APPENDIX E
AIR QUALITY AND CLIMATE

The information in this appendix supplements **Section 5.3** and **Section 5.4** and is comprised of the following:

- **E.1** Emission Inventories and Dispersion Modeling Supporting Data
- **Attachment E-1**
- **Attachment E-2**

E.1 EMISSION INVENTORIES AND DISPERSION MODELING SUPPORTING DATA

E.1.1 Emission Inventories

For the assessment of the Proposed Action, annual emissions of carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter less than 10 micrometers in diameter (coarse or PM_{10}), and particulate matter less than 2.5 micrometers in diameter (fine or $PM_{2.5}$) were prepared. Estimates of lead (Pb) were not prepared because less than one percent of the total aircraft operations at O'Hare International Airport (O'Hare) result from the use of piston aircraft, which use aviation fuel containing Pb (i.e., Avgas/100LL). To evaluate O_3, estimates of volatile organic compounds (VOC) and nitrogen oxides (NO_x)—the precursors to the air pollutant O_3—were prepared. Emission inventories were also prepared for hazardous air pollutants and greenhouse gases (GHG).

The emission inventories were prepared using Version 2d Service Pack 2 of the Federal Aviation Administration's (FAA) Aviation Environmental Design Tool (AEDT) and Version 2014b of the United States Environmental Protection Agency's (USEPA's) Motor Vehicle Emissions Simulator (MOVES).[1,2,3] The following describes the data used to prepare the emission estimates for aircraft, ground support equipment (GSE), auxiliary power units (APU), motor vehicles, and stationary sources. The data and methodology used to estimate construction-related emissions are also presented.

E.1.1.1 Aircraft

Fleet Mix

The number of annual aircraft operations and the aircraft fleet mix for the Existing, Interim, and Build Out Conditions are presented in **Table E-1**.[4] The operations and fleet mix for the Existing Condition were derived using data from the Chicago Department of Aviation's (CDA) Airport Noise and Operations Monitoring System (ANOMS) and Aerobahn databases.[5] The operations and fleet for the Interim and Build Out Conditions were derived using output from the Total Airspace and Airport Modeler (TAAM) that was performed in support of the EA (see **Appendix D**). Notably, the number of aircraft operations and fleet mix

1 FAA, Aviation Environmental Design Tool (AEDT) Users Guide, September 2017, https://aedt.faa.gov/
2 USEPA, Motor Vehicle Emission Simulator (MOVES, Version 2014b), https://www.epa.gov/moves
3 USEPA, Motor Vehicle Emissions Simulator (MOVES) User Guide for MOVES2014b, December 2018, https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves
4 An aircraft operation is either a landing or a takeoff; a landing/takeoff cycle or LTO equals 2 operations
5 Aerobahn is a ground-surveillance system that gives airline-ramp controllers and airport managers information regarding the aircraft on the ground.

for the No Action and Proposed Action Alternatives are the same. Aircraft engine assignments were made using a summary of airline-owned and/or operated aircraft prepared by Eastman Aviation Solutions.[6] In addition to the number of aircraft operations, aircraft fleet mix, and engine assignments, AEDT uses departure stage lengths (manifested as departure aircraft weight). In the air quality analysis, the stage lengths assumed were a weighted average of the lengths used to prepare the aircraft noise analysis (see **Appendix F**).

TABLE E-1
AIRCRAFT OPERATIONS/FLEET MIX/ENGINE ASSIGNMENTS

Aircraft Code	Aircraft	Engine	Number of Annual Operations		
			Existing Condition	Interim Condition	Build Out Condition
A306	Airbus A300B4-600 Series	PW4060	-	676	678
A306	Airbus A300B4-600 Series	PW4158	1,100	1,350	1,354
A306	Airbus A300F4-600 Series	CF6-80C2A5F	-	676	678
A319	Airbus A319-100 Series	CFM56-5A5	-	5,742	2,032
A319	Airbus A319-100 Series	V2522-A5	42,380	38,166	34,552
A320	Airbus A320-200 Series	CFM56-5A3	-	1,350	4,064
A320	Airbus A320-200 Series	CFM56-5B3/3	-	1,350	1,354
A320	Airbus A320-200 Series	CFM56-5B4	5,348	-	-
A320	Airbus A320-200 Series	CFM56-5B4/3	-	676	1,354
A320	Airbus A320-200 Series	V2527-A5	48,144	31,410	19,986
A320	Airbus A320-200 Series	V2527-A5 Upgrade Package	-	9,458	8,130
A320	Airbus A320-200 Series	V2527-A5E Upgrade Package	-	1,014	678
A320	Airbus A320-NEO	LEAP-1A26/26E1	1,604	2,026	2,710
A321	Airbus A321-100 Series	V2533-A5	36,434	-	-
A321	Airbus A321-200 Series	CFM56-5B3/3	-	6,080	6,098
A321	Airbus A321-200 Series	CFM56-5B3/P	-	21,954	20,324
A321	Airbus A321-200 Series	V2533-A5	-	338	678
A321	Airbus A321-200 Series	V2533-A5 Upgrade Package	-	12,834	16,260
A321	Airbus A321-NEO	CFM56-5B2/3	-	8,444	59,280
A321	Airbus A321-NEO	PW1133G-JM	-	-	678
A332	Airbus A330-200 series	CF6-80E1A2	-	676	678
A332	Airbus A330-200 series	Trent 772	-	2,702	2,032
A333	Airbus A330-300 Series	CF6-80E1A4	3,038	-	-
A333	Airbus A330-300 Series	Trent 772	2,096	676	-
A333	Airbus A330-900-NEO	Trent 772	-	676	678
A343	Airbus A340-300 Series	CFM56-5C4	650	-	-
A346	Airbus A340-600 Series	Trent 556-61	516	-	-

6 2018 Turbine-Engined Fleets of the World's Airlines, Eastman Aviation Solutions

Aircraft Code	Aircraft	Engine	Number of Annual Operations		
			Existing Condition	Interim Condition	Build Out Condition
A359	Airbus A350-1000 Series	Trent 772	-	1,350	2,710
A359	Airbus A350-900 Series	Trent 772	-	15,200	18,292
A380	Airbus A380-800 Series/Trent 970	GP7270	-	676	678
A380	Airbus A380-800 Series/Trent 970	Trent 970-84	-	1,350	1,354
B350	Raytheon Super King Air 300	PT6A-60	552	-	-
B712	Boeing 717-200 Series	BR700-715A1-30	7,416	8,782	-
B737	BD-500-1A10-CS100	CFM56-7B24	-	1,350	3,388
B737	BD-500-1A11-CS300	CFM56-7B24	-	12,834	20,664
B737	Boeing 737-700 MAX	LEAP-1A35A/33/33B2/32/30	-	6,756	51,150
B737	Boeing 737-700 Series	CFM56-7B24	13,308	-	-
B738	Boeing 737-800 MAX	LEAP-1A35A/33/33B2/32/30	-	33,436	39,972
B738	Boeing 737-800 Series	CFM56-7B24	-	676	678
B738	Boeing 737-800 Series	CFM56-7B24/3	28,970	-	-
B738	Boeing 737-800 Series	CFM56-7B24E	65,256	60,458	16,598
B738	Boeing 737-800 Series	CFM56-7B26	49,076	29,046	34,212
B738	Boeing 737-800 Series	CFM56-7B27	-	4,054	2,032
B739	Boeing 737-900 MAX	LEAP-1A35A/33/33B2/32/30	-	24,656	40,310
B739	Boeing 737-900-ER	CFM56-7B27E	35,768	43,232	25,744
B744	Boeing 747-400 Series	CF6-80C2B1F	6,204	-	-
B744	Boeing 747-400 Series	RB211-524H	-	676	678
B744	Boeing 747-400 Series Freighter	CF6-80C2B1F	2,616	2,702	2,710
B744	Boeing 747-400 Series Freighter	CF6-80C2B5F	-	1,350	3,388
B744	Boeing 747-400 Series Freighter	RB211-524H	-	-	678
B747	B787-8R	GENX-1B64	-	-	678
B747	B787-8R	GENX-1B70	-	-	7,114
B748	7478	GENX-2B67	4,684	676	678
B748	Boeing 747-800 Freighter	GENX-2B67	404	4,054	5,420
B752	Boeing 757-200 Series	RB211-535E4	-	676	678
B752	Boeing 757-200 Series	RB211-535E4B	3,660	-	-
B752	Boeing 757-200 Series Freighter	PW2040	682	-	-
B752	Boeing 757-200 Series Freighter	RB211-535E4	370	1,350	2,032
B753	Boeing 757-300 Series	RB211-535E4B	9,862	12,160	-
B763	Boeing 767-300 ER	CF6-80C2B6F	-	676	678
B763	Boeing 767-300 ER	PW4060	-	1,350	-
B763	Boeing 767-300 ER Freighter	CF6-80C2B6F	2,126	2,702	3,388
B763	Boeing 767-300 Series	CF6-80C2B6F	-	2,026	1,354

Aircraft Code	Aircraft	Engine	Number of Annual Operations		
			Existing Condition	Interim Condition	Build Out Condition
B763	Boeing 767-300 Series	PW4060	5,768	-	-
B772	Boeing 777-200 Series	GE90-110B1	-	-	678
B772	Boeing 777-200 Series	PW4090	8,098	-	-
B772	Boeing 777-200-ER	GE90-90B	2,182	7,092	2,032
B772	Boeing 777-200-ER	GE90-94B	-	676	678
B77L	Boeing 777-200-LR	GE90-115B	4,448	4,054	6,098
B77L	Boeing 777-300 ER	GE90-115B	-	6,080	-
B77W	Boeing 777-300 ER	GE90-115B	8,468	-	5,420
B77W	Boeing 777-9X	GE90-115B	-	676	2,710
B788	B787-8R	GENX-1B64	-	676	-
B788	B787-8R	GENX-1B70	10,890	5,742	-
B788	Boeing 787-10 Dreamliner	GENX-1B74/75/P1	-	676	678
B788	Boeing 787-10 Dreamliner	GENX-1B76/P2	-	1,350	6,436
B788	Boeing 787-10 Dreamliner	Trent 1000-J2	-	-	678
B788	Boeing 787-900 Dreamliner	GENX-1B74/75/P1	-	5,742	8,468
B788	Boeing 787-900 Dreamliner	Trent 1000-A2	-	8,106	8,468
B788	Boeing 787-900 Dreamliner	Trent 1000-J2	-	1,350	2,032
BE40	Raytheon Beechjet 400	JT15D-4series	438	-	-
BE58	Cessna 402	TIO-540-J2B2	-	2,702	2,710
BE58	Cessna 402	TIO-540-J2B2	2,546	-	-
C550	Cessna 550 Citation II	JT15D-5, -5A, -5B	-	676	678
C560	Cessna 525 Citation Jet	PW4090	774	-	-
C560	Cessna 560 Citation Excel	JT15D-5, -5A, -5B	528	-	-
C56X	Cessna 560 Citation XLS	PW307B	624	676	678
C680	Cessna 680 Citation Sovereign	PW306B	-	676	678
C680	Cessna 680-A Citation Latitude	BIZMEDIUMJET_F	-	676	678
C750	Cessna 680 Citation Sovereign	PW308C Build Spec 1289	708	-	-
C750	Cessna 750 Citation X	PW308A	-	676	678
CL60	Bombardier Challenger 600	CF34-3A1	1,176	-	-
CRJ2	Bombardier CRJ-200	CF34-3B	141,762	93,220	57,924
CRJ7	Bombardier CRJ-700	CF34-8C1	-	83,762	101,282
CRJ7	Bombardier CRJ-700	CF34-8C5B1	-	-	1,354
CRJ9	Bombardier CRJ-700	CF34-8C1	55,104	-	-
CRJ9	Bombardier CRJ-700	CF34-8C5B1	60,392	-	-
CRJ9	Bombardier CRJ-700-ER	CF34-8C5	-	27,694	35,906
CRJ9	Bombardier CRJ-900	CF34-8C5	-	26,344	49,794
E135	Embraer ERJ135-LR	AE3007A1/3	-	2,702	-

Aircraft Code	Aircraft	Engine	Number of Annual Operations		
			Existing Condition	Interim Condition	Build Out Condition
E145	Embraer ERJ145-LR	AE3007A1	73,610	110,784	70,796
E145	Embraer ERJ145-XR	AE3007A1E	19,962	-	-
E170	Embraer ERJ170	CF34-8E5	16,658	18,914	43,020
E170	Embraer ERJ175	CF34-8E5A1	-	54,716	58,940
E170	Embraer ERJ175-LR	CF34-8E5	86,136	54,716	66,392
E190	Embraer ERJ190-LR	CF34-10E5A1	8,908	-	-
E55P	Embraer 505	BIZLIGHTJET_F	666	-	-
F2TH	Bombardier Challenger 300	HTF7350 (AS907-2-1A)	-	676	678
F2TH	Bombardier Challenger 350	HTF7350 (AS907-2-1A)	-	676	678
F2TH	Dassault Falcon 2000	PW308C Build Spec 1289	1,598	-	-
FA20	Raytheon Hawker 800	TFE731-3	1,834	-	-
LJ45	Bombardier Learjet 45	TFE731-3	-	676	1,016
MD11	Boeing MD-10-1 Freighter	CF6-6D	1,724	-	-
MD11	Boeing MD-11	CF6-80C2D1F	1,026	-	-
MD11	Boeing MD-11 Freighter	CF6-80C2D1F	604	1,350	-
MD11	Boeing MD-11-ER	PW4060	592	1,350	-
MD82	Boeing MD-82	JT8D-217C	736	-	-
MD83	Boeing MD-83	JT8D-219	2,938	-	-
MD83	Boeing MD-88	JT8D-219	4,320	-	-
MD83	Boeing MD-90	V2525-D5	1,918	-	-
TBM8	Cessna 208 Caravan	PT6A-114	-	4,054	4,064
TBM8	Cessna 208 Caravan	PT6A-114	4,348	-	-
		Total	**903,748**	**952,464**	**1,013,852**

Emission Factors

AEDT default emission factors were used to estimate aircraft emissions for all aircraft except the Boeing 737-800 (including 737-900 MAX and 737-900-ER). After the release of AEDT 2d Service Pack 2, the FAA released updated noise and performance data for the Boeing 737-800 aircraft but deemed that data "non-standard," requiring users to request permission for its use. A request to use the 737-800 data for the EA was submitted on August 30, 2019, and approved by the FAA AEE on September 6, 2019. Documentation of FAA's approval is provided in **Appendix E, Attachment E-2**.

Time-in-Mode

Aircraft emissions are described within several operational modes: engine startup, taxi in and taxi out, climb (aboveground within takeoff and climb-out) and descend (aboveground within approach and landing). AEDT default times were assumed for each mode. Times in mode for taxi-in (for arrivals) and taxi-out (for departures) for the Existing Condition were obtained from the FAA's Aviation System Performance Metrics (ASPM) database. The taxi times for the Interim and Build Out Conditions were obtained from TAAM output (see **Appendix D**). The taxi times for the Existing, Interim, and Build Out

Conditions are provided in **Table E-2.** Taxi times are a function of runway use, aircraft ground delays, aircraft taxi speed, and the taxipath taken from the runway end to the terminal and back to a runway end.

TABLE E-2
AIRCRAFT TAXI TIMES

Condition	Alternative	Taxi Time (Minutes)	
		In (Arrivals)	Out (Departures)
Existing		13.64	22.59
Interim	No Action	17.03	14.97
	Proposed Action	18.08	16.02
Build Out	No Action	17.70	15.82
	Proposed Action	16.82	16.20
Source: FAA's Aviation System Performance Metrics (ASPM) database and CDA TAAM			

The Existing Condition is based on actual taxi in and taxi out time estimates, while the Interim and Build Out Condition taxi in and taxi out times were based on model estimates. The Existing Condition values are lower than the Interim and Build Out Conditions, in part, because of fewer aircraft operations. Notably, for the Interim Condition, the taxi times for the Proposed Action Alternative are greater than the taxi times for the No Action Alternative. This is due to the construction required to implement the Proposed Action and the resultant airfield inefficiencies of aircraft detouring and taxiing on alternative routes to/from the terminal area. However, due to the airfield efficiencies associated with the Proposed Action, taxi times are lower for the Proposed Action in the Build Out Condition.

E.1.1.2 Ground Support Equipment

GSE service the aircraft after arrival and before departure. The types of GSE at O'Hare include aircraft tugs, baggage tugs, belt loaders, fuel trucks, deicers, forklifts, and ground power units. GSE emission levels vary depending on the type of equipment, the fuel used, and the amount of time the equipment is in use. For the air quality assessment, the most recent O'Hare-specific inventory of GSE owned/operated by: American Airlines, Air Canada, Delta Air Lines, FedEx, JetBlue, Menzies, Spirit, United Airlines, and UPS was used. This inventory also provided O'Hare-specific GSE fuel types.

Emission Factors

Default AEDT emission factors were used to prepare emissions for GSE.

Operating Time

GSE operating times were obtained from the Transportation Research Board's (TRB) Improving Ground Support Equipment Operational Data for Airport Emissions Modeling.[7] To account for the use of electric GSE (eGSE), operating times were weighted based on the number of conventional fueled-GSE to the number of eGSE. For example, the operating time for a narrow body aircraft tug in the TRB documentation is seven minutes. Therefore, if 56 percent of the United Airlines narrowbody aircraft tugs are diesel-

[7] Airport Cooperative Research Program Report 149: Improving Ground Support Equipment Operational Data for Airport Emissions Modeling, 2015, http://www.trb.org/Publications/Blurbs/173715.aspx

powered, four percent are gasoline-powered, and 40 percent are electric, then it was assumed that each United Airlines diesel narrowbody aircraft tugs operate 3.9 minutes per Landing/Takeoff Cycle (LTO) (seven minutes times 56 percent), gasoline narrowbody aircraft tugs operate 0.3 minutes (seven minutes times four percent), and electric narrowbody aircraft tugs operate 2.8 minutes (seven minutes times 40 percent).

