A Human Health Risk Assessment of the John Wayne and Proposed Orange County International Airports in Orange County, California

David E. Lindberg, P.E., Q.E.P.
CH2M HILL
701 B Street, Suite 550
San Diego, CA 92101

John Castleberry
CH2M HILL
2485 Natomas Park Drive, Suite 600
Sacramento, CA 95833

Robert O. Price
P&D Environmental
999 Town & Country Road, 4th Floor
Orange, CA 92868

ABSTRACT

Recent growth in the air transportation industry is presenting challenges to regional planning agencies as they try to accommodate aviation growth without degrading air quality and public health. Significant concerns have been raised over potential health risks to communities near airports as a result of airport expansion and construction projects. Remarkably little is known about how much toxic air pollution is emitted by airport-related sources and to what extent large airports pose health risks to surrounding communities.

This paper provides an assessment of potential cancer risks posed by exposure to toxic substance emissions from the John Wayne Airport (JWA) and proposed Orange County International Airport (OCX) in Orange County, California. The health risk assessment is based on projected passenger volumes of 5.4 million annual passengers (MAP) and 28.9 MAP, respectively, in the year 2020. According to preliminary work, maximum (worst plausible) off-site residential excess lifetime cancer risks are predicted to be 27 in a million near JWA and 56 in a million near the proposed OCX. Excess lifetime cancer risks in this study were dominated by diesel exhaust from ground support equipment and fuel delivery trucks. Pollutants primarily responsible for excess lifetime cancer risks in this study are diesel exhaust (about 65 percent) and 1,3-butadiene (about 20 percent). Aircraft engines in taxi mode produce almost all of the 1,3-butadiene emissions in this study. Cancer risks attributed to the two airports are relatively low in comparison to excess lifetime cancer risk estimates of 1,400 in a million attributed to ambient air quality in the South Coast AQMD[1]. The methodology used to perform the cancer risk assessment of these two airports is presented in this paper, as well as the similarities and differences between this study and prior work.

Values presented in this paper are preliminary and indicative of work-in-progress on Environmental Impact Report (EIR) No. 573. Results presented may differ from results presented in the final EIR.

INTRODUCTION

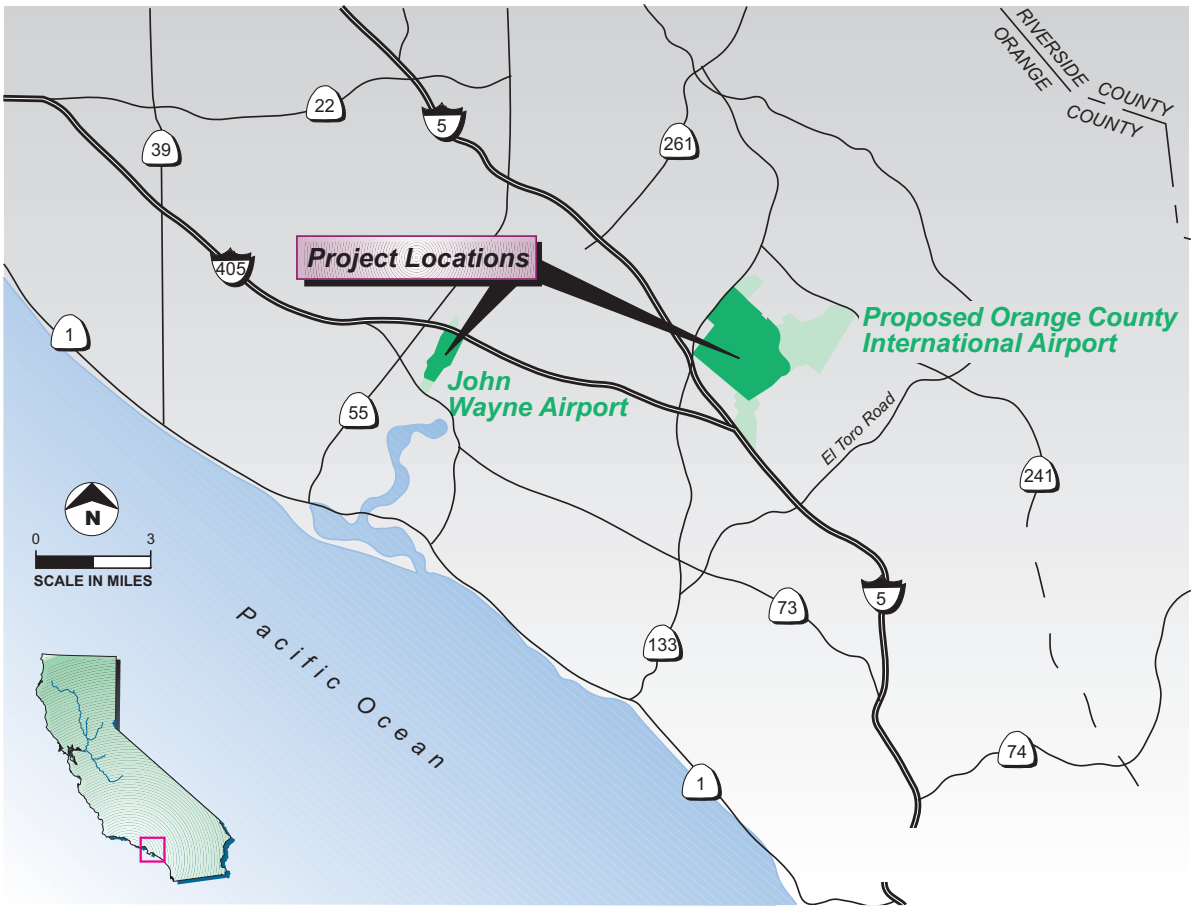
Public concern has been raised over the potential health risks associated with toxic substances in urban air. Exposed populations tend to reside in industrialized urban areas where the ambient concentrations of toxic substances are the highest. Environmental justice concerns by Illinois congressmen in 1990 precipitated a study by the U.S. EPA of cancer risks in Southwest Chicago, which included aircraft operations and other airport-related sources at Chicago Midway Airport (MDW). The Southwest Chicago study estimated that MDW accounted for approximately 11 percent of the total excess lifetime cancer risk attributed to air pollution[2]. The maximum off-site incremental cancer risk associated with MDW-mobile sources was estimated to be 223 in a million[2]. A similar study performed by the Los Angeles Unified School District estimated maximum off-site incremental cancer risk for proposed operations at the Santa Monica Municipal Airport to be 29 in a million[3].

