the USEPA (1999a) approach for conducting screening–level evaluations of hazardous air pollutants.

The potential for non-cancer health effects was evaluated by calculating separate Hazard Quotient (HQ) values for each chemical, as follows:

$$HQ = C / RfC$$

where:

HQ = Hazard Quotient (unitless)
C = average air concentration (averaged over the period of exposure) (ug/m^3)
RfC = reference concentration (ug/m^3).

Hazard Index (HI) values were calculated by summing HQ values, across all chemicals of potential concern.

Figure 3 presents risk contours using the 1988 meteorological data. (As previously indicated, the most recent five-year period for which a complete set of meteorological data are available is 1987 to 1991. There are relatively minor differences in the dispersion results from

INSERT FIGURE 3 HERE

year to year, which do not affect the overall results of the modeling). As shown in Figure 3, for a 70-year exposure, the 1×10^{-5} (one in one hundred thousand) cancer risk contour extends to the east and northeast of the airport covering an area of approximately 40 square miles. A 1×10^{-6} (one in one million) cancer risk contour extends approximately 40 miles to the east and northeast, encompassing a total area of more than 1,000 square miles (Figure II-3). The maximum hypothetical cancer risk estimated in offsite areas is approximately 1×10^{-4} (one in ten thousand). The major contributor to risks associated with the airport is 1,3-butadiene in aircraft emissions (Table II-4).

Under EPA's air toxics program (USEPA 1999a) the USEPA has adopted a tiered approach to evaluating the risks posed by air contaminants. If a screening-level assessment indicates that cancer risks for the most highly exposed individual is greater that approximately $1x10^{-6}$, then a more refined analysis may be required. In a refined analysis, risks exceeding one in 10,000 (one in ten thousand, or $1x10^{-4}$) are generally considered to be unacceptable, while the acceptability of risks between $1x10^{-6}$ and $1x10^{-4}$ are evaluated based on various factors, including the size of the population exposed. The results of such assessments are used to help determine whether additional controls for sources of HAPs are needed beyond the promulgated technology-based Maximum Achievable Control Technology (MACT) standards (USEPA 1999a).

E. Evaluation of Atmospheric Deposition from Airport Emissions

The ISCST3 model was also run to evaluate the amount of dry deposition that would occur in the airport vicinity. Deposition rate is a strong function of particle size distributions (PSD). Based on ENVIRON's review of available data, aircraft emissions are associated with submicron particle sizes. Using these PSD data, the deposition rates of 7-PAH in the airport vicinity were estimated to range from 2×10^{-6} to 3×10^{-6} grams per square meter per year. This is equivalent to 0.01 to 0.02 pounds per square mile per year. Thus, dry deposition of PAHs is not considered to be a significant exposure pathway, based on the KM Chng emission rate estimates. It should be noted that this modeling does not take into consideration growth of these particles into larger sizes, which would result in higher dry deposition rates.

Wet deposition was not quantitatively evaluated based on ENVIRON's experience that the contribution to total deposition from wet deposition is typically less than dry deposition.

TABLE II-4
Average Contribution to Total Risk

Source	% Total Risk	Chemical			
		Benzene	1,3-Butadiene	Formaldehyde	7-PAH
Aircraft	87.0	2.3	70.3	27.3	0.01
Roadway motor vehicles	0.5	65.5	0	34.2	0.2
Parking facilities	0.1	65.5	0	34.2	0.2
Terminal curbsides	0.4	65.5	0	34.2	0.2
Service vehicles	10.6	3.7	81.0	15.1	0.2
Fuel storage/handling	1.2	4.8	80.3	14.9	0

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