Table E-3 presents the GSE inventory and operating times by aircraft size, airline, and fuel type for passenger aircraft. **Table E-4** presents the GSE inventory and operating times for cargo aircraft. **Table E-5** presents the GSE inventory and operating times for commuter aircraft. However, the operating time for eGSE are not shown, as these types of equipment do not have local emissions.

TABLE E-3
GSE OPERATING TIMES: PASSENGER AIRCRAFT

Aircraft Type	Ground Support Equipment	Total Minutes in Use per LTO (see note 1)	Minutes in Use per LTO		
			Diesel	Gasoline	Propane
Narrow-Body Passenger American Airlines	Aircraft Tug Narrow	7	3.6	--	--
	Baggage Tug	39	0.8	27.3	--
	Belt Loader	44	11.3	32.7	--
	Cabin Service	19	6.7	12.3	--
	Lavatory Truck	10	10.0	--	--
	Other	20	6.7	12.0	--
	Ground Power Unit	5	4.0	0.1	--
	Service Truck	9	0.3	7.8	--
Narrow-Body Passenger United Airlines	Aircraft Tug Narrow	7	3.9	0.3	--
	Baggage Tug	39	10.8	28.2	--
	Belt Loader	44	21.2	15.7	--
	Cabin Service	19	14.3	4.8	--
	Lavatory Truck	10	10.0	--	--
	Other	20	9.0	6.4	0.5
	Ground Power Unit	5	4.8	0.1	--
	Service Truck	9	3.5	5.5	--
Narrow-Body Passenger Delta Airlines	Aircraft Tug Narrow	7	7.0	--	--
	Baggage Tug	39	2.8	18.1	--
	Belt Loader	44	0.0	22.0	--
	Cabin Service	19	14.6	4.3	--
	Lavatory Truck	10	0.0	10.0	--
	Other	20	12.1	6.6	0.3
	Ground Power Unit	5	3.9	0.5	--
	Service Truck	9	3.5	5.5	--
Narrow-Body Passenger Other Airlines	Aircraft Tug Narrow	7	5.4	0.7	--
	Baggage Tug	39	6.9	23.5	1.2
	Belt Loader	44	13.0	23.1	0.3
	Cabin Service	19	14.6	4.3	--
	Lavatory Truck	10	2.1	7.0	--

Aircraft Type	Ground Support Equipment	Total Minutes in Use per LTO (see note 1)	Minutes in Use per LTO		
			Diesel	Gasoline	Propane
	Other	20	12.1	6.6	0.3
	Ground Power Unit	5	3.9	0.5	--
	Service Truck	9	3.5	5.5	--
Wide-Body Passenger American Airlines	Aircraft Tug Wide	12	6.3	--	--
	Baggage Tug	62	1.3	43.4	--
	Belt Loader	40	10.2	29.8	--
	Cabin Service	68	24.0	44.0	--
	Cargo Loader	50	10.4	39.6	--
	Lavatory Truck	8	8.0	--	--
	Other	20	6.7	12.0	--
	Service Truck	4	0.1	3.5	--
	Forklifts	40	4.4	12.0	5.8
Wide-Body Passenger United Airlines	Aircraft Tug Wide	12	6.7	0.5	--
	Baggage Tug	62	17.2	44.8	--
	Belt Loader	40	19.2	14.2	--
	Cabin Service	68	51.0	17.0	--
	Cargo Loader	50	24.9	8.6	--
	Lavatory Truck	8	8.0	--	--
	Other	20	9.0	6.4	0.5
	Service Truck	4	1.6	2.4	--
	Forklifts	40	11.9	11.8	5.6
Wide-Body Passenger Delta Airlines	Aircraft Tug Wide	12	12.0	--	--
	Baggage Tug	62	4.4	28.8	--
	Belt Loader	40	0.0	20.0	--
	Cabin Service	68	52.4	15.3	--
	Cargo Loader	50	20.8	29.2	--
	Lavatory Truck	8	1.6	5.6	--
	Other	20	12.1	6.6	0.3
	Service Truck	4	1.6	2.4	--
	Forklifts	40	6.4	6.9	22.5
Wide-Body Passenger Other Airlines	Aircraft Tug Wide	12	9.3	1.1	--
	Baggage Tug	62	10.9	37.3	2.0
	Belt Loader	40	11.8	21.0	0.2
	Cabin Service	68	52.4	15.3	--
	Cargo Loader	50	45.2	4.3	0.2
	Lavatory Truck	8	1.6	5.6	--
	Other	20	12.1	6.6	0.3
	Service Truck	4	1.6	2.4	--
	Forklifts	40	6.4	6.9	22.5

-- = Not in GSE fleet
Note: . LTO = landing/takeoff cycle (two operations)
Source: GSE fleet inventories from American, Air Canada, Delta, JetBlue, Menzies, Spirit, and United, 2018 and 2019 and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-4
GSE OPERATING TIMES: CARGO AIRCRAFT

Aircraft Type	Ground Support Equipment	Total Minutes in Use per LTO (see note)	Minutes in Use per LTO		
			Diesel	Gasoline	Propane
Narrow-Body Cargo FedEx	Aircraft Tug Narrow	5	5.0	--	--
	Belt Loader	4	--	4.0	--
	Cargo Loader	47	20.1	25.2	--
	Cargo Tractor	13	9.0	3.5	--
	Forklift	11	0.3	--	3.3
	Fuel Truck	25	21.5	2.8	--
	Ground Power Unit	66	52.8	13.2	--
Narrow-Body Cargo UPS	Aircraft Tug Narrow	5	5.0	--	--
	Belt Loader	4	--	4.0	--
	Cargo Loader	47	11.3	35.7	--
	Cargo Tractor	13	2.3	7.8	0.4
	Forklift	11	5.5	5.5	--
	Fuel Truck	25	21.5	2.8	--
	Ground Power Unit	66	66.0	--	--
	Aircraft Tug Narrow	5	5.0	--	--
Narrow-Body Cargo Other	Aircraft Tug Narrow	5	3.9	0.5	--
	Belt Loader	4	1.2	2.1	--
	Cargo Loader	47	42.5	4.1	0.2
	Cargo Tractor	13	2.3	7.8	0.4
	Forklift	11	1.7	1.9	6.2
	Fuel Truck	25	21.5	2.8	--
	Ground Power Unit	66	51.5	6.1	--
	Aircraft Tug Narrow	5	3.9	0.5	--
Wide-Body Cargo FedEx	Aircraft Tug Wide	7	7.0	--	--
	Belt Loader	23	--	23.0	--
	Cargo Loader	91	39.0	48.8	--
	Cargo Tractor	29	20.2	7.8	--
	Forklift	40	0.9	--	11.8
	Fuel Truck	24	20.6	2.7	--
	Ground Power Unit	55	44.0	11.0	--
	Lavatory Truck	6	1.2	4.2	--
	Other	40	24.3	13.2	0.7
	Service Truck	3	1.2	1.8	--
Wide-Body Cargo UPS	Aircraft Tug Wide	7	7.0	0.0	--
	Belt Loader	23	--	23.0	--
	Cargo Loader	91	21.8	69.2	--

Aircraft Type	Ground Support Equipment	Total Minutes in Use per LTO (see note)	Minutes in Use per LTO		
			Diesel	Gasoline	Propane
	Cargo Tractor	29	5.1	17.4	0.9
	Forklift	40	20.0	20.0	--
	Fuel Truck	24	20.6	2.7	--
	Ground Power Unit	55	55.0	--	--
	Lavatory Truck	6	1.2	4.2	--
	Other	40	24.3	13.2	0.7
	Service Truck	3	1.2	1.8	--
Wide-Body Cargo Other	Aircraft Tug Wide	7	5.4	0.7	--
	Belt Loader	23	6.8	12.1	0.1
	Cargo Loader	91	82.3	7.9	0.4
	Cargo Tractor	29	5.1	17.4	0.9
	Forklift	40	6.4	6.9	22.5
	Fuel Truck	24	20.6	2.7	--
	Ground Power Unit	55	43.0	5.1	--
	Lavatory Truck	6	1.2	4.2	--
	Other	40	24.3	13.2	0.7
	Service Truck	3	1.2	1.8	--

Notes: LTO = landing/takeoff cycle (two operations)
-- = Not in GSE fleet
Source: GSE fleet inventories from FedEx and UPS, 2018 and 2019 and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-5
GSE OPERATING TIMES: COMMUTER AIRCRAFT

Aircraft Type	Ground Support Equipment	Total Minutes in Use per LTO (see note)	Minutes in Use per LTO		
			Diesel	Gasoline	Propane
Commuter/General Aviation	Aircraft Tug Narrow	9	7.0	0.8	--
	Baggage Tug	30	5.3	18.0	1.0
	Belt Loader	20	5.9	10.5	0.1
	Cabin Service	6	4.6	1.4	--
	Fuel Truck	11	9.5	1.3	--
	Ground Power Unit	35	27.3	3.2	--
	Lavatory Truck	4	0.8	2.8	--

Note: LTO = landing/takeoff cycle (two operations)
-- = Not in GSE fleet
Source: GSE fleet inventories from American, Air Canada, Delta, JetBlue, Menzies, Spirit, and United, 2018 and 2019 and Crawford, Murphy & Tilly, Inc./RCH Group

Using the GSE operating times, the total hours of operation for the population of GSE was derived based on the number of aircraft operations. The GSE hours of operation are provided in **Table E-6, Table E-7**, and **Table E-8** for the Existing, Interim, and Build Out Conditions, respectively. Notably, the number of hours of GSE operation are the same for the No Action and Proposed Action Alternatives because the aircraft fleet mix and the number of aircraft operations are the same. The ratio of conventionally fueled GSE and eGSE was conservatively assumed to be the same for the Existing, Interim, and Build Out Conditions.

TABLE E-6
GSE HOURS OF OPERATION: EXISTING CONDITION

Aircraft Type	Ground Support Equipment	Horsepower	Hours of Operation		
			Diesel	Gasoline	Propane
Passenger	Aircraft Tug Narrow	88	28,398	1,327	-
	Baggage Tug	107	46,881	202,194	542
	Belt Loader	107	117,639	169,512	112
	Cabin Service	210	86,609	59,967	-
	Lavatory Truck	56	67,569	4,916	-
	Other	140	60,744	63,548	2,142
	Ground Power Unit	107	31,694	730	-
	Service Truck	235	15,866	46,394	-
	Aircraft Tug Wide	475	1,016	50	-
	Cargo Loader	107	3,072	3,154	53
	Forklifts	55	1,368	1,812	948
Cargo	Aircraft Tug Narrow	88	97	4	-

Aircraft Type	Ground Support Equipment	Horsepower	Hours of Operation		
			Diesel	Gasoline	Propane
	Belt Loader	107	377	2,222	8
	Cargo Loader	107	7,237	4,402	24
	Cargo Tractor	88	1,413	1,762	73
	Forklift	55	797	781	1,847
	Fuel Truck	235	2,917	386	-
	Ground Power Unit	107	6,587	930	-
	Aircraft Tug Wide	475	751	36	-
	Lavatory Truck	56	147	503	-
	Other	140	2,894	1,574	83
	Service Truck	235	140	218	-
Commuter	Aircraft Tug Narrow	88	501	61	-
	Baggage Tug	107	377	1,291	69
	Belt Loader	107	422	752	8
	Cabin Service	210	330	97	-
	Fuel Truck	235	676	90	-
	Ground Power Unit	107	1,955	231	-
	Lavatory Truck	56	59	201	-

Source: GSE fleet inventories from American, Air Canada, Delta, JetBlue, Menzies, Spirit, and United, 2018 and 2019 and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-7
GSE HOURS OF OPERATION: INTERIM CONDITION

Aircraft Type	Ground Support Equipment	Horsepower	Hours of Operation		
			Diesel	Gasoline	Propane
Passenger	Aircraft Tug Narrow	88	28,999	1,312	-
	Baggage Tug	107	48,668	213,152	1,241
	Belt Loader	107	116,259	178,777	213
	Cabin Service	210	105,583	66,086	-
	Lavatory Truck	56	65,304	9,375	-
	Other	140	65,581	65,952	2,196
	Ground Power Unit	107	31,104	865	-
	Service Truck	235	16,205	47,085	-
	Aircraft Tug Wide	475	4,352	388	-
	Cargo Loader	107	17,615	6,071	171
	Forklifts	55	4,378	5,030	7,678
Cargo	Aircraft Tug Narrow	88	56	-	-
	Belt Loader	107	458	3,575	9

Aircraft Type	Ground Support Equipment	Horsepower	Hours of Operation		
			Diesel	Gasoline	Propane
	Cargo Loader	107	8,893	8,340	28
	Cargo Tractor	88	1,519	2,973	143
	Forklift	55	2,175	2,177	1,936
	Fuel Truck	235	4,069	539	-
	Ground Power Unit	107	9,686	789	-
	Aircraft Tug Wide	475	1,194	45	-
	Lavatory Truck	56	228	782	-
	Other	140	4,498	2,447	129
	Service Truck	235	217	339	-
Commuter	Aircraft Tug Narrow	88	632	76	-
	Baggage Tug	107	476	1,627	86
	Belt Loader	107	532	949	11
	Cabin Service	210	417	122	-
	Fuel Truck	235	853	113	-
	Ground Power Unit	107	2,465	291	-
	Lavatory Truck	56	74	253	-

Source: GSE fleet inventories from American, Air Canada, Delta, JetBlue, Menzies, Spirit, and United, 2018 and 2019 and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-8
GSE HOURS OF OPERATION: BUILD OUT CONDITION

Aircraft Type	Ground Support Equipment	Horsepower	Hours of Operation		
			Diesel	Gasoline	Propane
Passenger	Aircraft Tug Narrow	88	30,448	1,361	-
	Baggage Tug	107	52,126	228,164	975
	Belt Loader	107	124,945	188,915	176
	Cabin Service	210	110,764	72,702	-
	Lavatory Truck	56	70,919	8,383	-
	Other	140	68,615	70,266	2,333
	Ground Power Unit	107	32,940	874	-
	Service Truck	235	17,039	49,899	-
	Aircraft Tug Wide	475	4,351	319	-
	Cargo Loader	107	15,880	9,197	206
	Forklifts	55	5,187	6,376	5,952
Cargo	Aircraft Tug Narrow	88	85	-	-
	Belt Loader	107	570	4,431	11
	Cargo Loader	107	11,116	10,344	35
	Cargo Tractor	88	1,929	3,675	175

Aircraft Type	Ground Support Equipment	Horsepower	Hours of Operation		
			Diesel	Gasoline	Propane
	Forklift	55	2,643	2,643	2,443
	Fuel Truck	235	5,101	676	-
	Ground Power Unit	107	12,160	999	-
	Aircraft Tug Wide	475	1,476	55	-
	Lavatory Truck	56	283	967	-
	Other	140	5,567	3,029	160
	Service Truck	235	269	420	-
Commuter	Aircraft Tug Narrow	88	634	77	-
	Baggage Tug	107	477	1,634	87
	Belt Loader	107	534	952	11
	Cabin Service	210	418	123	-
	Fuel Truck	235	856	113	-
	Ground Power Unit	107	2,474	292	-
	Lavatory Truck	56	74	254	-

Source: GSE fleet inventories from American, Air Canada, Delta, JetBlue, Menzies, Spirit, and United, 2018 and 2019 and Crawford, Murphy & Tilly, Inc./RCH Group

GSE for Aircraft Repositioning Movements

In addition to GSE supporting aircraft at the gate, aircraft tugs are periodically used to reposition aircraft within the airfield. On a typical day, aircraft are repositioned from one gate to another, transported to maintenance hangars for scheduled and unscheduled servicing, and, in the event of a long layover, repositioned to holding areas. The time required to reposition an aircraft using an aircraft tug is estimated to be 15 minutes. Locations from/to which repositioning occurs include the northwest maintenance facility to a gate, Terminal 5 hardstands to a gate, and the central de-icing facility to a gate. The daily number of aircraft assumed to be repositioned for the Existing, Interim, and Build Out Conditions are provided in **Table E-9.**

TABLE E-9
AIRCRAFT REPOSITIONING MOVEMENTS

Condition	Alternative	Number of Aircraft Reposition Movements
Existing	Not Applicable	200
Interim	No Action	200
	Proposed Action	208
Build Out	No Action	240
	Proposed Action	184

Source: CDA, 2020

E.1.1.3 Auxiliary Power Units

All the existing commercial passenger terminal gates at O'Hare have preconditioned air (PCA) and ground power; the gates proposed as part of the Proposed Action would also have PCA and ground power. For these gates, an APU run time of seven minutes (3.5 minutes during taxi in, 3.5 minutes during taxi out) was assumed for each LTO.[8] For the analysis of cargo and APU-equipped general aviation aircraft, a default operating time per LTO of 26 minutes (13 minutes during taxi in, 13 minutes during taxi out) was assumed.

E.1.1.4 Motor Vehicles

Emissions from airport-related motor vehicle activity (i.e., surface transportation) occur from both on- and off-airport roadways as well as on-airport facilities such as parking lots and terminal curbsides. Emissions from non-airport motor vehicle activity were also considered within the study area, which included the major arterials in the vicinity of the airport (i.e., Interstate 190 [I-190], Interstate 90 [I-90], Bessie Coleman Drive, Elmhurst Road, Irving Park Road, Touhy Avenue, York Road, Thorndale Avenue, and Mannheim Road).