The County of Orange has proposed to convert the former Marine Corps Air Station (MCAS) El Toro to an international airport. John Wayne Airport, which currently serves Orange County, would remain operational as well. The proposal is documented in Environmental Impact Report (EIR) No. 573. In response to public concern, a human health risk assessment of toxic air emissions was performed for both airports. The risk assessment, which is included in EIR No. 573, addressed health risks from an existing operations scenario and a future operations scenario. However, this paper is limited to a discussion of the predicted excess lifetime cancer risks associated with the future operations scenario only. The location of JWA and the proposed OCX is shown in Figure 1.

If the conversion proceeds, OCX will provide domestic, international, and cargo service with a projected passenger volume of 28.9 MAP in the year 2020. Under this scenario, JWA will provide primarily short-haul domestic and general aviation service, and will have a projected passenger volume of 5.4 MAP in the year 2020. The proposed conversion represents an increase in domestic air transportation, new international service capability, and new cargo service capability within Orange County. It is expected that the proposed conversion would absorb a portion of its increased domestic, international, and cargo service from other airports in the region.

The human health risk assessment was prepared in accordance with California Air Pollution Control Officers Association (CAPCOA) guidelines and guidance from the South Coast Air Quality Management District (SCAQMD). This paper also presents a comparison of potential excess lifetime cancer risks estimated for OCX and JWA to cancer risks associated with background air quality in the South Coast AQMD and emissions from other US airports. A discussion of the sources of uncertainty in risk assessments in general, and in the risk assessment for this project, is also provided.

Figure 1. Project Location Map.



HAZARD ASSESSMENT

Toxic Substances

The list of substances for which emissions have been quantified in this risk assessment was obtained from EPA documents prepared in support of the *1996 Base Year National Toxics Inventory*[4,5]. A total of 23 toxic substances were identified for inclusion in this risk assessment, 10 of which are recognized by the California Air Resources Board (CARB) as potential carcinogens (including particulate matter less than 10 micrometers in diameter [PM_{10}] in diesel exhaust). This paper only addresses cancer risks, which are associated with exposure to these 10 carcinogenic substances. The list provided in Table 1 consists of 9 toxic substances from the national toxics inventory, plus diesel PM_{10}.

Polycyclic organic matter (POM) as 7-polycyclic aromatic hydrocarbons (7-PAH) includes the following 7 POM compounds determined by the International Agency for Research on

Table 1. List of Toxic Substances Evaluated In This Human Health Risk Assessment

1,3-Butadiene	POM as 7-PAH
Acetaldehyde	Styrene
Benzene	Diesel PM_{10}
Formaldehyde	Chromium (hexavalent)
Lead	Nickel

Cancer to cause cancer: benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Hazards associated with exposure to these substances have been characterized using benz(a)pyrene as a surrogate compound. This represents a conservative approach because benz(a)pyrene has the highes (most carcinogenic) unit risk factor of any in the group.

EXPOSURE ASSESSMENT

Emissions Calculation Methodology

Runway Use Configurations

The location of emission sources under each runway use configuration is shown in Figures 2 (OCX) and 3 (JWA). The majority of hydrocarbon emissions from airport operations occur during the aircraft taxi mode. In order to account for the various locations of aircraft taxi emissions, risks were calculated separately for *each* runway use configuration at JWA and OCX. These risk results were subsequently combined in proportion to the number of hours per year that each runway use configuration is in effect. For the purposes of this study, it was assumed that meteorological conditions (e.g. wind speed and direction) dictated which runway use configuration would be in effect at any time. Four runway use configurations were assumed to be possible for OCX and two runway use configurations were assumed to be possible for JWA. Descriptions of each configuration and the frequency of meteorological conditions corresponding to each condition are presented in Table 2.

The primary runway use configuration anticipated for OCX is the North & East Flow configuration, which consists of arrivals on runway 34 and departures on runways 34 and 7. The OCX North & East Flow configuration occurs approximately 95% of the time. The primary runway use configuration in effect for JWA is the South Flow configuration, which consists of arrivals and departures on Runway 19. The JWA South Flow configuration occurs approximately 97% of the time. For each runway use configuration, toxic substance emissions were quantified for aircraft operations, ground support equipment (GSE) operations, jet fuel (Jet-A) delivery tanker trucks, and jet fuel storage tanks. Of these emission sources, only aircraft emissions vary by runway use configuration.