Fleet Mix

The on-airport motor vehicle fleet mix was developed in support of the surface transportation analysis for the EA (see **Appendix K**). The vehicle fleet mix for non-airport motor vehicles travelling on the off-airport roadway network was derived from MOVES county-specific data files provided by the Illinois Environmental Protection Agency (IEPA).

Emission Factors

Motor vehicle emissions for on- and off-airport roadways were based on emission factors corresponding to the roadway speed, the year of analysis, and the vehicle-miles-traveled on the roadways (derived from the length of each evaluated roadway segment and the number of vehicles traversing each segment). For the purposes of preparing the annual emission estimates for motor vehicles, the emission factors (in grams per mile) were multiplied by the estimated vehicle miles traveled.

Emission factors were developed from MOVES using county-specific (e.g., inspection and maintenance data and meteorological data) as well as project-specific (i.e., vehicle/fuel types, vehicle speeds, idling times, and the year of analysis) data. Each project vehicle type was matched to the equivalent vehicle classification for the MOVES model, using the method outlined in the Airport Cooperative Research Program Research Report 180.[9] **Table E-10** provides the type(s) of motor vehicles, the MOVES model equivalent vehicle type, the fuel type, speed(s), and idling times assumed for each evaluated facility.

For the Existing Condition, motor vehicle emission factors were obtained for the year 2018. For the Interim and Build Out Conditions, the factors were obtained for the years 2023 and 2030, respectively. **Tables E-11 through E-13** provide the emission factors for motor vehicles for criteria air pollutants/precursors and GHG. Project delays that affect the corresponding years in which Interim and Build Out Conditions would occur would result in lower emission factors due to regulatory requirements and greater engine efficiencies.

[8] Federal Aviation Administration, 1998. Personal communication between J. A. Draper (Federal Aviation Administration) to J. R. Pehrson (Camp Dresser & McKee Inc.), November 4, 1998, subject: Air Quality Modeling Protocol for Criteria Pollutants for LAX Master Plan EIS/EIR

[9] Transportation Research Board, Airport Cooperative Research Program, Guidebook for Quantifying Airport Ground Access Vehicle Activity for Emissions Modeling, 2017,https://www.nap.edu/catalog/24954/guidebook-for-quantifying-airport-ground-access-vehicle-activity-for-emissions-modeling.

As such, the emission estimates prepared to evaluate the Proposed Action can be considered conservatively high estimates.[10]

Roadways

For the Existing, Interim, and Build Out Conditions, O'Hare-specific on- and off-airport traffic data was developed for the surface transportation analysis. Motor vehicle emissions for on- and off-airport roadways were based on emission factors corresponding to the vehicle speed and vehicle fleet mix (see **Table E-10**), traffic volume, and travel distance (see **Appendix K**).

Terminal Curbsides

Terminal curbside motor vehicle volumes, queue lengths, and dwell times were developed in support of the surface transportation analysis. **Table E-10** provides the fleet mix, fuel type, speed, and dwell time for motor vehicles on the terminal curbsides.

Parking Facilities

The evaluated parking facilities include both public and employee parking garages, surface lots, and O'Hare's Consolidated Car Rental Facility. For the parking facilities with exit stations, queue dwell times developed in support of the surface transportation analysis, were considered in the air quality analysis. Vehicle travel distances within each parking facility were determined based on the size of each facility and the type of facility (i.e., surface or garage). **Table E-10** provides the fleet mix, fuel type, speed, and dwell time for the motor vehicles in the parking facilities.

[10] Interim and Build Out implementation is expected to occur in 2025 and 2032.

TABLE E-10
MOTOR VEHICLE EMISSIONS MODELING INPUT DATA

			Input Data				
On-/Off-Airport	**Location**		**Project Vehicle Type**	**MOVES Vehicle Type(s) Equivalents**	**Fuel Type(s)**	**Speed (miles per hour)**	**Idling Time**
On-Airport	Roadways		Private and Airport-Operated	Composite of Passenger Cars/Trucks	Composite of gasoline, diesel, E-85, and electric	5 to 70	No Idling
			Rental Car				
			Taxi				
			Limos	Passenger Cars			
			Super Shuttle	Light Commercial Truck			
			Other Door-to-Door				
			Courtesy	Composite of Light Commercial Truck, Single Unit Short-Haul Truck, and Transit Bus	Composite of all available fuels within MOVES: gasoline, diesel, E-85, CNG, and electric		
			Charter/Intercity	Transit Bus	Composite of gasoline, diesel, and CNG		
			Buses (American Airlines and United Airlines Employees bused from Parking Lots to Terminals)	Transit Bus	Composite of gasoline/diesel	10 and 30	
	Parking	Lot A (Hourly)	Cars	Composite of Passenger Cars/Trucks	Composite of gasoline/diesel	5 and 10	10 seconds per vehicle
		Lot A (Daily)					
		Lot B					
		Lot C					
		Lot D (International)	Cars/Trucks	Cars: Passenger Cars/Trucks	Cars: Composite of gasoline/diesel		
				Trucks: Single Unit Short-Haul Truck / Combination Short-Haul Truck	Trucks: diesel		
		Lot E (Economy)	Cars	Composite of Passenger Cars/Trucks	Composite of gasoline/diesel		
		Lot G					

On-/Off-Airport	Location		Input Data: Project Vehicle Type	Input Data: MOVES Vehicle Type(s) Equivalents	Input Data: Fuel Type(s)	Input Data: Speed (miles per hour)	Input Data: Idling Time
		Lot H (Economy)					
		Rental Car Return					
		Taxi Holding Area					
		TNP (Rideshare Lot)					
		United Airlines Temporary Employee Parking					
		Guard Post 1-Northwest Maintenance Buildings/American Airlines Employee Parking	Cars/Trucks	Cars: Composite of Passenger Cars/Trucks	Cars: Composite of gasoline/diesel		
		Northeast Cargo Area		Trucks: Composite of Single Unit Short-Haul Truck, and Combination Short-Haul Truck	Trucks: diesel		
		Southeast Service Area					
		Delta					
		South Cargo Area					
	Terminal Curbsides		Go Airport Express	Light Commercial Truck	Composite of gasoline, diesel, E-85, and electric	10 MPH	10 seconds to up to 3 minutes per vehicle
			Limousine and Uber Black/Livery	Composite of Passenger Cars/Trucks			
			Private Vehicle	Composite of Passenger Cars/Trucks			
			Shuttle Bus Center	Light Commercial Truck			
			Taxi	Composite of Passenger Cars/Trucks			
			TNP				
			Charter Bus	Transit Bus	Composite of gasoline, diesel, and CNG		
			Multimodal Facility Shuttle	Composite of Light Commercial Truck, Single Unit Short-Haul Truck, and Transit Bus	Composite of all fuel types based on MOVES county data fuel mix from IEPA		
	Airport-Related Vehicles			See Assumptions for On-Airport Roadways			

On-/Off-Airport	Location	Input Data				
		Project Vehicle Type	MOVES Vehicle Type(s) Equivalents	Fuel Type(s)	Speed (miles per hour)	Idling Time
Off-Airport	Non-Airport Vehicles		Composite of all vehicle types based on MOVES county data	Composite of all fuel types based on MOVES county data fuel mix from IEPA	5 to 70	No Idling

TABLE E-11
MOTOR VEHICLE EMISSION FACTORS (GRAMS PER MILE) – EXISTING CONDITION

Roadway Type	Vehicle Speed	CO	HC	NOx	SOx	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_2O
Off-Airport	2.5	9.81	0.66	2.19	0.02	0.50	0.16	2,444	0.041	0.029
	5	6.26	0.36	1.20	0.01	0.34	0.09	1,354	0.023	0.015
	10	4.48	0.20	0.78	0.01	0.20	0.06	828	0.014	0.007
	15	3.90	0.15	0.65	<0.01	0.15	0.05	660	0.010	0.005
	20	3.46	0.12	0.58	<0.01	0.12	0.04	569	0.008	0.004
	25	2.90	0.10	0.53	<0.01	0.11	0.03	510	0.007	0.003
	30	2.75	0.09	0.50	<0.01	0.09	0.03	464	0.006	0.002
	35	2.51	0.08	0.46	<0.01	0.07	0.02	428	0.006	0.002
	40	2.31	0.07	0.45	<0.01	0.06	0.02	412	0.005	0.002
	45	2.19	0.07	0.44	<0.01	0.05	0.02	400	0.005	0.002
	50	2.14	0.06	0.43	<0.01	0.04	0.02	390	0.005	0.001
	55	2.15	0.06	0.43	<0.01	0.03	0.02	383	0.005	0.001
	60	2.21	0.06	0.43	<0.01	0.03	0.01	381	0.005	0.001
	65	2.35	0.06	0.46	<0.01	0.03	0.01	388	0.005	0.001
	70	2.69	0.06	0.49	<0.01	0.02	0.01	403	0.005	0.001
	75	3.48	0.07	0.54	<0.01	0.02	0.02	427	0.006	0.001
On-Airport – Passenger Cars	2.5	7.42	0.37	0.36	0.01	0.34	0.06	1,845	0.010	0.021
	5	4.82	0.20	0.25	0.01	0.19	0.04	1,032	0.006	0.011
	10	3.52	0.11	0.20	<0.01	0.12	0.02	626	0.004	0.005
	15	3.09	0.08	0.19	<0.01	0.10	0.02	491	0.004	0.004
	20	2.73	0.07	0.18	<0.01	0.08	0.02	421	0.003	0.003
	25	2.24	0.06	0.17	<0.01	0.07	0.01	373	0.003	0.002
	30	2.14	0.05	0.15	<0.01	0.06	0.01	333	0.003	0.002
	35	1.93	0.04	0.15	<0.01	0.05	0.01	314	0.002	0.002
	40	1.74	0.04	0.14	<0.01	0.04	0.01	302	0.002	0.001
	45	1.62	0.04	0.14	<0.01	0.03	0.01	292	0.002	0.001
	50	1.59	0.03	0.14	<0.01	0.02	0.01	286	0.002	0.001
	55	1.59	0.03	0.15	<0.01	0.02	0.01	282	0.002	0.001
	60	1.64	0.03	0.15	<0.01	0.02	0.01	280	0.002	0.001
	65	1.73	0.03	0.16	<0.01	0.02	0.01	282	0.002	0.001
	70	1.98	0.03	0.17	<0.01	0.01	0.01	291	0.003	0.001
	75	2.63	0.04	0.20	<0.01	0.01	0.01	306	0.004	0.001
On-Airport – Light Commercial Truck	2.5	12.8	0.64	1.31	0.02	0.40	0.09	2,472	0.028	0.042
	5	8.32	0.35	0.81	0.01	0.23	0.05	1,393	0.016	0.021
	10	6.06	0.21	0.56	0.01	0.14	0.03	854	0.011	0.010
	15	5.31	0.16	0.48	<0.01	0.11	0.03	674	0.009	0.007
	20	4.73	0.13	0.44	<0.01	0.09	0.02	581	0.008	0.005
	25	3.97	0.11	0.40	<0.01	0.08	0.02	520	0.007	0.004

Roadway Type	Vehicle Speed	CO	HC	NOx	SOx	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_2O
	30	3.74	0.10	0.37	<0.01	0.07	0.02	464	0.006	0.003
	35	3.47	0.09	0.36	<0.01	0.05	0.01	439	0.006	0.003
	40	3.24	0.08	0.36	<0.01	0.04	0.01	424	0.005	0.003
	45	3.08	0.07	0.35	<0.01	0.04	0.01	413	0.005	0.002
	50	2.99	0.07	0.36	<0.01	0.03	0.01	404	0.005	0.002
	55	3.00	0.07	0.36	<0.01	0.02	0.01	400	0.005	0.002
	60	3.10	0.06	0.38	<0.01	0.02	0.01	402	0.005	0.002
	65	3.31	0.07	0.39	<0.01	0.02	0.01	407	0.005	0.002
	70	3.81	0.07	0.43	<0.01	0.02	0.01	424	0.006	0.001
	75	4.85	0.08	0.48	<0.01	0.02	0.01	448	0.007	0.001
On-Airport – Transit Bus	2.5	18.9	4.58	51.1	0.07	2.53	1.40	7,718	0.353	0.035
	5	9.73	2.19	24.7	0.03	1.71	0.76	3,914	0.161	0.018
	10	5.40	1.18	13.3	0.02	0.91	0.42	2,203	0.090	0.009
	15	2.86	0.70	7.49	0.01	0.53	0.23	1,096	0.050	0.006
	20	2.68	0.56	6.75	0.01	0.47	0.21	1,128	0.042	0.004
	25	2.57	0.49	6.31	0.01	0.43	0.20	1,148	0.036	0.004
	30	2.50	0.43	6.02	0.01	0.40	0.19	1,161	0.033	0.003
	35	2.33	0.38	5.71	0.01	0.36	0.19	1,114	0.029	0.003
	40	2.21	0.34	5.48	0.01	0.33	0.18	1,080	0.026	0.002
	45	2.11	0.31	5.31	0.01	0.30	0.18	1,053	0.024	0.002
	50	2.41	0.37	6.03	0.01	0.24	0.16	1,226	0.025	0.002
	55	2.66	0.41	6.62	0.01	0.19	0.14	1,368	0.026	0.002
	60	2.54	0.39	6.54	0.01	0.17	0.12	1,367	0.024	0.001
	65	2.53	0.37	7.04	0.01	0.16	0.12	1,464	0.022	0.001
	70	2.54	0.35	7.52	0.01	0.15	0.12	1,555	0.021	0.001
	75	2.58	0.34	8.16	0.01	0.16	0.13	1,661	0.019	0.001

Source: USEPA, Motor Vehicle Emissions Simulator (MOVES) User Guide for MOVES2014b December 2018

TABLE E-12
MOTOR VEHICLE EMISSION FACTORS (GRAMS PER MILE) – INTERIM CONDITION

Roadway Type	Vehicle Speed	CO	HC	NOx	SOx	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_2O
On-Airport – Light Commercial Truck	2.5	8.12	0.34	0.56	0.01	0.38	0.07	2,124	0.021	0.027
	5	5.50	0.18	0.36	0.01	0.21	0.04	1,197	0.012	0.014
	10	4.19	0.10	0.26	<0.01	0.13	0.03	734	0.008	0.007
	15	3.75	0.08	0.23	<0.01	0.10	0.02	580	0.007	0.005
	20	3.37	0.06	0.21	<0.01	0.09	0.02	500	0.006	0.003
	25	2.82	0.05	0.20	<0.01	0.08	0.02	448	0.005	0.003

	30	2.70	0.05	0.18	<0.01	0.06	0.01	399	0.005	0.002
	35	2.52	0.04	0.18	<0.01	0.05	0.01	378	0.005	0.002
	40	2.35	0.04	0.18	<0.01	0.04	0.01	365	0.004	0.002
	45	2.25	0.04	0.18	<0.01	0.03	0.01	356	0.004	0.002
	50	2.20	0.03	0.18	<0.01	0.03	0.01	348	0.004	0.001
	55	2.23	0.03	0.19	<0.01	0.02	0.01	345	0.004	0.001
	60	2.33	0.03	0.20	<0.01	0.02	0.01	346	0.004	0.001
	65	2.53	0.03	0.21	<0.01	0.02	0.01	351	0.005	0.001
	70	2.97	0.04	0.24	<0.01	0.01	0.01	366	0.006	0.001
	75	3.84	0.05	0.28	<0.01	0.01	0.01	387	0.007	0.001
On-Airport – Transit Bus	2.5	11.0	2.82	29.7	0.06	1.92	0.84	7,526	0.437	0.035
	5	5.62	1.34	14.5	0.03	1.40	0.48	3,824	0.199	0.017
	10	3.12	0.73	7.80	0.02	0.75	0.26	2,152	0.112	0.009
	15	1.65	0.43	4.39	0.01	0.44	0.14	1,071	0.062	0.006
	20	1.54	0.35	3.96	0.01	0.38	0.13	1,103	0.051	0.004
	25	1.48	0.30	3.70	0.01	0.34	0.12	1,123	0.045	0.003
	30	1.44	0.27	3.53	0.01	0.32	0.12	1,136	0.041	0.003
	35	1.35	0.24	3.34	0.01	0.28	0.11	1,090	0.036	0.002
	40	1.28	0.21	3.19	0.01	0.25	0.11	1,056	0.032	0.002
	45	1.22	0.19	3.08	0.01	0.22	0.10	1,029	0.030	0.002
	50	1.40	0.22	3.50	0.01	0.17	0.09	1,199	0.031	0.002
	55	1.54	0.25	3.84	0.01	0.12	0.08	1,338	0.032	0.002
	60	1.47	0.23	3.78	0.01	0.11	0.07	1,338	0.030	0.001
	65	1.45	0.22	4.06	0.01	0.10	0.07	1,431	0.027	0.001
	70	1.44	0.21	4.32	0.01	0.09	0.07	1,520	0.025	0.001
	75	1.45	0.20	4.67	0.01	0.09	0.07	1,624	0.024	0.001
On-Airport – Passenger Cars/Trucks Composite	2.5	6.08	0.28	0.20	0.01	0.35	0.06	1,743	0.008	0.020
	5	4.08	0.15	0.15	0.01	0.20	0.03	978	0.005	0.010
	10	3.08	0.08	0.12	<0.01	0.12	0.02	596	0.004	0.005
	15	2.74	0.06	0.11	<0.01	0.09	0.02	469	0.003	0.003
	20	2.44	0.05	0.11	<0.01	0.08	0.02	403	0.003	0.002
	25	2.01	0.04	0.10	<0.01	0.07	0.01	359	0.003	0.002
	30	1.93	0.04	0.10	<0.01	0.06	0.01	321	0.003	0.002
	35	1.76	0.03	0.09	<0.01	0.05	0.01	303	0.002	0.001
	40	1.61	0.03	0.10	<0.01	0.04	0.01	292	0.002	0.001
	45	1.52	0.03	0.10	<0.01	0.03	0.01	284	0.002	0.001
	50	1.50	0.03	0.10	<0.01	0.02	0.01	278	0.002	0.001
	55	1.51	0.02	0.10	<0.01	0.02	0.01	275	0.002	0.001
	60	1.58	0.02	0.11	<0.01	0.02	0.01	275	0.002	0.001
	65	1.71	0.02	0.12	<0.01	0.01	0.00	278	0.003	0.001
	70	2.01	0.03	0.14	<0.01	0.01	0.01	287	0.003	0.001
	75	2.70	0.03	0.16	<0.01	0.01	0.01	304	0.004	0.001
On-Airport –	2.5	8.65	0.71	3.23	0.03	0.63	0.20	3,494	0.116	0.033

Courtesy Shuttles	5	5.47	0.38	1.61	0.01	0.50	0.12	1,833	0.063	0.017
	10	3.95	0.21	0.98	0.01	0.29	0.07	1,108	0.034	0.008
	15	3.51	0.15	0.77	0.01	0.21	0.05	874	0.025	0.006
	20	3.17	0.12	0.65	0.01	0.16	0.04	751	0.020	0.004
	25	2.71	0.10	0.57	<0.01	0.13	0.03	664	0.016	0.003
	30	2.59	0.09	0.54	<0.01	0.11	0.03	613	0.015	0.003
	35	2.36	0.08	0.49	<0.01	0.09	0.03	551	0.013	0.002
	40	2.20	0.07	0.46	<0.01	0.07	0.02	522	0.012	0.002
	45	2.09	0.06	0.45	<0.01	0.06	0.02	500	0.011	0.002
	50	2.02	0.06	0.44	<0.01	0.05	0.02	481	0.010	0.002
	55	2.01	0.05	0.43	<0.01	0.04	0.02	468	0.010	0.002
	60	2.05	0.05	0.41	<0.01	0.04	0.02	451	0.010	0.001
	65	2.18	0.05	0.43	<0.01	0.03	0.02	459	0.009	0.001
	70	2.49	0.05	0.46	<0.01	0.03	0.02	474	0.010	0.001
	75	3.12	0.06	0.50	<0.01	0.03	0.02	500	0.010	0.001

Source: USEPA, Motor Vehicle Emissions Simulator (MOVES) User Guide for MOVES2014b, December 2018

TABLE E-13
MOTOR VEHICLE EMISSION FACTORS (GRAMS PER MILE) – BUILD OUT CONDITION

Roadway Type	Vehicle Speed	CO	HC	NOx	SOx	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_2O
Off-Airport	2.5	4.19	0.30	0.59	0.01	0.41	0.07	1,827	0.038	0.019
	5	2.80	0.16	0.32	0.01	0.29	0.05	1,008	0.021	0.009
	10	2.11	0.09	0.21	<0.01	0.17	0.03	616	0.012	0.005
	15	1.89	0.06	0.17	<0.01	0.12	0.02	492	0.009	0.003
	20	1.68	0.05	0.15	<0.01	0.10	0.02	425	0.007	0.002
	25	1.37	0.04	0.14	<0.01	0.09	0.02	381	0.006	0.002
	30	1.34	0.04	0.13	<0.01	0.07	0.01	348	0.005	0.002
	35	1.24	0.03	0.12	<0.01	0.06	0.01	319	0.005	0.001
	40	1.15	0.03	0.12	<0.01	0.04	0.01	307	0.004	0.001
	45	1.10	0.03	0.12	<0.01	0.04	0.01	298	0.004	0.001
	50	1.09	0.03	0.12	<0.01	0.03	0.01	289	0.004	0.001
	55	1.11	0.03	0.12	<0.01	0.02	0.01	283	0.004	0.001
	60	1.16	0.03	0.12	<0.01	0.02	0.01	282	0.004	0.001
	65	1.26	0.03	0.13	<0.01	0.02	0.01	288	0.004	0.001
	70	1.48	0.03	0.15	<0.01	0.01	0.01	299	0.004	0.001
	75	1.97	0.03	0.17	<0.01	0.01	0.01	316	0.005	0.001
On-Airport – Passenger Cars	2.5	3.48	0.20	0.04	0.01	0.33	0.05	1,278	0.003	0.016
	5	2.38	0.11	0.03	<0.01	0.19	0.03	715	0.002	0.008
	10	1.84	0.06	0.03	<0.01	0.11	0.02	433	0.002	0.004

	15	1.65	0.04	0.03	<0.01	0.09	0.01	339	0.002	0.003
	20	1.47	0.03	0.03	<0.01	0.08	0.01	290	0.002	0.002
	25	1.17	0.03	0.03	<0.01	0.07	0.01	258	0.001	0.002
	30	1.15	0.02	0.03	<0.01	0.05	0.01	230	0.001	0.001
	35	1.04	0.02	0.03	<0.01	0.04	0.01	217	0.001	0.001
	40	0.94	0.02	0.03	<0.01	0.03	0.01	208	0.001	0.001
	45	0.88	0.02	0.03	<0.01	0.03	0.01	202	0.001	0.001
	50	0.88	0.02	0.03	<0.01	0.02	<0.01	198	0.001	0.001
	55	0.89	0.02	0.04	<0.01	0.02	<0.01	195	0.001	0.001
	60	0.93	0.02	0.04	<0.01	0.01	<0.01	194	0.001	0.001
	65	1.00	0.02	0.04	<0.01	0.01	<0.01	195	0.001	0.001
	70	1.18	0.02	0.05	<0.01	0.01	<0.01	201	0.002	0.001
	75	1.61	0.02	0.07	<0.01	0.01	<0.01	212	0.002	0.001
On-Airport – Light Commercial Truck	2.5	4.78	0.22	0.24	0.01	0.37	0.06	1,736	0.017	0.021
	5	3.30	0.12	0.16	0.01	0.21	0.03	978	0.010	0.011
	10	2.56	0.07	0.12	<0.01	0.13	0.02	599	0.006	0.005
	15	2.31	0.05	0.10	<0.01	0.10	0.02	473	0.005	0.004
	20	2.08	0.04	0.10	<0.01	0.09	0.02	408	0.004	0.003
	25	1.72	0.03	0.09	<0.01	0.08	0.01	365	0.004	0.002
	30	1.67	0.03	0.09	<0.01	0.06	0.01	325	0.004	0.002
	35	1.56	0.03	0.09	<0.01	0.05	0.01	308	0.003	0.002
	40	1.47	0.03	0.09	<0.01	0.04	0.01	298	0.003	0.001
	45	1.41	0.02	0.09	<0.01	0.03	0.01	290	0.003	0.001
	50	1.39	0.02	0.09	<0.01	0.02	0.01	284	0.003	0.001
	55	1.41	0.02	0.09	<0.01	0.02	0.01	281	0.003	0.001
	60	1.49	0.02	0.10	<0.01	0.02	<0.01	282	0.003	0.001
	65	1.64	0.03	0.11	<0.01	0.01	<0.01	286	0.003	0.001
	70	1.98	0.03	0.14	<0.01	0.01	<0.01	297	0.004	0.001
	75	2.61	0.04	0.17	<0.01	0.01	0.01	314	0.005	0.001
On-Airport – Transit Bus	2.5	5.25	1.51	14.1	0.06	1.51	0.47	7,463	0.475	0.034
	5	2.64	0.71	7.02	0.03	1.20	0.29	3,796	0.216	0.017
	10	1.47	0.39	3.76	0.02	0.63	0.16	2,135	0.121	0.009
	15	0.78	0.22	2.13	0.01	0.38	0.09	1,064	0.068	0.006
	20	0.73	0.18	1.92	0.01	0.33	0.08	1,095	0.056	0.004
	25	0.70	0.16	1.79	0.01	0.29	0.07	1,113	0.049	0.003
	30	0.67	0.14	1.71	0.01	0.27	0.07	1,126	0.044	0.003
	35	0.64	0.13	1.61	0.01	0.23	0.06	1,079	0.039	0.002
	40	0.61	0.11	1.53	0.01	0.20	0.06	1,045	0.035	0.002
	45	0.59	0.10	1.47	0.01	0.17	0.06	1,018	0.032	0.002
	50	0.66	0.11	1.66	0.01	0.12	0.05	1,185	0.034	0.002
	55	0.73	0.12	1.82	0.01	0.08	0.04	1,322	0.035	0.002
	60	0.69	0.11	1.79	0.01	0.07	0.04	1,322	0.032	0.001
	65	0.66	0.10	1.90	0.01	0.06	0.03	1,414	0.030	0.001

	70	0.65	0.10	2.01	0.01	0.06	0.03	1,501	0.027	0.001
	75	0.64	0.09	2.17	0.01	0.05	0.04	1,603	0.025	0.001
On-Airport – Passenger Cars/Trucks Composite	2.5	3.82	0.20	0.07	0.01	0.34	0.05	1,405	0.005	0.017
	5	2.63	0.11	0.06	0.01	0.19	0.03	788	0.004	0.008
	10	2.03	0.06	0.05	<0.01	0.12	0.02	480	0.003	0.004
	15	1.83	0.04	0.05	<0.01	0.09	0.02	377	0.002	0.003
	20	1.64	0.03	0.05	<0.01	0.08	0.01	324	0.002	0.002
	25	1.32	0.03	0.04	<0.01	0.07	0.01	289	0.002	0.002
	30	1.29	0.03	0.04	<0.01	0.06	0.01	258	0.002	0.001
	35	1.19	0.02	0.04	<0.01	0.04	0.01	243	0.002	0.001
	40	1.09	0.02	0.04	<0.01	0.04	0.01	235	0.002	0.001
	45	1.04	0.02	0.05	<0.01	0.03	0.01	228	0.002	0.001
	50	1.03	0.02	0.05	<0.01	0.02	<0.01	223	0.002	0.001
	55	1.05	0.02	0.05	<0.01	0.02	<0.01	221	0.002	0.001
	60	1.11	0.02	0.06	<0.01	0.01	<0.01	221	0.002	0.001
	65	1.21	0.02	0.06	<0.01	0.01	<0.01	223	0.002	0.001
	70	1.45	0.02	0.08	<0.01	0.01	<0.01	230	0.002	0.001
	75	1.97	0.03	0.10	<0.01	0.01	<0.01	244	0.003	0.001
On-Airport – Courtesy Shuttles	2.5	5.15	0.48	1.73	0.02	0.54	0.11	3,193	0.118	0.027
	5	3.29	0.25	0.86	0.01	0.46	0.08	1,664	0.063	0.014
	10	2.40	0.14	0.52	0.01	0.26	0.05	1,003	0.034	0.007
	15	2.15	0.10	0.41	0.01	0.19	0.03	792	0.024	0.005
	20	1.94	0.08	0.35	0.01	0.15	0.03	680	0.020	0.003
	25	1.64	0.07	0.31	<0.01	0.12	0.02	600	0.016	0.003
	30	1.59	0.06	0.29	<0.01	0.10	0.02	556	0.014	0.002
	35	1.46	0.05	0.26	<0.01	0.08	0.02	497	0.013	0.002
	40	1.36	0.05	0.25	<0.01	0.06	0.01	470	0.012	0.002
	45	1.30	0.04	0.24	<0.01	0.05	0.01	449	0.011	0.002
	50	1.26	0.04	0.24	<0.01	0.04	0.01	431	0.010	0.001
	55	1.27	0.04	0.23	<0.01	0.03	0.01	419	0.010	0.001
	60	1.30	0.03	0.23	<0.01	0.03	0.01	402	0.009	0.001
	65	1.40	0.03	0.24	<0.01	0.03	0.01	409	0.009	0.001
	70	1.62	0.04	0.25	<0.01	0.02	0.01	422	0.009	0.001
	75	2.07	0.04	0.28	<0.01	0.02	0.01	445	0.009	0.001
Source: USEPA, Motor Vehicle Emissions Simulator (MOVES) User Guide for MOVES2014b, December 2018										

Employee Busing

Motor vehicle-related emissions that result from American Airlines and United Airlines buses transporting employees from parking lots to terminals were estimated from the number of annual trips and the distance travelled. Except for the analysis for Build Out Proposed Action, the American Airlines and United Airlines employee parking lots were evaluated in the northwest airfield. For the Build Out Proposed Action, the capacity of the current American Airlines and United Airlines employee parking lots would be relocated to the garage next to the western employee screening facility.

E.1.1.5 Stationary Sources

The stationary sources included in the air quality analysis are boilers (natural gas and #2 fuel oil), emergency generators (diesel), aircraft engine runup enclosures, training fires, and fuel storage and handling (Jet A).

Boilers and Generators

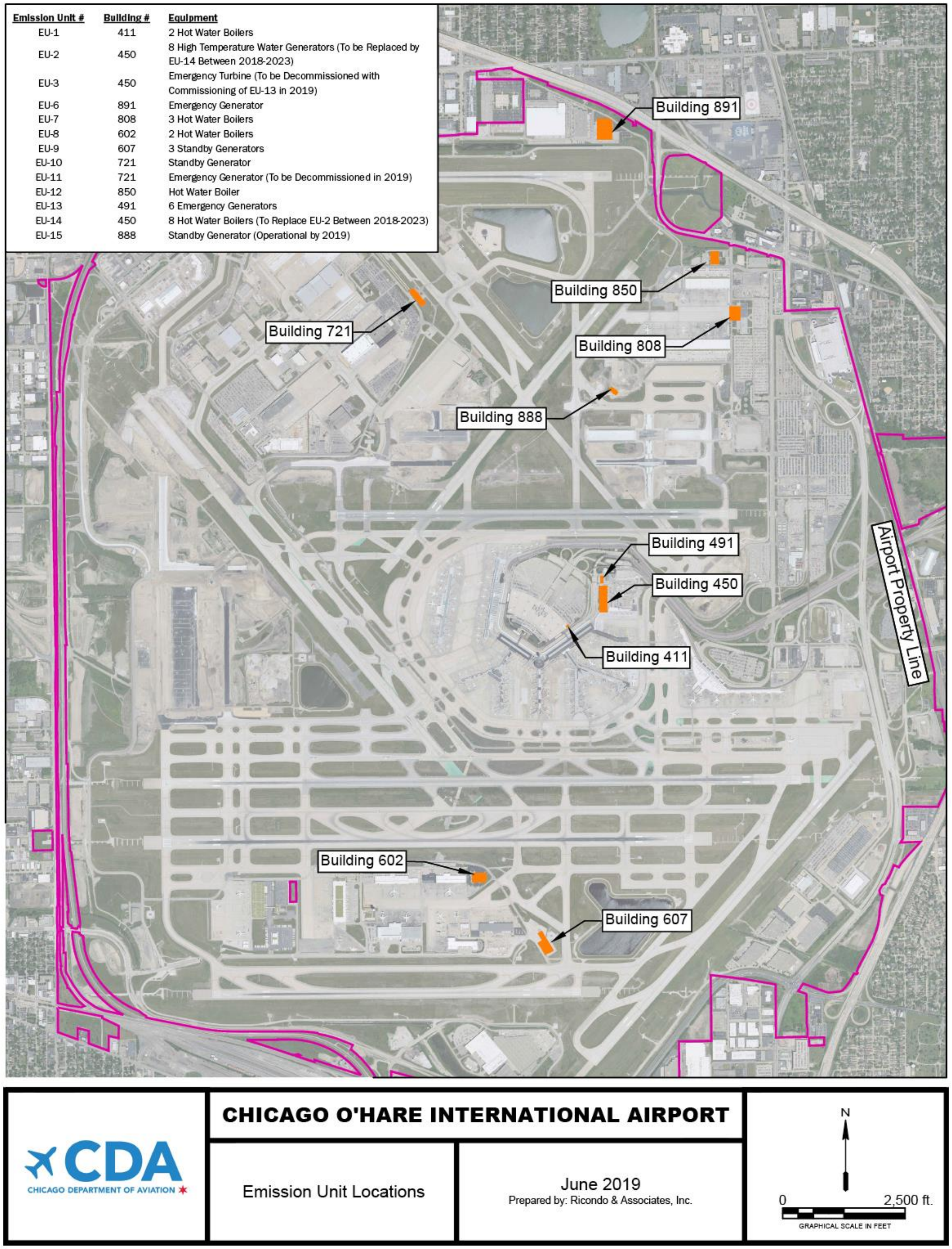
For the Existing Condition, emissions for boilers were based on the amount of fuel consumed in 2018 and emission factors from the CDA's Clean Air Act (CAA) Permit Program Application.[11] For the assessment of future conditions for the heating and refrigeration (H&R) plants, a projected amount of annual fuel usage was determined as a function of the change in terminal square footage. Other boilers' fuel usage was assumed to not change from the Existing Condition.

Several generators are used for backup power and airfield safety. For the Existing Condition, each generator was assigned an annual fuel usage and/or hours of operation based on actual operating records for 2018. For the Interim and Build Out Conditions, each generator was assigned the same annual fuel usage and hours of operation as the Existing Condition, adjusted as a function of the change in terminal square footage or the change in the number of aircraft operations—or to be conservative, assumed to operate for 500 hours per year depending on the purpose of the generator. Some generators from the Existing Condition were expected to be removed regardless of the No Action or Proposed Action Alternatives.

Figure E-1 illustrates the location of the boilers and generators for the Existing Condition. For the Interim Proposed Action, a temporary H&R plant would be built on the west airfield; for the Build Out Proposed Action, a permanent H&R plant would be constructed on the west airfield (see the Project Description of this EA for additional details regarding the H&R plant). **Table E-14** provides a list of boilers and generators and the estimated fuel usage or hours of operation for the Existing, Interim, and Build Out Conditions. **Section 5.12** provides detailed fuel usage information.