Figure 2. OCX Runway Use Configurations

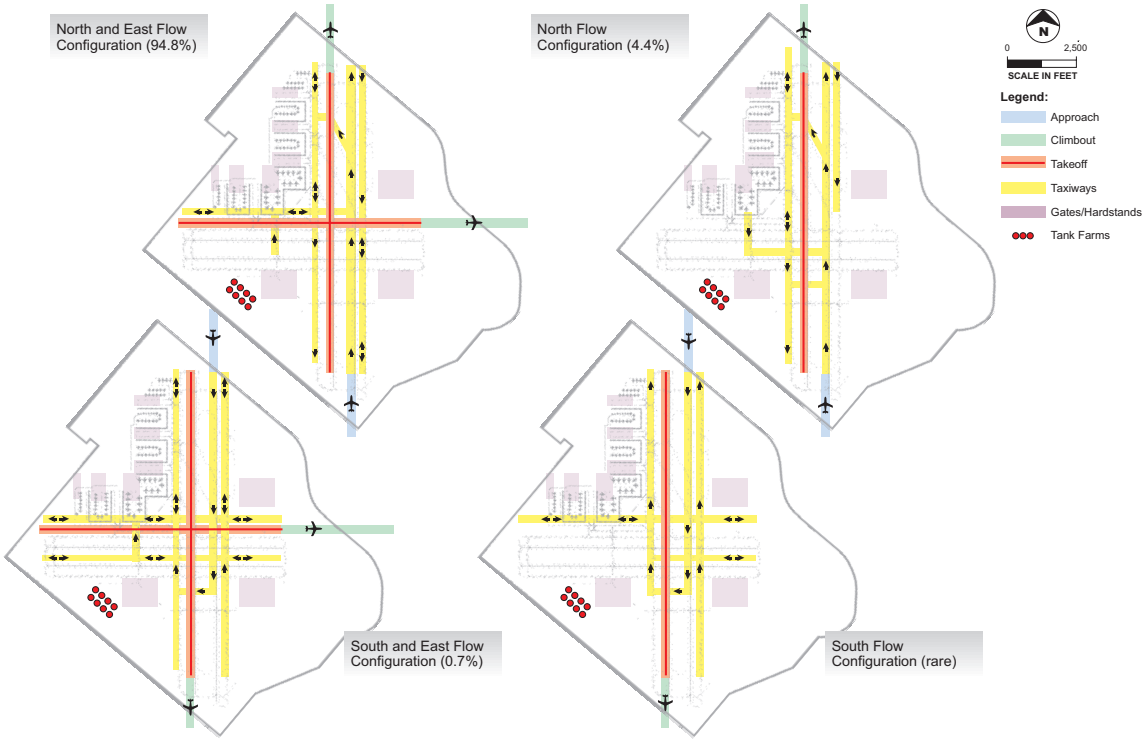


Figure 3. JWA Runway Use Configurations.

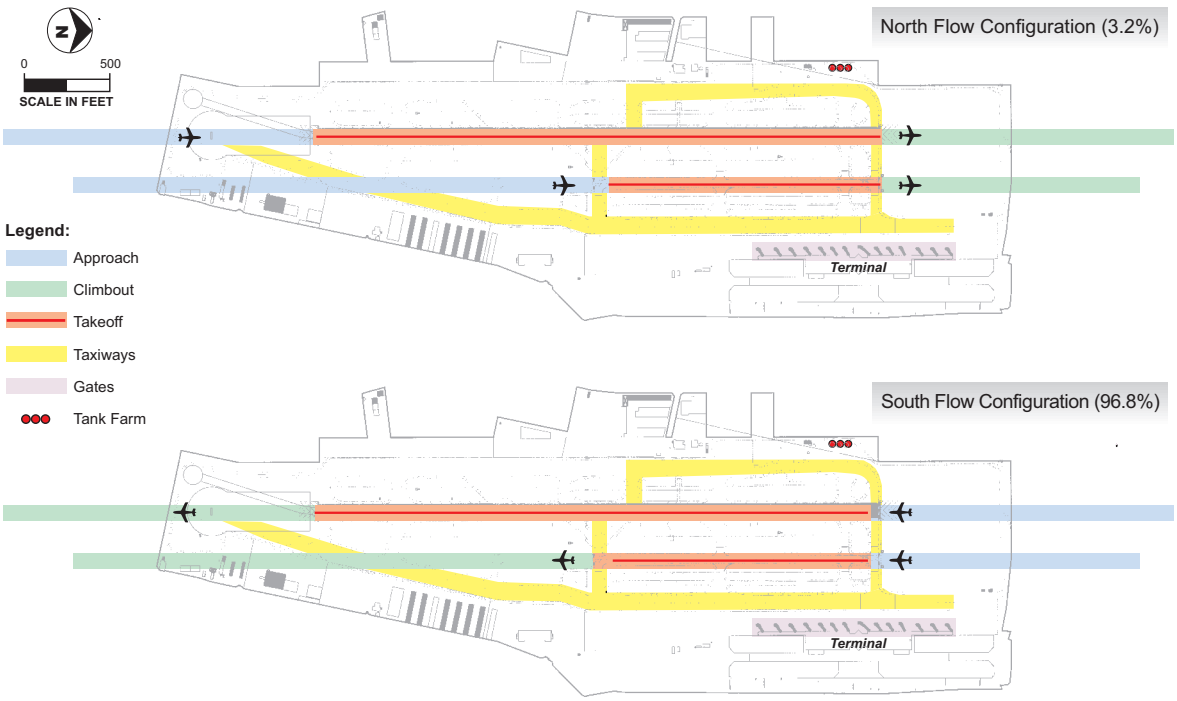


Table 2. Description of Airport Runway Use Configurations

Airport	Description of Configuration	Runways in Use	Approximate Frequency
OCX	North & East Flow	07 and 34	94.8%
	North Flow	34	4.4%
	South & East Flow	07 and 16	0.7%
	South Flow	16	<0.1%
JWA	South Flow	19L/R	96.8%
	North Flow	01L/R	3.2%

Note: Annual toxic substance emissions were proportioned between each runway use configuration based on the frequency of runway use configuration occurrence.

Aircraft Operations

Emissions from aircraft operations were categorized into the different modes of aircraft operation: approach, climb-out, takeoff, and taxi/idle. Approach mode emissions occur from the point where the aircraft drop below the local inversion height (2,400 feet) to the runway threshold. Takeoff mode emissions occur along the runway and continue until the aircraft reaches an altitude of 500 feet. Climb-out emissions occur between an altitude of 500 feet and the inversion height. Taxi/idle mode emissions occur as the aircraft taxi into the passenger terminal gates after landing and as the aircraft taxi out to the runways for takeoff. Site-specific time in mode (TIM) values for all four modes obtained from the SIMMOD model were used to calculate emissions.

Toxic substance speciation factors used in this study are listed in Table 3. Speciation factors for aircraft operations were obtained from documentation of the 1996 Base Year National Toxics Inventory[4]. Speciation factors for acetaldehyde, POM as 7-PAH, and styrene are based on the fraction of total volatile organic compounds (VOC) emitted. Speciation factors for 1,3-butadiene, benzene, and formaldehyde are based on the fraction of total organic gases (TOG) emitted. Emissions of toxic substances were calculated according to the following relationship:

$$E_{A,i}(lb/yr) = N * HC_i * TIM_i * LTO * \left(\frac{2.206}{60}\right)\left(\frac{VOC}{HC}\right)\left(\frac{TOG}{VOC}\right) * y$$

Where $E_{A,i}$ = modal emissions of toxic substance A, lb/year
N = number of engines/aircraft
HC_i = aircraft engine hydrocarbon modal emission factor, kg/hr
i = aircraft operating mode
LTO = landing-takeoff cycles/year
TIM_i = time in mode, minutes
TOG/VOC = ratio of aircraft engine TOG to VOC emissions
VOC/HC = ratio of aircraft engine VOC to HC emissions
y = toxic substance hydrocarbon fraction.

Table 3. Toxic Substance Emission Factors

		Aircraft[4]			GSE and Truck Engines[5]	
Compound	**Units**	**Jet**	**Turboprop**	**Piston**	**Diesel**	**Gasoline**
Acetaldehyde	VOC fraction	0.0465	0.0432	0.0062	NA	0.0045
Benzene	TOG fraction	0.0194	0.0179	0.0405	NA	0.0489
1,3-Butadiene	TOG fraction	0.0180	0.0157	0.0098	NA	0.0079
Formaldehyde	TOG fraction	0.1501	0.1414	0.0269	NA	0.0101
POM as 7-PAH	VOC fraction	1.5×10^{-6}	9.06×10^{-6}	7.2×10^{-6}	NA	9.8×10^{-6}
Styrene	VOC fraction	0.0039	0.0037	0.0034	NA	0.0003
Chromium	PM_{10} fraction	NA	NA	6.0×10^{-5}	NA	6.0×10^{-5}
Lead	grams/gallon	NA	NA	1.5	NA	0.0002
Nickel	PM_{10} fraction	NA	NA	7.0×10^{-5}	NA	7.0×10^{-5}
Diesel PM_{10}	grams/mile	NA	NA	NA	0.26	NA

NA = not applicable
ND = no data
VOC = volatile organic compounds
TOG = total organic gases

Table 4. VOC and TOG Emissions Conversion Factors[6].

	Aircraft Engines			GSE and Truck Engines	
	Jet	**Turboprop**	**Piston**	**Diesel**	**Gasoline**
VOC/HC	1.0947	0.9914	0.9708	0.9807	0.9056
TOG/VOC	1.1167	1.1347	1.0738	1.012	1.086

Hydrocarbon emission factors were obtained from the International Civil Aviation Organization (ICAO) Engine Exhaust Emissions Databank. Factors used to convert engine hydrocarbon emissions to VOC and TOG were obtained from EPA documentation[6] and are provided in Table 4.

Ground Support Equipment

GSE assignments and operating times per LTO cycle were obtained from the FAA Emissions and Dispersion Modeling Systems (EDMS), version 3.1, computer program[5] with the exception that food service trucks, cabin service trucks, and lavatory trucks were excluded from cargo aircraft emission inventories. Except for gasoline baggage tugs, all GSE were assumed to be equipped with diesel engines. These assumptions represent a conservative approach, since the future GSE fleet in Orange County is likely to have a higher percentage of electric and alternative-fueled equipment than reflected in EDMS. Hydrocarbon emission indices used to calculate toxic substance emissions were obtained from EPA documentation[8,9,10]. Emissions of toxic substances from the operation of GSE were calculated according to the following relationship:

$$E_{A,\,gse}(lb/yr) = HC_{gse} * T_{gse} * LTO * \left(\frac{2.206}{60}\right)\left(\frac{VOC}{HC}\right)\left(\frac{TOG}{VOC}\right) * y$$

Where $E_{A,gse}$ = GSE emissions of toxic substance A, lb/year
HC_{gse} = GSE hydrocarbon emission factor, kg/hr
T_{gse}= GSE operating time, mins/LTO cycle
VOC/HC = ratio of GSE engine VOC to HC emissions
TOG/VOC = ratio of GSE engine TOG to VOC emissions
y = toxic substance hydrocarbon fraction.

Speciation factors for diesel and gasoline GSE are provided in Table 3, and factors for conversion of HC emissions to TOG and VOC emissions are provided in Table 4.

Jet-A Fuel Delivery Trucks

It was assumed that all jet fuel required to operate each airport would be delivered by tanker truck. Based on jet fuel consumption, 244 daily tanker truck fuel deliveries to the tank farm area would be required to operate OCX. Emissions from on-road, heavy-duty diesel vehicles (HDDVs) were limited to the portion of vehicle travel on or near airport property. Emissions of diesel PM_{10} from HDDVs were calculated using an emission factor of 0.26 grams per vehicle mile traveled (g/VMT), obtained from the MVEI7G computer model. This factor corresponds to post-1994 model year vehicles in winter conditions with average speed of 25 miles per hour (mph). Idle emissions from HDDVs were calculated using a diesel PM_{10} emission factor of 1.0 g/hr, obtained from MVEI7G, and an assumed idle time of 1-hour per truck.

Jet-A Fuel Storage Tanks

Evaporative emissions (working and breathing losses) were calculated from the Jet-A storage tank farms at each airport. Jet-A is a non-volatile petroleum mixture, so emissions are relatively insignificant in comparison to the other process categories. Evaporative emissions were calculated using the EPA Tanks program[12].

Toxic Substance Emissions Inventories

In the year 2020, OCX is projected to have an annual capacity of 28.9 MAP with 300,600 annual operations. The total number of annual LTO cycles (flights) by aircraft type, and TIM values assigned to each aircraft at OCX in 2020 are provided in Table 5. The distribution of anticipated flights by aircraft type indicate that OCX will serve as an international, medium- to long-haul domestic, and cargo service airport. Almost all aircraft using OCX will be either jets or turboprop aircraft. Very few piston-engine aircraft are expected to use OCX.

Table 5. Projected Aircraft Operations at OCX in 2020.