[11] IEPA, Title V – CAAPP Permit, City of Chicago Department of Aviation, O'Hare International Airport, I.D. No. 031600FQP, Permit 95110002, June 29, 2020

FIGURE E-1
BOILER AND GENERATOR LOCATIONS: EXISTING CONDITION



Source: CDA, 2019

TABLE E-14
BOILER AND GENERATOR ANNUAL USAGE

<table>
<tr><th rowspan="2">Emission Unit Description</th><th rowspan="2">Number of Units</th><th rowspan="2">Size per Unit</th><th rowspan="2">Fuel Type</th><th rowspan="2">Existing Condition</th><th colspan="2">Interim Condition</th><th colspan="2">Build Out Condition</th></tr>
<tr><th>No Action</th><th>Proposed Action</th><th>No Action</th><th>Proposed Action</th></tr>
<tr><td>H&R_BLDG_411</td><td>2</td><td>17 MMBtu/hour</td><td>Natural Gas</td><td colspan="5">3,466,797 cubic feet per Unit</td></tr>
<tr><td>H&R_BLDG_450</td><td>8</td><td>96 MMBtu/hour</td><td>Natural Gas</td><td colspan="4">98,883,206 cubic feet per Unit</td><td>128,633,207 cubic feet per Unit</td></tr>
<tr><td>H&R_BLDG_450</td><td>8</td><td>96 MMBtu/hour</td><td># 2 Oil</td><td>0 gallons</td><td colspan="3">3,750 gallons per Unit</td><td>3,750 gallons per Unit</td></tr>
<tr><td>Turbine_BLDG_450</td><td>1</td><td>2,414 hp</td><td>Diesel</td><td>9 hours</td><td colspan="4">Removed from Service</td></tr>
<tr><td>Generator_BLDG_491</td><td>6</td><td>4,023 hp</td><td>Diesel</td><td>-</td><td colspan="4">500 hours per Unit</td></tr>
<tr><td>H&R_BLDG_602</td><td>2</td><td>2 MMBtu/hour</td><td>Natural Gas</td><td colspan="5">2,296,016 cubic feet per Unit</td></tr>
<tr><td>Generator_BLDG_607</td><td>3</td><td>3,017 hp</td><td>Diesel</td><td colspan="5">367 hours per Unit</td></tr>
<tr><td>Generator_BLDG_721</td><td>1</td><td>3,017 hp</td><td>Diesel</td><td colspan="5">1088 hours per Unit</td></tr>
<tr><td>Generator_BLDG_712</td><td>1</td><td>1,522 hp</td><td>Diesel</td><td>0.5 hours per Unit</td><td colspan="4">Removed from Service</td></tr>
<tr><td>H&R_BLDG_808</td><td>3</td><td>3 MMBtu/hour</td><td>Natural Gas</td><td colspan="5">1,837,732 cubic feet per Unit</td></tr>
<tr><td>H&R NG_BLDG_850</td><td>1</td><td>4 MMBtu/hour</td><td>Natural Gas</td><td>2,371,084 cubic feet per Unit</td><td colspan="4">Removed from Service</td></tr>
<tr><td>Generator_BLDG_888</td><td>1</td><td>2,682 hp</td><td>Diesel</td><td>-</td><td colspan="4">500 hours per Unit</td></tr>
<tr><td>Generator_BLDG_891</td><td>1</td><td>1,676 hp</td><td>Diesel</td><td colspan="5">27.2 hours</td></tr>
<tr><td>TEMP H&R</td><td>8</td><td>95 MMBtu/hour</td><td>Natural Gas</td><td>-</td><td>-</td><td>7,304,789 cubic feet per Unit</td><td>-</td><td>-</td></tr>
<tr><td>TEMP H&R</td><td>8</td><td>95 MMBtu/hour</td><td># 2 Oil</td><td>-</td><td>-</td><td>3,750 gallons per Unit</td><td>-</td><td>-</td></tr>
<tr><td>WEST H&R</td><td>8</td><td>95 MMBtu/hour</td><td>Natural Gas</td><td>-</td><td>-</td><td>-</td><td>-</td><td>54,642,684 cubic feet per Unit</td></tr>
<tr><td>WEST H&R</td><td>8</td><td>95 MMBtu/hour</td><td># 2 Oil</td><td>-</td><td>-</td><td>-</td><td>-</td><td>3,750 gallons per Unit</td></tr>
<tr><td colspan="9">Source: IEPA, Title V – CAAPP Permit, City of Chicago Department of Aviation, O'Hare International Airport, I.D. No. 031600FQP, Permit 95110002, June 29, 2020, CDA, and Crawford, Murphy & Tilly, Inc./RCH Group</td></tr>
</table>

The estimated exhaust release parameters for the boilers and generators are provided in **Table E-15**.

TABLE E-15
STATIONARY SOURCE EXHAUST PARAMETERS

Emission Unit Description	Stack Height (m)	Stack Diameter (m)	Exit Temperature (F)	Exit Velocity (m/s)
H&R_BLDG_411	7.62	0.61	260	15.0
H&R_BLDG_450, Turbine_BLDG_450, TEMP H&R, WEST H&R	19.2	1.37	535	11.0
Generator_BLDG_491, Generator_BLDG_891, H&R_BLDG_808, H&R_BLDG_602, Generator_BLDG_607	20.0	1.00	400	15.0
H&R NG_BLDG_850	26.2	0.61	500	15.0
Source: Crawford, Murphy & Tilly, Inc./RCH Group.				

Aircraft Engine Run-up Enclosure

Airlines routinely inspect and maintain their aircraft to ensure the safety of the traveling public. Each aircraft is on a stringent maintenance schedule based on its number of hours in operation. As part of this regularly scheduled maintenance, the FAA requires aircraft engine ground run-ups. Run-ups are routine aircraft engine maintenance tests that require the operation of an engine at various power settings for several minutes on the ground. O'Hare's engine run-up enclosure is located at the Scenic Hold Pad on the north airfield. **Table E-16** provides the annual number of run-ups evaluated for the Existing, Interim, and Build Out Conditions. As with the annual aircraft operations, the annual run-ups are the same for the No Action and Proposed Action Alternatives.

TABLE E-16
ANNUAL GROUND RUN-UP OPERATIONS

		Number of Annual Run-Ups		
Aircraft	Engine	Existing Condition	Interim Condition	Build Out Condition
Airbus A319-100 Series	V2522-A5	29	71	77
Airbus A320-200 Series	V2527-A5	33	55	37
Airbus A321-200 Series	V2533-A5	5	-	
Airbus A321-200 Series	CFM56-5B3/P	-	35	46
Airbus A321-NEO	CFM56-5B2/3	-	19	125
Airbus A350-900 Series	Trent 772	-	20	30
Boeing 737-700 MAX	LEAP-1A35A/33/33B2/32/30	-	-	115
Boeing 737-800 MAX	LEAP-1A35A/33/33B2/32/30	-	60	90

Aircraft	Engine	Number of Annual Run-Ups		
		Existing Condition	Interim Condition	Build Out Condition
Boeing 737-800 Series	CFM56-7B24E	305	113	39
Boeing 737-800 Series	CFM56-7B26	-	43	67
Boeing 737-900 MAX	LEAP-1A35A/33/33B2/32/30	-	36	72
Boeing 737-900-ER	CFM56-7B27E	-	73	37
Boeing 757-200 Series	RB211-535E4B	58	-	-
Boeing 767-300 Series	PW4060	21	23	-
Boeing 777-200 Series	PW4090	14	-	-
Boeing 787-900 Dreamliner	GEnx-1B70	21	18	15
Bombardier CRJ-200	CF34-3B	216	156	85
Bombardier CRJ-700	CF34-8C1	110	156	150
Bombardier CRJ-700-ER	CF34-8C5	-	51	60
Bombardier CRJ-900	CF34-8C5	-	39	60
Bombardier CRJ-900	CF34-8C5A1	8	-	-
Embraer ERJ145-LR	AE3007A1	200	175	87
Embraer ERJ145-LR	AE3007A1E	-	31	15
Embraer ERJ170	CF34-8E5	52	48	71
Embraer ERJ175	CF34-8E5A1	-	88	95
Embraer ERJ175-LR	CF34-10E5A1	58	82	103

Source: CDA, Ricondo & Associates, June 2019, and Crawford, Murphy & Tilly, Inc./RCH Group
Note: Annual run-ups are based on aircraft operations forecast.

Training Fires

Training of airport fire and rescue staff requires burning propane, Jet A, and gasoline fuel to simulate fires from burning aircraft during an emergency. Annual fuel usage data for propane fuel, Jet A, and gasoline consumed in training fires was based on the CDA's Title V Operating Permit, which limits consumption to 130,000 gallons, 90 gallons, and 10 gallons, respectively. For the air quality analysis, the annual fuel usage for fire training is assumed to be the same for the Existing, Interim, and Build Out Conditions.

Fuel Storage and Handling Facilities

Fuel storage tank breathing and working losses, and losses from the filling of tanker trucks, add to airport-related VOC emissions. VOC emissions from this source were derived using AEDT and annual estimates of fuel throughput. For the Existing Condition, Jet A and Avgas fuel throughputs were based on CDA records from 2018. Fuel throughputs of Jet A for the Interim and Build Out Conditions were calculated using the ratio of the number of aircraft operations for each condition compared to the number of aircraft operations for the Existing Condition. Because the number of aircraft operations and fleet mix is the same in the No Action and the Proposed Action Alternatives, the fuel usage is assumed to be the same. The fuel usage of the Existing Condition is lower than the Interim and Build Out Conditions because there are less aircraft operations. **Table E-17** provides the fuel throughput for the Existing, Interim, and Build Out Conditions. As shown in **Table E-17**, the aircraft fuel usage for the No Action and Proposed Action are the same. The value for the Build Out is greater than the Interim, which is greater than the Existing Condition because the number of operations are greater.

TABLE E-17
STORAGE TANK FUEL THROUGHPUT

Condition	Gallons	
	Jet A	**Avgas**
Existing	1,172,901,029	26,045
Interim	1,236,159,377	26,045
Build Out	1,315,802,703	26,045
Source: CDA, Crawford, Murphy & Tilly, Inc./RCH Group		

E.1.1.6 Construction

The construction emissions inventory was prepared for a 10-year construction period that would include passenger terminal development, airfield improvements, landside infrastructure, and commercial development. The construction emissions inventory was developed based on a detailed listing of each project element; the number of pieces and types of construction equipment/vehicle to be used; an approximate daily operating time per piece of equipment/vehicle; and a construction equipment schedule provided by the CDA. The data was provided for baseline projects (i.e., projects to be constructed in the future, but not associated with the Proposed Action), and for the Proposed Action. A consolidated list of the construction equipment/vehicles, equipment horsepower, load factors, and use factors in the development of the construction emissions inventory is provided in **Table E-18**.

Emission Factors

The emission factors for off-road construction equipment and on-road vehicles were derived from MOVES, using area-specific information (e.g., fuel specifications, inspection maintenance program, and meteorology data) provided by the IEPA. The off-road construction equipment was assumed to be powered by diesel fuel. On-road construction vehicles were assumed to travel at a speed of 10 mph on-site and 40 mph off-site and used different types of fuels. Specifically, within MOVES, on-road material delivery/haul trucks/trailers were modeled as single-unit or combination short-haul diesel trucks; worker vehicles were modeled as a combination of passenger cars/trucks; and survey crew/tool trucks were modeled as pick-up trucks. The fuel mix of the worker vehicles and survey crew/tool trucks was a composite of fuels (i.e., gasoline, diesel, ethanol (E-85), and electric).

The emission factors for construction activities correspond to 2021 (Year 1) through 2030 (Year 10). Project delays that affect the corresponding years in which construction would occur would result in lower emission factors due to regulatory requirements and greater engine efficiencies. As such, the emission estimates prepared to evaluate the Proposed Action can be considered conservatively high estimates.[12] **Appendix N** provides a description of the implications to air quality analysis as a result of the Covid pandemic and project delays.

12 Construction implementation is expected to occur from 2023 through 2032.

Off-road construction equipment emission factors for the 10-year construction period are presented by pollutant in **Tables E-19 through E-27**. Off-road construction vehicle emission factors for the 10-year construction period are presented by pollutant in **Tables E-28 through E-36**.

Fugitive Emissions

Fugitive emissions of PM_{10}/$PM_{2.5}$ are expected from construction activities, such as site preparation, land clearing, demolition, material handling/storage of raw materials, and wind erosion of open aggregate storage piles. The CDA provided the estimated total construction material consumption and demolition data associated with the Proposed Action.

Methodologies and assumptions used to estimate fugitive dust emissions, except emissions that would result from demolition, are described in USEPA's AP-42 (Sections 13.2, 13.2.4, and 13.2.5).[13] Dust emissions from demolition were estimated using the methods and assumptions prepared by USEPA's Midwest Research Institute (MRI).[14] Fugitive particulate matter emissions are expected from the handling and storage of raw materials from quarry processing. Evaporative VOC emissions expected from asphalt paving during construction were estimated using the methodology and assumptions presented in the California Emissions Estimator Model (CalEEMod).[15]

[13] USEPA, AP 42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, https://www3.epa.gov/ttnchie1/ap42/ch13/
[14] MRI, Gap Filling PM_{10} Emission Factors for Selected Open Area Dust Sources, 1988
[15] California Air Resources Board, User's Guide for CalEEMod Version 2020.4.0, http://www.aqmd.gov/caleemod/user's-guide

TABLE E-18
ANNUAL CONSTRUCTION EQUIPMENT/VEHICLES USE

Equipment/Vehicle Type	HP	UF	LF	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
40-ton Crane	155	0.50	0.43	68	85	102	26	21	60	78	29	7	--
90-ton Crane	300	0.43	0.43	34	30	76	18	12	--	--	--	--	--
Backhoe	100	0.80	0.21	313	439	144	47	130	148	87	25	17	--
Caisson Drilling Rig	175	0.43	0.43	12	59	20	11	47	13	11	1	--	--
Concrete Breaker	150	0.40	0.43	21	17	4	8	28	24	15	7	4	--
Concrete Pump	15	0.60	0.43	111	145	158	26	66	65	72	12	14	--
Concrete Saw	50	0.40	0.50	22	6	2	12	48	48	--	--	--	--
Concrete/Asphalt Paver	250	0.80	0.59	74	192	152	77	42	14	13	49	3	--
Concrete/Asphalt Plant	600	0.85	0.43	9	41	38	10	15	12	15	7	--	--
Concrete/Asphalt Truck	--	0.80	--	1,213	2,178	1,957	1,086	928	523	496	699	104	--
Concrete/Grout Mixer	600	0.50	0.43	18	60	72	192	--	1	--	--	--	--
Dozer	175	0.80	0.59	175	302	169	60	107	107	45	22	--	--
Dump Truck (12 CY)	--	0.50	--	1,063	2,278	1,227	591	1,303	1,042	380	496	91	--
Dump Truck - Haul-off	--	0.50	--	259	383	130	172	198	535	233	32	--	--
Excavator	250	0.60	0.59	90	111	177	46	72	30	3	10	-	--
Excavator with Claw	250	0.60	0.59	14	31	17	6	11	25	4	--	--	--
Finish Grader	175	0.60	0.59	21	22	2	1	--	6	14	2	--	--
Fork Truck	100	0.30	0.59	36	0	0	0	120	84	192	126	--	--
Forklift	100	0.30	0.59	184	206	350	297	168	54	189	138	14	60
Generator	40	0.43	0.43	--	36	76	--	--	72	96	8	--	--
Grader	300	0.59	0.59	15	37	36	38	21	11	3	12	--	--
High Lift	100	0.59	0.59	24	18	58	48	24	31	72	39	--	24
Hydroseeder	600	0.59	0.59	15	37	36	38	15	8	--	6	--	--
Light-Duty Vehicle	--	0.50	--	--	--	--	6	24	24	--	--	--	--
Loader	175	0.80	0.21	282	406	253	102	151	167	99	47	9	--
Man Lift (Fascia)	75	0.30	0.59	--	--	--	--	--	9	12	1	--	--

Equipment/Vehicle Type	HP	UF	LF	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Man Lift	75	0.30	0.59	222	317	555	520	280	147	606	474	14	60
Motor Grader	175	0.60	0.59	31	34	2	1	2	8	15	1	--	--
Other General Equipment	25	0.59	0.43	--	---	--	---	--	--	36	40	--	--
Paint Truck	--	0.80	--	6	20	24	64	2	--	--	--	--	--
Passenger Vehicle	--	0.10	--	8,195	13,620	11,444	6,833	5,938	4,143	5,603	5,016	458	264
Pickup Truck	-	0.60	--	100	207	231	65	76	30	60	68	--	--
Pile Driver	175	0.43	0.43	43	89	106	39	56	13	1	1	--	--
Roller	100	0.80	0.59	105	208	222	101	69	22	33	28	--	--
Sheet Piling Equipment	175	0.43	0.43	34	30	76	18	12	--	--	--	--	--
Scraper	600	0.59	0.59	15	37	36	38	12	8	--	6	--	--
Skid Steer Loader	75	0.50	0.21	274	388	330	137	122	102	106	67	7	--
Survey Crew Trucks	--	0.59	--	--	--	--	--	12	3	--	---	--	--
Tool Truck	--	0.80	--	94	242	252	326	202	89	205	160	12	--
Tower Crane	300	0.50	0.43	4	--	--	--	16	2	5	--	--	--
Tractor Trailer	--	0.59	--	3	32	16	10	35	7	--	--	10	--
Tractor Trailer - Delivery	--	0.59	--	784	1,202	1,099	775	492	391	764	715	51	36
Tractor Trailer - Haul-off	--	0.50	--	2,642	3,608	2,000	449	428	468	190	--	78	--
Tractor Trailers Temp Fac.	--	0.59	--	3	32	16	10	15	3	--	8	--	--
Trowel Machine	175	0.43	0.59	--	9	19	--	--	9	12	1	--	--
Vibratory Compactor	300	0.80	0.59	80	90	25	2	8	24	10	3	--	--
Water Truck	--	0.59	--	114	155	75	56	71	68	69	34	3	--

Note: HP = Horsepower, UF = Usage Factor, and LF = Load Factor. Load factors and horsepower only apply to off-road construction equipment and therefore are not applicable for construction on-road vehicles.