		Time-In-Mode (min)			
Aircraft	**Annual LTO**	**Approach**	**Climb-Out**	**Takeoff**	**Taxi**
Passenger					
A300	707	4.13	0.78	0.80	12.86
A310	74	4.00	0.53	0.63	12.86
A319	161	4.00	0.53	0.63	12.86
A320	3,382	4.00	0.53	0.63	12.86
A340	2,824	4.08	0.59	0.55	12.86
ATR42	1,995	2.70	1.30	0.50	12.86
ATR72	2,793	2.70	1.30	0.50	12.86
B7XX/A3XX	1,583	4.08	1.00	1.00	12.86
BE1900	200	2.70	1.30	0.50	12.86
CRJ	2,194	2.40	1.14	0.70	12.86
DC10	232	4.08	0.59	0.55	12.86
DHC8	4,987	2.70	1.30	0.50	12.86
EM2	1,994	4.00	0.53	0.63	12.86
F70	2,793	2.40	1.14	0.70	12.86
J31	1,995	2.40	1.14	0.70	12.86
MD11	3,006	3.98	0.75	0.75	12.86
MD80 series	6,692	2.40	0.53	0.63	12.86
MD90 series	3,857	4.00	0.53	0.63	12.86
SF340	997	2.70	1.30	0.50	12.86
B717 (MD-95)	2,379	4.00	0.53	0.63	12.86
B737-300/500	35,381	4.00	0.53	0.63	12.86
B737-400	4,458	2.40	1.14	0.70	12.86
B747-SP	3,049	4.08	1.00	1.00	12.86
B757	17,838	4.25	0.63	0.57	12.86
B767	14,451	4.08	0.59	0.55	12.86
B777	5,526	4.08	0.59	0.55	12.86
Subtotal	125,541				
Cargo					
CAN	1,139	2.40	1.14	0.70	12.86
DC10F	399	4.08	0.59	0.55	12.86
MD11F	1,847	3.98	0.52	0.75	12.86
SWM	725	2.70	1.30	0.50	12.86
B737F	1,065	2.40	1.14	0.70	12.86
B747F	1,846	4.08	1.00	1.00	12.86
B757F	3,430	4.25	0.63	0.57	12.86
B767F	1,819	4.08	0.59	0.55	12.86
B777F	1,033	4.08	0.59	0.55	12.86
Subtotal	13,299				
General Aviation					
Multi Engine	786	0.96	0.26	0.40	11.79
Business Jet	7,856	0.96	1.30	0.50	11.79
Turboprop	1,572	2.70	2.60	0.30	11.79
Helicopter	786	4.50	6.51	-	11.79
Subtotal	11,000				
Military Transport	449	2.70	1.30	0.50	12.86
TOTAL	**150,288**				

In the year 2020, JWA is projected to have an annual capacity of 5.4 MAP with 426,700 operations. The total number of annual LTO cycles (flights) by aircraft type, and TIM values assigned to each aircraft at JWA in 2020 are provided in Table 6. The distribution of anticipated flights by aircraft type indicate that JWA will serve as a short- to medium-haul domestic and general aviation airport. Due to its relatively short runway, large aircraft cannot use JWA. A significant fraction of the total operations at JWA (with OCX) will consist of general aviation aircraft with piston engines.

Table 6. Projected Aircraft Operations at JWA in 2020.

		Time-In-Mode (min)			
Aircraft	**Annual LTO**	**Approach**	**Climb-Out**	**Takeoff**	**Taxi**
Passenger					
A320	563	2.99	0.78	0.75	11.80
ATR42	670	4.27	0.85	0.75	11.80
ATR72	938	2.99	0.77	1.12	11.80
B727-200	670	6.21	2.21	0.75	11.80
B737-300/400/500	18,184	2.99	0.80	0.81	11.80
B757-200	2,501	2.99	0.80	0.81	11.80
B767-300	1,664	3.16	0.92	0.73	11.80
CRJ	737	3.04	0.92	0.81	11.80
DHC6	67	3.29	0.87	1.00	11.80
DHC8-100	737	6.21	2.21	0.75	11.80
DHC8-300	938	5.45	0.80	0.75	11.80
F70	938	4.24	0.80	0.75	11.80
J31	670	2.99	0.78	1.12	11.80
MD80 series	1,958	3.08	0.92	1.00	11.80
MD90 series	1,260	2.99	0.80	0.75	11.80
B717 (MD-95)	922	2.99	0.80	0.75	11.80
SF340	335	2.99	0.80	0.75	11.80
Subtotal	33,752				
General Aviation					
Multi Engine	14,360	6.00	5.00	0.30	6.95
Business Jet	12,027	1.60	0.50	0.40	6.95
Turboprop	4,667	1.60	0.50	0.40	6.95
Single Engine	109,494	6.00	5.00	0.30	6.95
Single Engine (TGO)	35,770	6.00	5.00	0.30	6.95
Helicopter	3,052	4.50	2.50	0.50	6.95
Subtotal	179,370				
Military					
Transport	100	3.04	0.78	1.12	6.95
Subtotal	100				
TOTAL	**213,222**				

Total annual toxic substance emissions from OCX and JWA in 2020 are summarized in Table 7. The primary toxic substances emitted from aircraft engines are formaldehyde, acetaldehyde, benzene, and 1,3-butadiene. PM_{10} was the only toxic substance for which emissions were quantified from GSE and trucks. Since lead, chromium, and nickel are only emitted by spark ignition engines sources (gasoline engines, including piston-engine aircraft), emissions of these pollutants are expected to be higher at JWA than at OCX.

Dispersion Modeling

ISCST3

Ground-level concentrations of toxic substances resulting from the emitting processes at each airport discussed above were predicted using the EPA Industrial Source Complex-Short Term (ISCST3) computer dispersion model, version 99155. Aircraft taxiways (emissions from aircraft in the taxi mode), gates and hardstand areas (emissions from GSE), and the tank farm area (emissions from the tank farm) were modeled as area sources. The aircraft approach, climb-out, and takeoff modes, and roadways (emissions from Jet-A fuel delivery trucks) were modeled as series of volume sources.

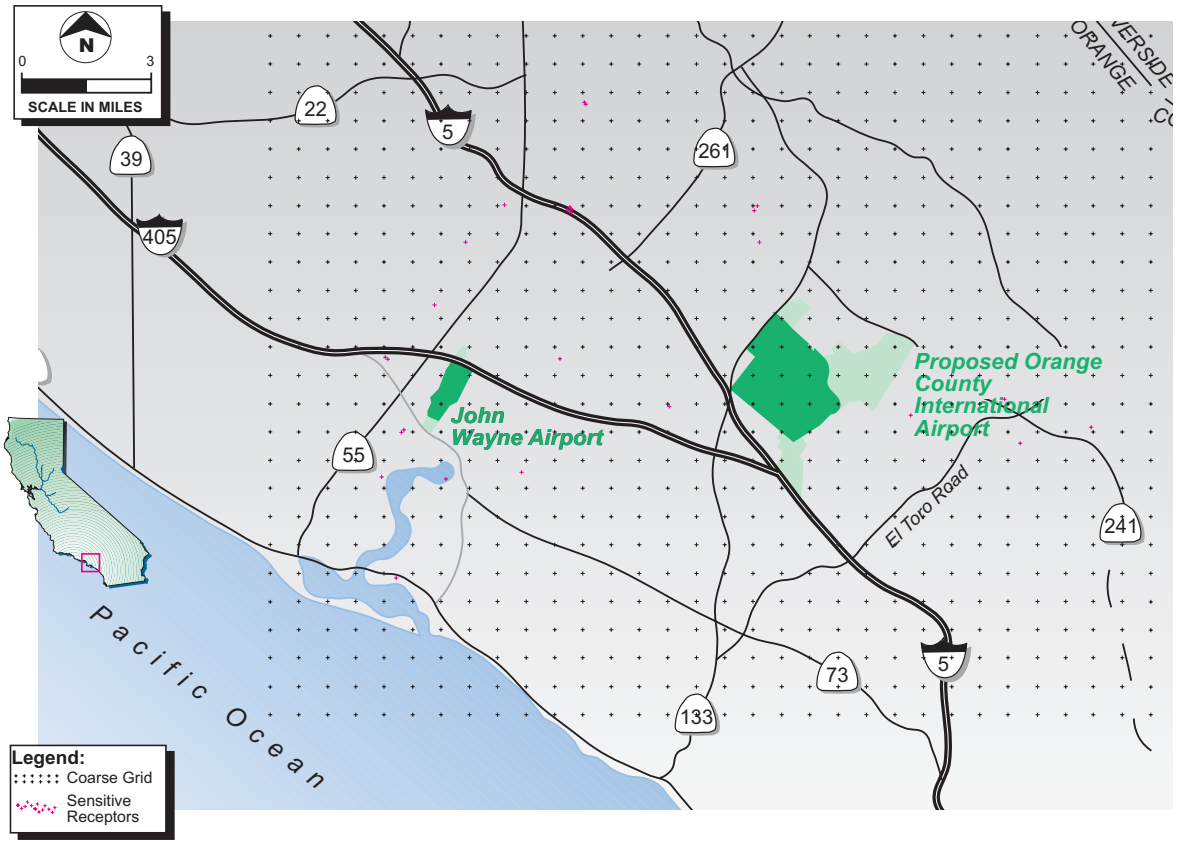
The meteorological data used in the air dispersion modeling consisted of surface observations from the MCAS El Toro (Station ID 3190) and upper air observations from San Diego (Station ID 93101) for the years 1994 through 1996. Each runway use configuration was modeled with a specific subset of meteorological data that reflects the conditions under which that particular configuration would be in effect. Runway wind coverage and utilization criteria were obtained from the *MCAS El Toro Redevelopment Authority, Technical Report 5: Facility Requirements*[13].

The initial ISCST3 coarse receptor grid used in this study is shown in Figure 4. The coarse grid has dimensions of 24 kilometers (km) in the north-south direction by 31 km in the east-west direction and consists of 800 receptors. Course grid receptors were spaced 1 km apart.

Table 7. Estimated Annual Emissions of Carcinogens at JWA and OCX in 2020.

Substance	JWA Emissions (lb/yr)	OCX Emissions (lb/yr)
Acetaldehyde	1,660	11,300
Benzene	3,240	8,820
1,3-Butadiene	1,160	4,900
Formaldehyde	6,190	36,500
POM as 7-PAH	0.572	1.27
Styrene	255	889
Chromium (hexavalent)	0.053	0.141
Lead	966	25.5
Nickel	0.062	0.165
Diesel PM_{10}	8,740	21,200

Figure 4. Coarse Grid Receptor Diagram.



Subsequent dispersion modeling was performed using a fine grid of receptors. Fine grid receptors were spaced 100 meters apart and were located in areas of highest predicted cancer risk, as determined by the coarse grid modeling analysis. The following fine-grid receptor types were evaluated in this study:

- *Residential Receptors* – Continuous exposure (24 hours per day, 365 days per year) for 70 years was assumed for residential receptors. A total of 427 residential receptors were included in the fine grid analysis– 200 near OCX and 227 near JWA.
- *Occupational Receptors* – Occupational receptors were assumed to be exposed 8 hours per day, 240 days per year, for a 46-year duration. A total of 369 occupational receptors were included in the fine grid analysis – 233 near OCX and 136 near JWA.
- *On-Site Receptors* – Located on-site in areas where worker activity is concentrated (cargo loading areas, fuel handling areas, etc.), and at the passenger terminal. Seventeen on-site receptors were included in the fine grid analysis – 11 at OCX and 6 at JWA. Occupational exposure assumptions were assumed.
- *Sensitive Receptors* – hospitals, day care centers, and schools. Twenty-eight Sensitive receptors were evaluated with residential exposure assumptions (see Figure 4).

Fine grids of residential receptors were located in the vicinity of each airport where the coarse grid modeling indicated the highest excess cancer risk in residential areas. In a similar manner, fine grids of occupational receptors were located on the north end of JWA and west of OCX where coarse grid modeling indicated the highest excess cancer risk would occur in commercial, industrial, and agricultural areas.