Source: CDA. Consolidated by Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-19
OFF-ROAD CONSTRUCTION EQUIPMENT/VEHICLES EMISSION FACTORS – CO

Equipment	Grams Per Horsepower-Hour									
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
40-ton Crane	0.22	0.19	0.17	0.16	0.14	0.11	0.08	0.07	0.07	0.06
90-ton Crane	0.16	0.14	0.12	0.10	0.08	0.06	0.05	0.04	0.03	0.03
Backhoe	4.65	4.08	3.44	2.68	2.14	1.78	1.55	1.36	1.18	1.02
Caisson Drilling Rig	1.07	1.00	0.91	0.83	0.76	0.67	0.58	0.48	0.40	0.34
Concrete/Asphalt Paver	0.21	0.18	0.14	0.10	0.07	0.06	0.05	0.04	0.04	0.03
Concrete/Asphalt Plant	0.53	0.46	0.39	0.34	0.29	0.24	0.21	0.18	0.14	0.12
Concrete Breaker	0.29	0.26	0.21	0.18	0.15	0.13	0.11	0.09	0.08	0.07
Concrete Pump	1.78	1.71	1.67	1.63	1.59	1.56	1.54	1.53	1.52	1.51
Concrete Saw	0.49	0.42	0.38	0.34	0.32	0.30	0.29	0.28	0.28	0.28
Concrete/Grout Mixer	1.20	1.12	1.03	0.95	0.87	0.79	0.71	0.63	0.53	0.43
Dozer	0.23	0.18	0.15	0.12	0.09	0.08	0.07	0.07	0.06	0.05
Excavator	0.12	0.08	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.02
Excavator with Claw	0.12	0.08	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.02
Finish Grader	0.22	0.18	0.15	0.11	0.09	0.08	0.07	0.06	0.06	0.05
Fork Truck	0.17	0.11	0.08	0.06	0.05	0.05	0.05	0.05	0.05	0.05
Forklift	0.17	0.11	0.08	0.06	0.05	0.05	0.05	0.05	0.05	0.05
Generator	1.20	1.06	0.96	0.86	0.77	0.71	0.66	0.59	0.52	0.46
Grader	0.16	0.12	0.09	0.07	0.05	0.04	0.04	0.03	0.03	0.02
High Lift	0.87	0.75	0.64	0.55	0.47	0.40	0.34	0.28	0.20	0.13
Hydroseeder	1.45	1.35	1.25	1.16	1.09	1.02	0.95	0.87	0.76	0.65
Loader	1.96	1.72	1.45	1.14	0.92	0.77	0.67	0.58	0.50	0.43
Man Lift (Fascia)	0.84	0.72	0.62	0.54	0.47	0.40	0.35	0.30	0.26	0.22
Man Lift	0.84	0.72	0.62	0.54	0.47	0.40	0.35	0.30	0.26	0.22
Motor Grader	0.22	0.18	0.15	0.11	0.09	0.08	0.07	0.06	0.06	0.05
Pile Driver	0.29	0.26	0.21	0.18	0.15	0.13	0.11	0.09	0.08	0.07
Roller	0.76	0.67	0.58	0.49	0.40	0.26	0.18	0.15	0.13	0.11
Scraper	0.32	0.27	0.23	0.19	0.16	0.13	0.11	0.09	0.06	0.04
Sheet Piling Equipment	0.29	0.26	0.21	0.18	0.15	0.13	0.11	0.09	0.08	0.07
Skid Steer Loader	6.50	6.10	5.69	5.33	4.97	4.59	4.18	3.68	3.08	2.49
Tower Crane	0.16	0.14	0.12	0.10	0.08	0.06	0.05	0.04	0.03	0.03
Trowel Machine	0.39	0.33	0.28	0.24	0.21	0.18	0.16	0.14	0.12	0.10
Vibratory Compactor	0.22	0.19	0.16	0.13	0.09	0.07	0.05	0.04	0.04	0.03

Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b) and the NONROAD emission factor model

TABLE E-20
OFF-ROAD CONSTRUCTION EQUIPMENT/VEHICLES EMISSION FACTORS – VOC

Equipment	Grams Per Horsepower-Hour									
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
40-ton Crane	0.06	0.05	0.04	0.04	0.03	0.02	0.02	0.01	0.01	0.01
90-ton Crane	0.05	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01
Backhoe	0.88	0.76	0.63	0.50	0.40	0.34	0.29	0.26	0.22	0.19
Caisson Drilling Rig	0.37	0.35	0.32	0.29	0.27	0.24	0.20	0.16	0.13	0.11
Concrete/Asphalt Paver	0.04	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Concrete/Asphalt Plant	0.11	0.10	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.03
Concrete Breaker	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01
Concrete Pump	0.44	0.42	0.41	0.40	0.38	0.37	0.37	0.36	0.36	0.36
Concrete Saw	0.13	0.12	0.11	0.10	0.10	0.10	0.09	0.09	0.09	0.09
Concrete/Grout Mixer	0.25	0.24	0.22	0.20	0.19	0.17	0.16	0.14	0.12	0.10
Dozer	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Excavator	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Excavator with Claw	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Finish Grader	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Fork Truck	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Forklift	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Generator	0.33	0.30	0.27	0.25	0.22	0.21	0.19	0.17	0.15	0.14
Grader	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
High Lift	0.11	0.09	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.01
Hydroseeder	0.24	0.23	0.21	0.19	0.18	0.16	0.15	0.14	0.12	0.10
Loader	0.65	0.57	0.48	0.37	0.30	0.25	0.21	0.19	0.16	0.14
Man Lift (Fascia)	0.13	0.12	0.10	0.09	0.08	0.08	0.07	0.06	0.06	0.05
Man Lift	0.13	0.12	0.10	0.09	0.08	0.08	0.07	0.06	0.06	0.05
Motor Grader	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Pile Driver	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01
Roller	0.07	0.06	0.05	0.04	0.03	0.02	0.01	0.01	0.01	0.01
Scraper	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01
Sheet Piling Equipment	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01
Skid Steer Loader	1.34	1.24	1.15	1.07	0.99	0.91	0.82	0.72	0.60	0.50
Tower Crane	0.05	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01
Trowel Machine	0.10	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.02	0.02
Vibratory Compactor	0.05	0.04	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01

Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b) and the NONROAD emission factor model

TABLE E-21
OFF-ROAD CONSTRUCTION EQUIPMENT/VEHICLES EMISSION FACTORS – NO_X

Equipment	Grams Per Horsepower-Hour									
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
40-ton Crane	0.98	0.86	0.75	0.66	0.51	0.39	0.31	0.27	0.25	0.23
90-ton Crane	0.68	0.57	0.47	0.39	0.30	0.23	0.19	0.16	0.15	0.14
Backhoe	4.28	3.82	3.32	2.77	2.38	2.13	1.96	1.82	1.69	1.58
Caisson Drilling Rig	4.53	4.23	3.89	3.52	3.22	2.82	2.42	1.97	1.64	1.42
Concrete/Asphalt Paver	0.61	0.53	0.40	0.29	0.24	0.20	0.18	0.16	0.15	0.14
Concrete/Asphalt Plant	1.92	1.63	1.37	1.19	1.03	0.87	0.75	0.66	0.56	0.48
Concrete Breaker	1.23	1.08	0.90	0.76	0.64	0.52	0.42	0.34	0.29	0.26
Concrete Pump	4.02	3.96	3.92	3.89	3.85	3.83	3.81	3.80	3.79	3.78
Concrete Saw	2.72	2.66	2.62	2.59	2.57	2.55	2.54	2.53	2.53	2.53
Concrete/Grout Mixer	4.77	4.48	4.17	3.86	3.56	3.26	2.95	2.59	2.16	1.74
Dozer	0.91	0.69	0.50	0.40	0.33	0.29	0.26	0.23	0.20	0.18
Excavator	0.37	0.29	0.24	0.20	0.16	0.14	0.13	0.12	0.11	0.11
Excavator with Claw	0.37	0.29	0.24	0.20	0.16	0.14	0.13	0.12	0.11	0.11
Finish Grader	0.88	0.66	0.48	0.38	0.32	0.28	0.25	0.22	0.19	0.18
Fork Truck	0.96	0.90	0.88	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Forklift	0.96	0.90	0.88	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Generator	3.67	3.50	3.38	3.24	3.14	3.06	3.00	2.92	2.84	2.77
Grader	0.51	0.37	0.28	0.24	0.20	0.17	0.16	0.14	0.12	0.12
High Lift	1.66	1.53	1.42	1.32	1.24	1.17	1.10	1.04	0.98	0.92
Hydroseeder	3.29	3.10	2.90	2.71	2.56	2.44	2.29	2.10	1.84	1.57
Loader	3.78	3.28	2.78	2.20	1.80	1.53	1.34	1.19	1.05	0.93
Man Lift (Fascia)	2.95	2.88	2.81	2.75	2.71	2.67	2.63	2.60	2.58	2.56
Man Lift	2.95	2.88	2.81	2.75	2.71	2.67	2.63	2.60	2.58	2.56
Motor Grader	0.88	0.66	0.48	0.38	0.32	0.28	0.25	0.22	0.19	0.18
Pile Driver	1.23	1.08	0.90	0.76	0.64	0.52	0.42	0.34	0.29	0.26
Roller	1.58	1.47	1.38	1.27	1.13	1.05	0.97	0.95	0.93	0.91
Scraper	0.88	0.75	0.63	0.53	0.45	0.38	0.32	0.26	0.20	0.16
Sheet Piling Equipment	1.23	1.08	0.90	0.76	0.64	0.52	0.42	0.34	0.29	0.26
Skid Steer Loader	5.89	5.67	5.45	5.24	5.03	4.82	4.59	4.31	4.00	3.71
Tower Crane	0.68	0.57	0.47	0.39	0.30	0.23	0.19	0.16	0.15	0.14
Trowel Machine	1.14	0.97	0.83	0.72	0.63	0.54	0.46	0.40	0.34	0.28
Vibratory Compactor	0.63	0.53	0.45	0.36	0.27	0.22	0.18	0.16	0.15	0.14

Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b) and the NONROAD emission factor model

TABLE E-22
OFF-ROAD CONSTRUCTION EQUIPMENT/VEHICLES EMISSION FACTORS – SOx

Equipment	Grams Per Horsepower-Hour									
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
40-ton Crane	0.0038	0.0037	0.0037	0.0037	0.0036	0.0036	0.0035	0.0035	0.0035	0.0035
90-ton Crane	0.0037	0.0037	0.0037	0.0036	0.0036	0.0036	0.0035	0.0035	0.0035	0.0035
Backhoe	0.0057	0.0056	0.0054	0.0052	0.0051	0.0050	0.0050	0.0049	0.0049	0.0048
Caisson Drilling Rig	0.0046	0.0046	0.0045	0.0044	0.0043	0.0042	0.0041	0.0040	0.0039	0.0038
Concrete/Asphalt Paver	0.0037	0.0037	0.0037	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0035
Concrete/Asphalt Plant	0.0041	0.0040	0.0040	0.0039	0.0038	0.0038	0.0037	0.0037	0.0037	0.0036
Concrete Breaker	0.0039	0.0038	0.0037	0.0037	0.0036	0.0036	0.0036	0.0036	0.0035	0.0035
Concrete Pump	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054
Concrete Saw	0.0041	0.0040	0.0040	0.0040	0.0040	0.0039	0.0039	0.0039	0.0039	0.0039
Concrete/Grout Mixer	0.0047	0.0046	0.0046	0.0045	0.0044	0.0044	0.0043	0.0042	0.0041	0.0039
Dozer	0.0037	0.0037	0.0036	0.0036	0.0036	0.0036	0.0036	0.0035	0.0035	0.0035
Excavator	0.0036	0.0036	0.0036	0.0036	0.0036	0.0035	0.0035	0.0035	0.0035	0.0035
Excavator with Claw	0.0036	0.0036	0.0036	0.0036	0.0036	0.0035	0.0035	0.0035	0.0035	0.0035
Finish Grader	0.0037	0.0037	0.0036	0.0036	0.0036	0.0036	0.0036	0.0035	0.0035	0.0035
Fork Truck	0.0040	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039
Forklift	0.0040	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039
Generator	0.0047	0.0046	0.0045	0.0044	0.0044	0.0043	0.0043	0.0042	0.0041	0.0041
Grader	0.0037	0.0036	0.0036	0.0036	0.0036	0.0036	0.0035	0.0035	0.0035	0.0035
High Lift	0.0042	0.0042	0.0042	0.0041	0.0041	0.0041	0.0040	0.0040	0.0040	0.0040
Hydroseeder	0.0044	0.0044	0.0043	0.0043	0.0043	0.0042	0.0042	0.0041	0.0041	0.0040
Loader	0.0052	0.0050	0.0049	0.0047	0.0046	0.0045	0.0045	0.0044	0.0044	0.0044
Man Lift (Fascia)	0.0042	0.0041	0.0041	0.0041	0.0040	0.0040	0.0040	0.0040	0.0040	0.0039
Man Lift	0.0042	0.0041	0.0041	0.0041	0.0040	0.0040	0.0040	0.0040	0.0040	0.0039
Motor Grader	0.0037	0.0037	0.0036	0.0036	0.0036	0.0036	0.0036	0.0035	0.0035	0.0035
Pile Driver	0.0039	0.0038	0.0037	0.0037	0.0036	0.0036	0.0036	0.0036	0.0035	0.0035
Roller	0.0042	0.0042	0.0041	0.0041	0.0040	0.0040	0.0040	0.0040	0.0040	0.0039
Scraper	0.0038	0.0038	0.0037	0.0037	0.0037	0.0036	0.0036	0.0036	0.0036	0.0036
Sheet Piling Equipment	0.0039	0.0038	0.0037	0.0037	0.0036	0.0036	0.0036	0.0036	0.0035	0.0035
Skid Steer Loader	0.0061	0.0061	0.0060	0.0059	0.0058	0.0057	0.0056	0.0055	0.0053	0.0052
Tower Crane	0.0037	0.0037	0.0037	0.0036	0.0036	0.0036	0.0035	0.0035	0.0035	0.0035
Trowel Machine	0.0038	0.0038	0.0038	0.0037	0.0037	0.0037	0.0036	0.0036	0.0036	0.0036
Vibratory Compactor	0.0038	0.0037	0.0037	0.0037	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036

Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b) and the NONROAD emission factor model

TABLE E-23
OFF-ROAD CONSTRUCTION EQUIPMENT/VEHICLES EMISSION FACTORS – PM_{10}

Equipment	Grams Per Horsepower-Hour									
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
40-ton Crane	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02
90-ton Crane	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Backhoe	0.70	0.60	0.50	0.40	0.33	0.28	0.24	0.21	0.18	0.16
Caisson Drilling Rig	0.25	0.24	0.22	0.20	0.18	0.16	0.14	0.11	0.09	0.08
Concrete/Asphalt Paver	0.04	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Concrete/Asphalt Plant	0.08	0.07	0.06	0.06	0.05	0.04	0.03	0.03	0.03	0.02
Concrete Breaker	0.07	0.07	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02
Concrete Pump	0.22	0.21	0.20	0.19	0.19	0.18	0.18	0.18	0.17	0.17
Concrete Saw	0.06	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02
Concrete/Grout Mixer	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.07	0.06
Dozer	0.06	0.05	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.01
Excavator	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Excavator with Claw	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Finish Grader	0.06	0.04	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01
Fork Truck	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Forklift	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Generator	0.22	0.19	0.17	0.14	0.12	0.11	0.10	0.09	0.07	0.06
Grader	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
High Lift	0.13	0.11	0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02
Hydroseeder	0.24	0.22	0.21	0.19	0.17	0.16	0.15	0.14	0.12	0.10
Loader	0.40	0.35	0.29	0.23	0.19	0.16	0.14	0.12	0.11	0.09
Man Lift (Fascia)	0.11	0.09	0.08	0.06	0.05	0.05	0.04	0.03	0.03	0.02
Man Lift	0.11	0.09	0.08	0.06	0.05	0.05	0.04	0.03	0.03	0.02
Motor Grader	0.06	0.04	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01
Pile Driver	0.07	0.07	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02
Roller	0.11	0.10	0.09	0.08	0.07	0.05	0.03	0.03	0.02	0.02
Scraper	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01
Sheet Piling Equipment	0.07	0.07	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02
Skid Steer Loader	1.00	0.93	0.87	0.81	0.75	0.69	0.62	0.54	0.45	0.37
Tower Crane	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Trowel Machine	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.02
Vibratory Compactor	0.04	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01

Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b) and the NONROAD emission factor model