Separate maximally exposed individuals (MEIs) were determined for each receptor type near each airport. The MEIs represent the locations of maximum predicted cancer risk to the nearest 100 meters.

RISK CHARACTERIZATION

ACE2588

Health risks were estimated using the Assessment of Chemical Exposure for AB 2588 (ACE2588) computer model, version 93288. ACE2588 is a California Air Resources Board (CARB) approved risk assessment computer model that estimates health risks associated with exposure to specific chemicals using the algorithms and recommendations in the CAPCOA guidelines. This model directly interfaces with output from ISCST3.

Dose-response assessments have characterized the relationship between exposure to an agent and the incidence of an adverse health effect in exposed populations. In quantitative cancer risk assessment, the dose-response relationship may be expressed in terms of an inhalation unit risk factor, which is used to calculate the probability of risk of cancer associated with a given exposure level in the air. Exposure via the non-inhalation pathway may be expressed as an oral potency value, which is used to calculate the probability of risk of cancer associated with ingestion of a substance through various means. Inhalation unit risk factors and oral potency values for toxic substances included in this health risk assessment are provided in Table 8.

Table 8. Unit Risk Factors and Oral Potency Values.

Substance	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Oral Potency $(mg/kg/day)^{-1}$	Reference
Acetaldehyde	2.7×10^{-6}	n/a	OEHHA, 1999
Benzene	2.9×10^{-5}	n/a	OEHHA, 1999
1,3-Butadiene	1.7×10^{-4}	n/a	OEHHA, 1999
Formaldehyde	6.0×10^{-6}	n/a	OEHHA, 1999
POM as 7-PAH	1.1×10^{-3}	$1.2 \times 10^{+1}$	OEHHA, 1999
Styrene	5.7×10^{-7}	n/a	CAPCOA, 1993
Chromium (+6)	1.5×10^{-1}	1.9×10^{-1}	OEHHA, 1999
Lead	1.2×10^{-5}	8.5×10^{-3}	OEHHA, 1999
Nickel	2.6×10^{-4}	n/a	OEHHA, 1999
Diesel PM_{10}	3.0×10^{-4}	n/a	OEHHA, 1999

Relative toxicity of a compound is determined by its Unit Risk Factor (URF). The inhalation exposure pathway was assessed for all substances evaluated in this study. In accordance with CAPCOA requirements[14], 7-PAH, chromium, and lead were also evaluated for the non-inhalation pathway. The following non-inhalation exposure pathways were assessed:

- Soil ingestion
- Dermal contact
- Homegrown produce ingestion (residential and sensitive receptors only)

Toxicity data published by the California Office of Environmental Health Hazard Assessment (OEHHA)[15] were used as the primary source of risk factors for this risk assessment. However, the unit risk factor for styrene was obtained from the CAPCOA guidelines[14] because neither the U.S. EPA nor OEHHA has published a unit risk factor for styrene.

Excess Lifetime Cancer Risk

Cancer risk isopleths associated with 2020 airport operation emissions are shown in Figure 5. The isopleths shown are based on the coarse grid analysis and reflect residential (i.e., continuous) exposure conditions. Two distinct areas of elevated cancer risk appear – one in the vicinity of each airport. Off-site excess incremental lifetime cancer risks exceed 100 in a million near JWA and 250 in a million near OCX. The airports are close enough together so that their health effects combine. The excess incremental cancer risk in the area between JWA and OCX remains above 25 in a million.

Table 9 presents the worst plausible excess lifetime cancer risks attributed to exposure to emissions at the two airports. These results are based on the fine grid analysis. The cancer risks are considered worst plausible because the exposed individual is assumed to be located at the point of maximum risk. Additionally, for occupational and on-site receptors, exposure is assumed to occur 8 hr/day over a period of 46 years. For residential and sensitive receptors, exposure is assumed to occur 24 hr/day over a period of 70 years.

The highest on-site excess lifetime cancer risks were 142 in a million at OCX and 216 in a million at JWA. These risks are based on the application of occupational exposure assumptions to receptors in areas to which the public and airport employees have access. On-site receptors were not located on taxiways or runways, since access is prohibited. Excess lifetime cancer risks for off-site occupational MEIs are predicted to be 86 and 50 in a million, respectively. These values generally represent risks along the airport property boundary. Excess lifetime cancer risks at the residential MEIs are predicted to be 56 in a million near OCX and 27 in a million near JWA. These values represent health risks in zoned residential areas proximate to the two airports. As a result of the more distant location of residential receptors from the airports, excess lifetime cancer risks are lower for this type of exposure than for occupational exposure. The primary contributors to the predicted cancer risks are diesel PM_{10} (about 65 percent) and 1,3-butadiene (about 20 percent). GSE produce the majority of diesel PM_{10} emissions. Aircraft engines in idle and taxi mode produce the majority of 1,3-butadiene emissions (about 95 percent).

Figure 5. Excess Incremental Lifetime Cancer Risk.

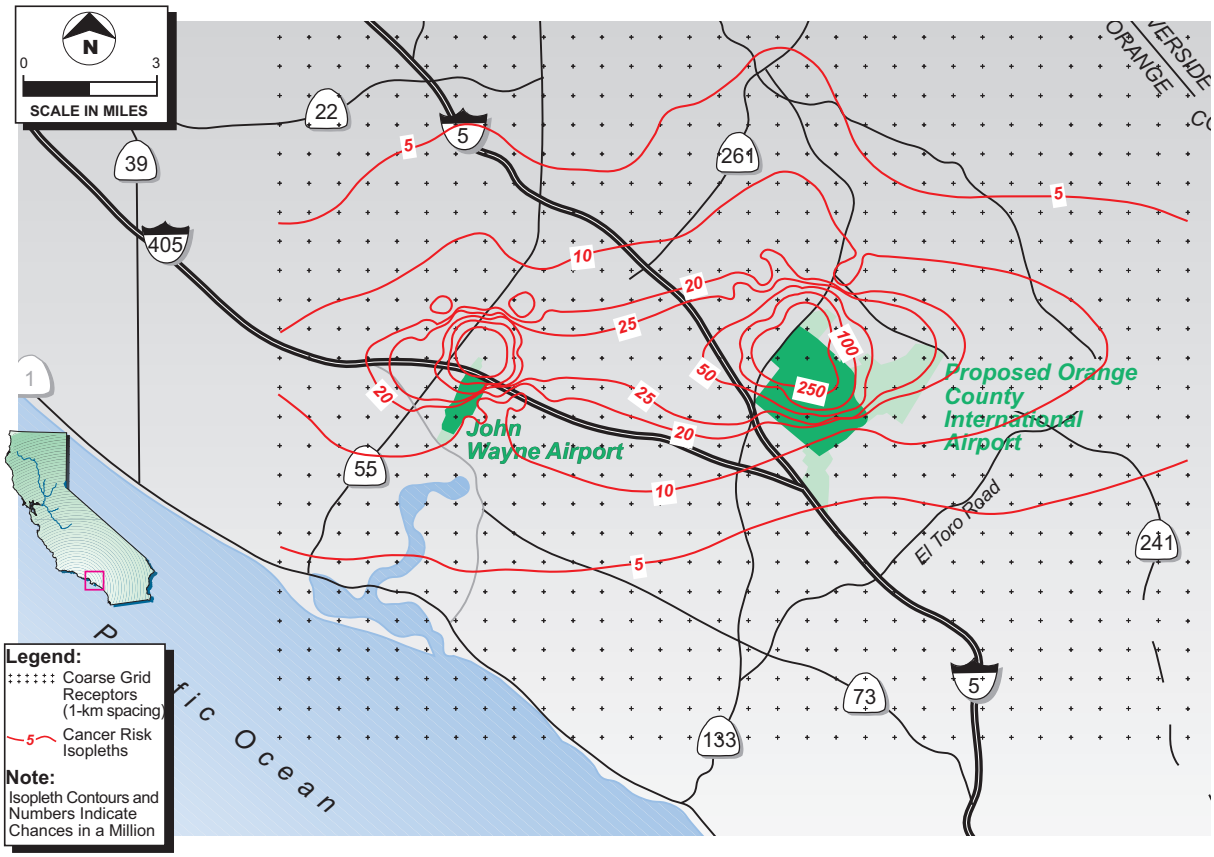


Table 9. Worst Plausible Excess Lifetime Cancer Risks (Chances in a Million) for the Maximally Exposed Individuals.

MEI Receptor	OCX	JWA
On-Site	142	216
Residential	56	27
Occupational	86	50
Sensitive	47	22

UNCERTAINTY IN HEALTH RISK ASSESSMENTS

There are inherent uncertainties in risk assessment with regard to the identification of compounds as causing cancer or other health effects in humans, the cancer potencies, the exposure levels of compounds, and the exposures that individuals receive. It is common practice to use conservative (health protective) assumptions with respect to uncertain parameters. Uncertainty occurs from the application of individual results to the general population.

This section summarizes some of the major areas of uncertainty and the assumptions used to address them.

1. The determination of risk values for each compound carries a level of uncertainty. The risk factors developed by regulatory agencies commonly incorporate safety factors to ensure that they are health protective.
2. Dispersion modeling is probabilistic, not deterministic. Dispersion models are based on assumptions that are intended to be conservative and that do not reflect actual conditions.
3. The complexity of a large airport is an inherent source of uncertainty because it is not possible to accurately model the complex network of aircraft operations on the ground and in the air.
4. Significant uncertainties exist with regard to quantification of toxic substance emissions. Most of the factors used to speciate toxic substances from aircraft engine hydrocarbon emissions are based on a relatively small amount of data.
5. Conservative assumptions used to quantify risk from long-term (chronic) exposures, such as the assumption that an individual would remain at the same location for a 70-year lifetime, are unrealistic.

In summary, the estimates generated in this risk assessment (as well as other CAPCOA-based AB2588 risk assessments) are expected to over-predict risk to human health. As a result, risk assessments are best used to compare one source of air contaminants with another on relative terms.

FINDINGS AND CONCLUSIONS

The key results and conclusions from the cancer risk assessment are as follows:

- The maximum (worst-case) excess lifetime cancer risks in residential areas associated with exposure to toxic substance emissions from aircraft, GSE, and fuel delivery truck operations in the year 2020 are estimated to be 56 in a million near OCX and 27 in a million near JWA.
- Diesel exhaust emissions are primary contributors to the cancer risk projections. The differences in the risk from one site to another are much more driven by the influence of mobile sources (such as GSE and fuel delivery trucks) than from stationary sources (fuel tank farm).
- The pollutants responsible for estimated cancer risks at the MEI, in order of significance, are diesel exhaust (67%), 1,3-butadiene, (20%), benzene (5%), and formaldehyde (5%). Cancer risks associated with the remaining pollutants are estimated to account for less than 1% at the MEI.
- The overwhelming majority of cancer risk (>95%) predicted for exposure to emissions from aircraft operations is due to aircraft in the taxi/idle mode.

- Higher estimates of lifetime excess cancer risks are observed in areas close to the passenger terminal (diesel exhaust) and aircraft taxiways (1,3-butadiene).
- The proximity of receptors to the aircraft approach and climb-out pathways does not appear to have a significant effect on predicted cancer risks.
- Implementation of mitigation measures targeted at the use of electric GSE could reduce the total predicted cancer risk by up to 60 percent.
- Estimated worst plausible excess lifetime cancer risks ranged from 22 (predicted for the JWA sensitive MEI) to 216 (JWA on-site MEI). These results are consistent with health risk assessments performed for the Chicago Midway (airport MEI = 224 in a million) and Santa Monica Municipal Airports (MEI = 29 in a million).
- Aircraft, GSE, and fuel delivery truck operations at JWA and the proposed OCX represent a relatively small portion of the total background cancer risk (1,400 in a million) estimated for exposure to ambient air in the South Coast Air Basin.

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KEYWORDS

Air Quality, Airports, Aviation, Health Risk Assessment; Cancer, Orange County International Airport, John Wayne Airport, Diesel Exhaust, 1,3-Butadiene, Formaldehyde, Benzene