TABLE E-24
OFF-ROAD CONSTRUCTION EQUIPMENT/VEHICLES EMISSION FACTORS – $PM_{2.5}$

Equipment	Grams Per Horsepower-Hour									
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
40-ton Crane	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02
90-ton Crane	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Backhoe	0.68	0.59	0.48	0.38	0.32	0.27	0.23	0.21	0.20	0.18
Caisson Drilling Rig	0.25	0.23	0.21	0.19	0.18	0.15	0.13	0.11	0.11	0.09
Concrete/Asphalt Paver	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Concrete/Asphalt Plant	0.08	0.07	0.06	0.05	0.05	0.04	0.03	0.03	0.03	0.02
Concrete Breaker	0.07	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02
Concrete Pump	0.21	0.20	0.19	0.19	0.18	0.18	0.17	0.18	0.17	0.17
Concrete Saw	0.06	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02
Concrete/Grout Mixer	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.09	0.08	0.07
Dozer	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.01
Excavator	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Excavator with Claw	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Finish Grader	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01
Fork Truck	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Forklift	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Generator	0.21	0.18	0.16	0.14	0.12	0.11	0.10	0.09	0.08	0.07
Grader	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
High Lift	0.12	0.11	0.09	0.08	0.07	0.06	0.05	0.04	0.04	0.03
Hydroseeder	0.24	0.22	0.20	0.18	0.17	0.16	0.15	0.14	0.13	0.12
Loader	0.39	0.34	0.29	0.22	0.18	0.15	0.13	0.12	0.12	0.10
Man Lift (Fascia)	0.11	0.09	0.08	0.06	0.05	0.04	0.04	0.03	0.03	0.02
Man Lift	0.11	0.09	0.08	0.06	0.05	0.04	0.04	0.03	0.03	0.02
Motor Grader	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01
Pile Driver	0.07	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02
Roller	0.11	0.10	0.09	0.08	0.06	0.04	0.03	0.03	0.03	0.02
Scraper	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.01
Sheet Piling Equipment	0.07	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02
Skid Steer Loader	0.97	0.91	0.84	0.79	0.73	0.67	0.60	0.54	0.52	0.44
Tower Crane	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Trowel Machine	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.03
Vibratory Compactor	0.04	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01

Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b) and the NONROAD emission factor model

TABLE E-25
OFF-ROAD CONSTRUCTION EQUIPMENT/VEHICLES EMISSION FACTORS – CO_2

Equipment	Grams Per Horsepower-Hour									
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
40-ton Crane	531	531	531	531	531	531	531	531	531	531
90-ton Crane	531	531	531	531	531	531	531	531	531	531
Backhoe	693	694	694	695	695	695	695	695	695	695
Caisson Drilling Rig	530	530	530	530	530	530	530	531	531	531
Concrete/Asphalt Paver	537	537	537	537	537	537	537	537	537	537
Concrete/Asphalt Plant	531	531	531	531	531	531	531	531	531	531
Concrete Breaker	531	531	531	531	531	531	531	531	531	531
Concrete Pump	589	589	589	589	589	589	589	589	589	589
Concrete Saw	596	596	596	596	596	596	596	596	596	596
Concrete/Grout Mixer	530	530	530	530	531	531	531	531	531	531
Dozer	537	537	537	537	537	537	537	537	537	537
Excavator	537	537	537	537	537	537	537	537	537	537
Excavator with Claw	537	537	537	537	537	537	537	537	537	537
Finish Grader	537	537	537	537	537	537	537	537	537	537
Fork Truck	596	596	596	596	596	596	596	596	596	596
Forklift	596	596	596	596	596	596	596	596	596	596
Generator	589	590	590	590	590	590	590	590	590	590
Grader	537	537	537	537	537	537	537	537	537	537
High Lift	596	596	596	596	596	596	596	596	596	596
Hydroseeder	536	536	536	536	536	536	536	536	536	537
Loader	625	625	625	625	626	626	626	626	626	626
Man Lift (Fascia)	596	596	596	596	596	596	596	596	596	596
Man Lift	596	596	596	596	596	596	596	596	596	596
Motor Grader	537	537	537	537	537	537	537	537	537	537
Pile Driver	531	531	531	531	531	531	531	531	531	531
Roller	596	596	596	596	596	596	596	596	596	596
Scraper	531	531	531	531	531	531	531	531	531	531
Sheet Piling Equipment	537	537	537	537	537	537	537	537	537	537
Skid Steer Loader	692	692	693	693	693	693	694	694	694	695
Tower Crane	531	531	531	531	531	531	531	531	531	531
Trowel Machine	537	537	537	537	537	537	537	537	537	537
Vibratory Compactor	537	537	537	537	537	537	537	537	537	537

Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b) and the NONROAD emission factor model

TABLE E-26
OFF-ROAD CONSTRUCTION EQUIPMENT/VEHICLES EMISSION FACTORS – CH_4

Equipment	Grams Per Horsepower-Hour									
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
40-ton Crane	0.005	0.004	0.004	0.003	0.003	0.002	0.001	0.001	0.001	0.001
90-ton Crane	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001
Backhoe	0.033	0.030	0.027	0.020	0.015	0.012	0.011	0.010	0.008	0.008
Caisson Drilling Rig	0.016	0.016	0.015	0.014	0.013	0.012	0.011	0.008	0.006	0.005
Concrete/Asphalt Paver	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
Concrete/Asphalt Plant	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.003	0.002
Concrete Breaker	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001
Concrete Pump	0.033	0.032	0.032	0.032	0.032	0.032	0.031	0.031	0.031	0.031
Concrete Saw	0.015	0.014	0.014	0.013	0.013	0.013	0.012	0.012	0.012	0.012
Concrete/Grout Mixer	0.010	0.010	0.010	0.009	0.009	0.008	0.008	0.007	0.005	0.004
Dozer	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
Excavator	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
Excavator with Claw	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
Finish Grader	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Fork Truck	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Forklift	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Generator	0.022	0.021	0.020	0.020	0.019	0.018	0.018	0.017	0.016	0.015
Grader	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000
High Lift	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Hydroseeder	0.009	0.009	0.009	0.009	0.008	0.008	0.008	0.007	0.006	0.006
Loader	0.034	0.031	0.026	0.020	0.015	0.012	0.011	0.010	0.009	0.008
Man Lift (Fascia)	0.012	0.011	0.011	0.011	0.010	0.010	0.010	0.010	0.009	0.009
Man Lift	0.012	0.011	0.011	0.011	0.010	0.010	0.010	0.010	0.009	0.009
Motor Grader	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Pile Driver	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001
Roller	0.005	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001
Scraper	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001
Sheet Piling Equipment	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001
Skid Steer Loader	0.038	0.038	0.037	0.036	0.035	0.033	0.032	0.030	0.026	0.022
Tower Crane	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001
Trowel Machine	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.001
Vibratory Compactor	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001

Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b) and the NONROAD emission factor model

TABLE E-27
OFF-ROAD CONSTRUCTION EQUIPMENT/VEHICLES EMISSION FACTORS – N_2O

Equipment	Grams Per Horsepower-Hour									
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
40-ton Crane	--	--	--	--	--	--	--	--	--	--
90-ton Crane	--	--	--	--	--	--	--	--	--	--
Backhoe	--	--	--	--	--	--	--	--	--	--
Caisson Drilling Rig	--	--	--	--	--	--	--	--	--	--
Concrete/Asphalt Paver	--	--	--	--	--	--	--	--	--	--
Concrete/Asphalt Plant	--	--	--	--	--	--	--	--	--	--
Concrete Breaker	--	--	--	--	--	--	--	--	--	--
Concrete Pump	--	--	--	--	--	--	--	--	--	--
Concrete Saw	--	--	--	--	--	--	--	--	--	--
Concrete/Grout Mixer	--	--	--	--	--	--	--	--	--	--
Dozer	--	--	--	--	--	--	--	--	--	--
Excavator	--	--	--	--	--	--	--	--	--	--
Excavator with Claw	--	--	--	--	--	--	--	--	--	--
Finish Grader	--	--	--	--	--	--	--	--	--	--
Fork Truck	--	--	--	--	--	--	--	--	--	--
Forklift	--	--	--	--	--	--	--	--	--	--
Generator	--	--	--	--	--	--	--	--	--	--
Grader	--	--	--	--	--	--	--	--	--	--
High Lift	--	--	--	--	--	--	--	--	--	--
Hydroseeder	--	--	--	--	--	--	--	--	--	--
Loader	--	--	--	--	--	--	--	--	--	--
Man Lift (Fascia)	--	--	--	--	--	--	--	--	--	--
Man Lift	--	--	--	--	--	--	--	--	--	--
Motor Grader	--	--	--	--	--	--	--	--	--	--
Pile Driver	--	--	--	--	--	--	--	--	--	--
Roller	--	--	--	--	--	--	--	--	--	--
Scraper	--	--	--	--	--	--	--	--	--	--
Sheet Piling Equipment	--	--	--	--	--	--	--	--	--	--
Skid Steer Loader	--	--	--	--	--	--	--	--	--	--
Tower Crane	--	--	--	--	--	--	--	--	--	--
Trowel Machine	--	--	--	--	--	--	--	--	--	--
Vibratory Compactor	--	--	--	--	--	--	--	--	--	--

-- designates pollutants for which MOVES does not provide emissions data.
Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b) and the NONROAD emission factor model

TABLE E-28
ON-ROAD CONSTRUCTION VEHICLES EMISSION FACTORS – CO

Equipment	Speed (MPH)	Grams Per Mile									
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Concrete Trucks On-Site	10	1.72	1.57	1.43	1.34	1.25	1.17	1.08	1.00	0.91	0.82
Concrete Trucks Off-Site	40	0.76	0.70	0.64	0.60	0.56	0.52	0.49	0.45	0.41	0.38
Dump Truck On-Site	10	1.72	1.57	1.43	1.34	1.25	1.17	1.08	1.00	0.91	0.82
Dump Truck Off-Site	40	0.76	0.70	0.64	0.60	0.56	0.52	0.49	0.45	0.41	0.38
Light-Duty Vehicle On-Site	10	4.57	4.31	4.04	3.81	3.58	3.35	3.12	2.89	2.66	2.43
Light-Duty Vehicle Off-Site	40	2.52	2.39	2.26	2.13	2.01	1.89	1.76	1.64	1.52	1.39
Paint Truck On-Site	10	1.72	1.57	1.43	1.34	1.25	1.17	1.08	1.00	0.91	0.82
Paint Truck Off-Site	40	0.76	0.70	0.64	0.60	0.56	0.52	0.49	0.45	0.41	0.38
Passenger Vehicle On-Site	10	3.56	3.36	3.17	3.00	2.84	2.68	2.52	2.36	2.19	2.03
Passenger Vehicle Off-Site	40	1.85	1.76	1.66	1.58	1.50	1.42	1.34	1.42	1.17	1.09
Pickup Truck On-Site	10	4.57	4.31	4.04	3.81	3.58	3.35	3.12	2.89	2.66	2.43
Pickup Truck Off-Site	40	2.52	2.39	2.26	2.13	2.01	1.89	1.76	1.64	1.52	1.39
Survey Crew Trucks On-Site	10	4.57	4.31	4.04	3.81	3.58	3.35	3.12	2.89	2.66	2.43
Survey Crew Trucks Off-Site	40	2.52	2.39	2.26	2.13	2.01	1.89	1.76	1.64	1.52	1.39
Tool Truck On-Site	10	4.57	4.31	4.04	3.81	3.58	3.35	3.12	2.89	2.66	2.43
Tool Truck Off-Site	40	2.52	2.39	2.26	2.13	2.01	1.89	1.76	1.64	1.52	1.39
Tractor Trailer On-Site	10	2.21	2.04	1.87	1.75	1.62	1.50	1.37	1.24	1.12	0.99
Tractor Trailer Off-Site	40	0.96	0.89	0.82	0.77	0.71	0.66	0.60	0.55	0.50	0.44
Water Truck On-Site	10	1.72	1.57	1.43	1.34	1.25	1.17	1.08	1.00	0.91	0.82
Water Truck Off-Site	40	0.76	0.70	0.64	0.60	0.56	0.52	0.49	0.45	0.41	0.38

Note: MPH = Miles per hour
Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b)

TABLE E-29
ON-ROAD CONSTRUCTION VEHICLES EMISSION FACTORS – VOC

Equipment	Speed (MPH)	Grams Per Mile									
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Concrete Trucks On-Site	10	0.58	0.52	0.46	0.42	0.38	0.34	0.31	0.27	0.23	0.19
Concrete Trucks Off-Site	40	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.07	0.06
Dump Truck On-Site	10	0.58	0.52	0.46	0.42	0.38	0.34	0.31	0.27	0.23	0.19
Dump Truck Off-Site	40	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.07	0.06
Light-Duty Vehicle On-Site	10	0.12	0.11	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.06
Light-Duty Vehicle Off-Site	40	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02
Paint Truck On-Site	10	0.58	0.52	0.46	0.42	0.38	0.34	0.31	0.27	0.23	0.19
Paint Truck Off-Site	40	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.07	0.06
Passenger Vehicle On-Site	10	0.10	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06
Passenger Vehicle Off-Site	40	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.02
Pickup Truck On-Site	10	0.12	0.11	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.06
Pickup Truck Off-Site	40	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02
Survey Crew Trucks On-Site	10	0.12	0.11	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.06
Survey Crew Trucks Off-Site	40	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02
Tool Truck On-Site	10	0.12	0.11	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.06
Tool Truck Off-Site	40	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02
Tractor Trailer On-Site	10	0.53	0.50	0.46	0.43	0.40	0.36	0.33	0.29	0.26	0.22
Tractor Trailer Off-Site	40	0.17	0.16	0.15	0.13	0.12	0.11	0.10	0.09	0.08	0.07
Water Truck On-Site	10	0.58	0.52	0.46	0.42	0.38	0.34	0.31	0.27	0.23	0.19
Water Truck Off-Site	40	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.07	0.06

Note: MPH = Miles per hour
Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b)

TABLE E-30
ON-ROAD CONSTRUCTION VEHICLES EMISSION FACTORS – NO_X

Equipment	Speed (MPH)	Grams Per Mile									
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Concrete Trucks On-Site	10	4.39	3.95	3.50	3.28	3.06	2.84	2.63	2.41	2.19	1.97
Concrete Trucks Off-Site	40	1.78	1.60	1.42	1.33	1.24	1.15	1.06	0.97	0.88	0.80
Dump Truck On-Site	10	4.39	3.95	3.50	3.28	3.06	2.84	2.63	2.41	2.19	1.97
Dump Truck Off-Site	40	1.78	1.60	1.42	1.33	1.24	1.15	1.06	0.97	0.88	0.80
Light-Duty Vehicle On-Site	10	0.26	0.22	0.19	0.18	0.16	0.15	0.13	0.11	0.10	0.08
Light-Duty Vehicle Off-Site	40	0.19	0.17	0.15	0.14	0.13	0.12	0.11	0.09	0.08	0.07
Paint Truck On-Site	10	4.39	3.95	3.50	3.28	3.06	2.84	2.63	2.41	2.19	1.97
Paint Truck Off-Site	40	1.78	1.60	1.42	1.33	1.24	1.15	1.06	0.97	0.88	0.80
Passenger Vehicle On-Site	10	0.17	0.15	0.12	0.11	0.10	0.09	0.08	0.07	0.06	0.05
Passenger Vehicle Off-Site	40	0.13	0.11	0.09	0.09	0.08	0.07	0.07	0.07	0.05	0.04
Pickup Truck On-Site	10	0.26	0.22	0.19	0.18	0.16	0.15	0.13	0.11	0.10	0.08
Pickup Truck Off-Site	40	0.19	0.17	0.15	0.14	0.13	0.12	0.11	0.09	0.08	0.07
Survey Crew Trucks On-Site	10	0.26	0.22	0.19	0.18	0.16	0.15	0.13	0.11	0.10	0.08
Survey Crew Trucks Off-Site	40	0.19	0.17	0.15	0.14	0.13	0.12	0.11	0.09	0.08	0.07
Tool Truck On-Site	10	0.26	0.22	0.19	0.18	0.16	0.15	0.13	0.11	0.10	0.08
Tool Truck Off-Site	40	0.19	0.17	0.15	0.14	0.13	0.12	0.11	0.09	0.08	0.07
Tractor Trailer On-Site	10	6.59	5.98	5.37	5.07	4.77	4.47	4.17	3.88	3.58	3.28
Tractor Trailer Off-Site	40	3.55	3.19	2.84	2.66	2.49	2.32	2.14	1.97	1.79	1.62
Water Truck On-Site	10	4.39	3.95	3.50	3.28	3.06	2.84	2.63	2.41	2.19	1.97
Water Truck Off-Site	40	1.78	1.60	1.42	1.33	1.24	1.15	1.06	0.97	0.88	0.80

Note: MPH = Miles per hour
Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b)

TABLE E-31
ON-ROAD CONSTRUCTION VEHICLES EMISSION FACTORS – SO_X

Equipment	Speed (MPH)	Grams Per Mile									
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Concrete Trucks On-Site	10	0.019	0.019	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Concrete Trucks Off-Site	40	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Dump Truck On-Site	10	0.019	0.019	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Dump Truck Off-Site	40	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Light-Duty Vehicle On-Site	10	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004
Light-Duty Vehicle Off-Site	40	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Paint Truck On-Site	10	0.019	0.019	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Paint Truck Off-Site	40	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Passenger Vehicle On-Site	10	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003
Passenger Vehicle Off-Site	40	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Pickup Truck On-Site	10	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004
Pickup Truck Off-Site	40	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Survey Crew Trucks On-Site	10	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004
Survey Crew Trucks Off-Site	40	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Tool Truck On-Site	10	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004
Tool Truck Off-Site	40	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Tractor Trailer On-Site	10	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.023	0.023	0.023
Tractor Trailer Off-Site	40	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.013	0.013	0.013
Water Truck On-Site	10	0.019	0.019	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Water Truck Off-Site	40	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008

Note: MPH = Miles per hour
Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b)

TABLE E-32
ON-ROAD CONSTRUCTION VEHICLES EMISSION FACTORS – PM_{10}

Equipment	Speed (MPH)	Grams Per Mile									
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Concrete Trucks On-Site	10	0.87	0.84	0.81	0.79	0.78	0.76	0.74	0.72	0.70	0.69
Concrete Trucks Off-Site	40	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.15	0.14	0.13
Dump Truck On-Site	10	0.87	0.84	0.81	0.79	0.78	0.76	0.74	0.72	0.70	0.69
Dump Truck Off-Site	40	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.15	0.14	0.13
Light-Duty Vehicle On-Site	10	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Light-Duty Vehicle Off-Site	40	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Paint Truck On-Site	10	0.87	0.84	0.81	0.79	0.78	0.76	0.74	0.72	0.70	0.69
Paint Truck Off-Site	40	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.15	0.14	0.13
Passenger Vehicle On-Site	10	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Passenger Vehicle Off-Site	40	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Pickup Truck On-Site	10	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Pickup Truck Off-Site	40	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Survey Crew Trucks On-Site	10	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Survey Crew Trucks Off-Site	40	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Tool Truck On-Site	10	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Tool Truck Off-Site	40	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Tractor Trailer On-Site	10	1.42	1.39	1.36	1.34	1.31	1.29	1.26	1.24	1.22	1.19
Tractor Trailer Off-Site	40	0.31	0.30	0.29	0.28	0.26	0.25	0.24	0.23	0.22	0.21
Water Truck On-Site	10	0.87	0.84	0.81	0.79	0.78	0.76	0.74	0.72	0.70	0.69
Water Truck Off-Site	40	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.15	0.14	0.13

Note: MPH = Miles per hour
Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b)

TABLE E-33
ON-ROAD CONSTRUCTION VEHICLES EMISSION FACTORS – $PM_{2.5}$

Equipment	Speed (MPH)	Grams Per Mile									
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Concrete Trucks On-Site	10	0.29	0.27	0.24	0.23	0.21	0.19	0.18	0.16	0.15	0.13
Concrete Trucks Off-Site	40	0.09	0.08	0.08	0.07	0.06	0.06	0.05	0.05	0.04	0.03
Dump Truck On-Site	10	0.29	0.27	0.24	0.23	0.21	0.19	0.18	0.16	0.15	0.13
Dump Truck Off-Site	40	0.09	0.08	0.08	0.07	0.06	0.06	0.05	0.05	0.04	0.03
Light-Duty Vehicle On-Site	10	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Light-Duty Vehicle Off-Site	40	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Paint Truck On-Site	10	0.29	0.27	0.24	0.23	0.21	0.19	0.18	0.16	0.15	0.13
Paint Truck Off-Site	40	0.09	0.08	0.08	0.07	0.06	0.06	0.05	0.05	0.04	0.03
Passenger Vehicle On-Site	10	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Passenger Vehicle Off-Site	40	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Pickup Truck On-Site	10	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Pickup Truck Off-Site	40	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Survey Crew Trucks On-Site	10	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Survey Crew Trucks Off-Site	40	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Tool Truck On-Site	10	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Tool Truck Off-Site	40	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Tractor Trailer On-Site	10	0.43	0.41	0.38	0.36	0.34	0.32	0.29	0.27	0.25	0.23
Tractor Trailer Off-Site	40	0.16	0.15	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.06
Water Truck On-Site	10	0.29	0.27	0.24	0.23	0.21	0.19	0.18	0.16	0.15	0.13
Water Truck Off-Site	40	0.09	0.08	0.08	0.07	0.06	0.06	0.05	0.05	0.04	0.03

Note: MPH = Miles per hour
Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b)

TABLE E-34
ON-ROAD CONSTRUCTION VEHICLES EMISSION FACTORS – CO_2

Equipment	Speed (MPH)	Grams Per Mile									
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Concrete Trucks On-Site	10	589	589	589	589	589	589	589	589	589	589
Concrete Trucks Off-Site	40	2,219	2,206	2,193	2,185	2,177	2,169	2,161	2,153	2,145	2,177
Dump Truck On-Site	10	2,219	2,206	2,193	2,185	2,177	2,169	2,161	2,153	2,145	2,177
Dump Truck Off-Site	40	948	942	937	934	930	927	923	920	916	930
Light-Duty Vehicle On-Site	10	771	746	721	700	679	658	637	616	594	679
Light-Duty Vehicle Off-Site	40	386	373	361	350	340	329	319	308	298	340
Paint Truck On-Site	10	2,219	2,206	2,193	2,185	2,177	2,169	2,161	2,153	2,145	2,177
Paint Truck Off-Site	40	948	942	937	934	930	927	923	920	916	930
Passenger Vehicle On-Site	10	642	622	601	584	566	549	532	514	497	566
Passenger Vehicle Off-Site	40	314	304	294	286	277	269	260	271	243	277
Pickup Truck On-Site	10	771	746	721	700	679	658	637	616	594	679
Pickup Truck Off-Site	40	386	373	361	350	340	329	319	308	298	340
Survey Crew Trucks On-Site	10	771	746	721	700	679	658	637	616	594	679
Survey Crew Trucks Off-Site	40	386	373	361	350	340	329	319	308	298	340
Tool Truck On-Site	10	771	746	721	700	679	658	637	616	594	679
Tool Truck Off-Site	40	386	373	361	350	340	329	319	308	298	340
Tractor Trailer On-Site	10	2,859	2,850	2,841	2,834	2,827	2,820	2,814	2,807	2,800	2,827
Tractor Trailer Off-Site	40	1,649	1,643	1,637	1,631	1,626	1,621	1,615	1,610	1,605	1,626
Water Truck On-Site	10	2,219	2,206	2,193	2,185	2,177	2,169	2,161	2,153	2,145	2,177
Water Truck Off-Site	40	948	942	937	934	930	927	923	920	916	930

Note: MPH = Miles per hour
Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b)

TABLE E-35
ON-ROAD CONSTRUCTION VEHICLES EMISSION FACTORS – CH_4

Equipment	Speed (MPH)	Grams Per Mile									
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Concrete Trucks On-Site	10	0.15	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Concrete Trucks Off-Site	40	0.047	0.046	0.046	0.047	0.047	0.047	0.048	0.048	0.048	0.047
Dump Truck On-Site	10	0.15	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Dump Truck Off-Site	40	0.047	0.046	0.046	0.047	0.047	0.047	0.048	0.048	0.048	0.047
Light-Duty Vehicle On-Site	10	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.004	0.004	0.005
Light-Duty Vehicle Off-Site	40	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Paint Truck On-Site	10	0.15	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Paint Truck Off-Site	40	0.047	0.046	0.046	0.047	0.047	0.047	0.048	0.048	0.048	0.047
Passenger Vehicle On-Site	10	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003
Passenger Vehicle Off-Site	40	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Pickup Truck On-Site	10	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.004	0.004	0.005
Pickup Truck Off-Site	40	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Survey Crew Trucks On-Site	10	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.004	0.004	0.005
Survey Crew Trucks Off-Site	40	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Tool Truck On-Site	10	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.004	0.004	0.005
Tool Truck Off-Site	40	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Tractor Trailer On-Site	10	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.15
Tractor Trailer Off-Site	40	0.043	0.043	0.043	0.044	0.044	0.045	0.045	0.046	0.046	0.044
Water Truck On-Site	10	0.15	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Water Truck Off-Site	40	0.047	0.046	0.046	0.047	0.047	0.047	0.048	0.048	0.048	0.047

Note: MPH = Miles per hour
Source: USEPA, Motor Vehicle Emissions Simulator (MOVES, Version 2014b)

TABLE E-36
ON-ROAD CONSTRUCTION VEHICLES EMISSION FACTORS – N_2O

Equipment	Speed (MPH)	Grams Per Mile									
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Concrete Trucks On-Site	10	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Concrete Trucks Off-Site	40	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Dump Truck On-Site	10	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Dump Truck Off-Site	40	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Light-Duty Vehicle On-Site	10	0.007	0.007	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.006
Light-Duty Vehicle Off-Site	40	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Paint Truck On-Site	10	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Paint Truck Off-Site	40	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Passenger Vehicle On-Site	10	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.005
Passenger Vehicle Off-Site	40	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Pickup Truck On-Site	10	0.007	0.007	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.006
Pickup Truck Off-Site	40	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Survey Crew Trucks On-Site	10	0.007	0.007	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.006
Survey Crew Trucks Off-Site	40	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Tool Truck On-Site	10	0.007	0.007	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.006
Tool Truck Off-Site	40	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Tractor Trailer On-Site	10	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Tractor Trailer Off-Site	40	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Water Truck On-Site	10	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Water Truck Off-Site	40	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002

Note: MPH = Miles per hour
Source: USEPA, Motor Vehicle Emissions Simulator (MOVES), Version 2014b)

E.1.2 Macroscale Dispersion Analysis

Dispersion is the process by which atmospheric pollutants spread due to wind and vertical stability. The base data for this type of analysis is emissions inventories (**Section E.1.1**). A dispersion model uses an emissions inventory to estimate concentrations of pollutants at specific locations. Dispersion models use hourly average meteorological data, terrain elevation data, and source emission release characteristics to compute downwind pollutant concentrations over periods that can range from one hour to one year.

The dispersion model used for the air quality analysis, USEPA's AERMOD (Version 19191), is state-of-the-art.[16,17] Given the accuracy of the input data, the model results offer the best available estimates with which to predict ambient concentrations of air pollutants. AERMOD simulates point, area, volume, and line emissions sources. AERMOD was executed using regulatory default options for stack-tip downwash, buoyancy-induced dispersion, and final plume rise, default wind speed profile categories, default potential temperature gradients, and—except for an analysis that was performed to convert predicted concentrations of NO_x to concentrations of NO_2 (see **Section E.1.2.5**)—no pollutant decay.

E.1.2.1 Meteorological Data

Surface data from O'Hare and upper-air meteorological conditions from Peoria, Illinois were used in AERMOD. The meteorological data used in the evaluation was obtained from the National Climatic Data Center. The dispersion modeling analysis used actual hour-of-day meteorological data collected at O'Hare by the National Weather Service for the most recent three-year period for which data was available (2016 through 2018). As part of the meteorological data processing, USEPA's AERSURFACE was used to determine the surface characteristics for input to AERMET, AERMOD's meteorological processor.[18] **Figure E-2** displays the wind rose for this period. As shown, the wind direction is predominantly from the south, southwest, west, and northeast sectors with a low frequency (two percent) of calm wind speed conditions. The figure shows the percentage of the year in which wind flows from a particular direction (e.g., for the evaluated period, the wind blew from the northeast 7.08 percent of the time)

To determine the year of meteorological data that would result in the greatest predicted pollutant concentrations, a screening analysis was performed. Because it was anticipated that the predicted concentrations of NO_2 would be closest to the National Ambient Air Quality Standard (NAAQS), the screening analysis was performed for one-hour and annual NO_2 concentrations. The meteorological year resulting in the highest one-hour and annual NO_2 concentrations was 2017. This year was used to evaluate all pollutants and averaging periods for Existing, Interim, and Build Out Conditions.[19]

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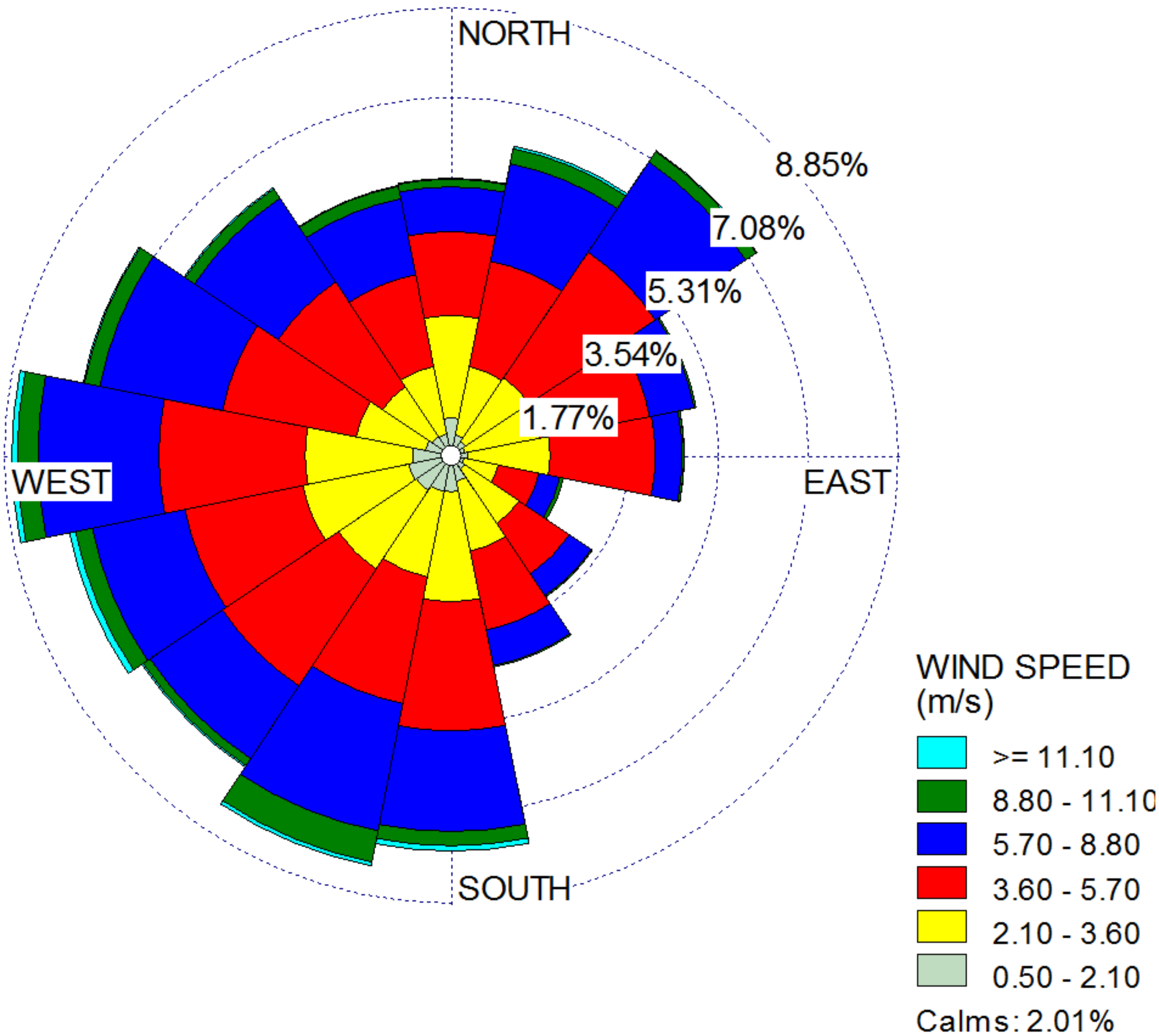
16 USEPA Preferred/Recommended Models, AERMOD Modeling System, http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod

16 Title 40 CFR Part 51, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule, http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf

18 AERMOD is more sensitive to surface roughness, which tends to be higher in urban environments due to greater obstructions and thus greater turbulence. Bowen ratio has little effect on the AERMOD results, while albedo can alter results slightly. Higher surface roughness lengths may produce lower concentrations for surface-based emissions but higher concentrations for elevated emission sources.

19 The emission distribution for NO_x resembles the emission distributions for CO, SO_2, PM_{10}, and $PM_{2.5}$ because most of the emissions result from aircraft and the temporal operational profiles for aircraft are the same regardless of pollutant. The one-hour and annual NO_2 concentration is worst-case for the same meteorological year. As such, the worst-case concentrations of CO, SO_2, PM_{10}, and $PM_{2.5}$ for both short- and long-term averaging periods occur in the same year. Of note, based on experience, the percentage of the airport/project contribution to the total concentration (airport/project plus background) are highest for NO_2 and the closest to the NAAQS compared to the other pollutants. Therefore, it is unlikely that using a different year of meteorological data would substantially change the resulting conclusions for CO, SO_2, PM_{10}, or $PM_{2.5}$.

FIGURE E-2
WIND ROSE FOR O'HARE FROM 2016 THROUGH 2018



Source: National Climatic Data Center, 2019

E.1.2.2 Atmospheric Mixing Height

The term "atmospheric mixing height" generally describes the height above ground level where the mixing of most air pollutants in the ambient (i.e., outdoor) air occurs. Within the atmosphere, this height is determined by an assortment of environmental factors, including temperature, humidity, solar radiation, wind speed, and topographic features on the ground (i.e., valleys, mountains, water bodies, etc.). The atmospheric mixing height is dynamic and moves up or down both spatially and temporally throughout the day, season, and year with corresponding changes in these abovementioned factors. The mixing height (i.e., the top of the layer of unstable or neutral air aboveground) determines the limits of vertical transport and diffusion of pollutants. Based on available data for the nearest upper air station (Peoria, Illinois), a mixing height of 2,510 feet was used for the air quality analysis.[20]

E.1.2.3 Receptors

Pollutant concentrations were predicted at publicly accessible locations and along the airport property line at approximate intervals of 10 degrees. On-airport receptors were located at terminal curbsides, public and employee parking facilities, and other areas where the public has/would have reasonable access. Pollutant concentrations were also predicted at off-airport receptors. The selection of locations for off-airport receptors considered locations at which the public has/will have reasonable access, areas in which dominant emission sources are in proximity (i.e., at the end of a runway), model limitations, and professional judgment.[21] The height of each receptor was assumed to be 1.8 meters aboveground (i.e., breathing height), consistent with USEPA modelling guidance. **Table E-37** and **Figure E-3** briefly describe and illustrate the receptor locations evaluated in the macroscale dispersion modeling analysis.

TABLE E-37
MACROSCALE DISPERSION ANALYSIS RECEPTOR LOCATIONS

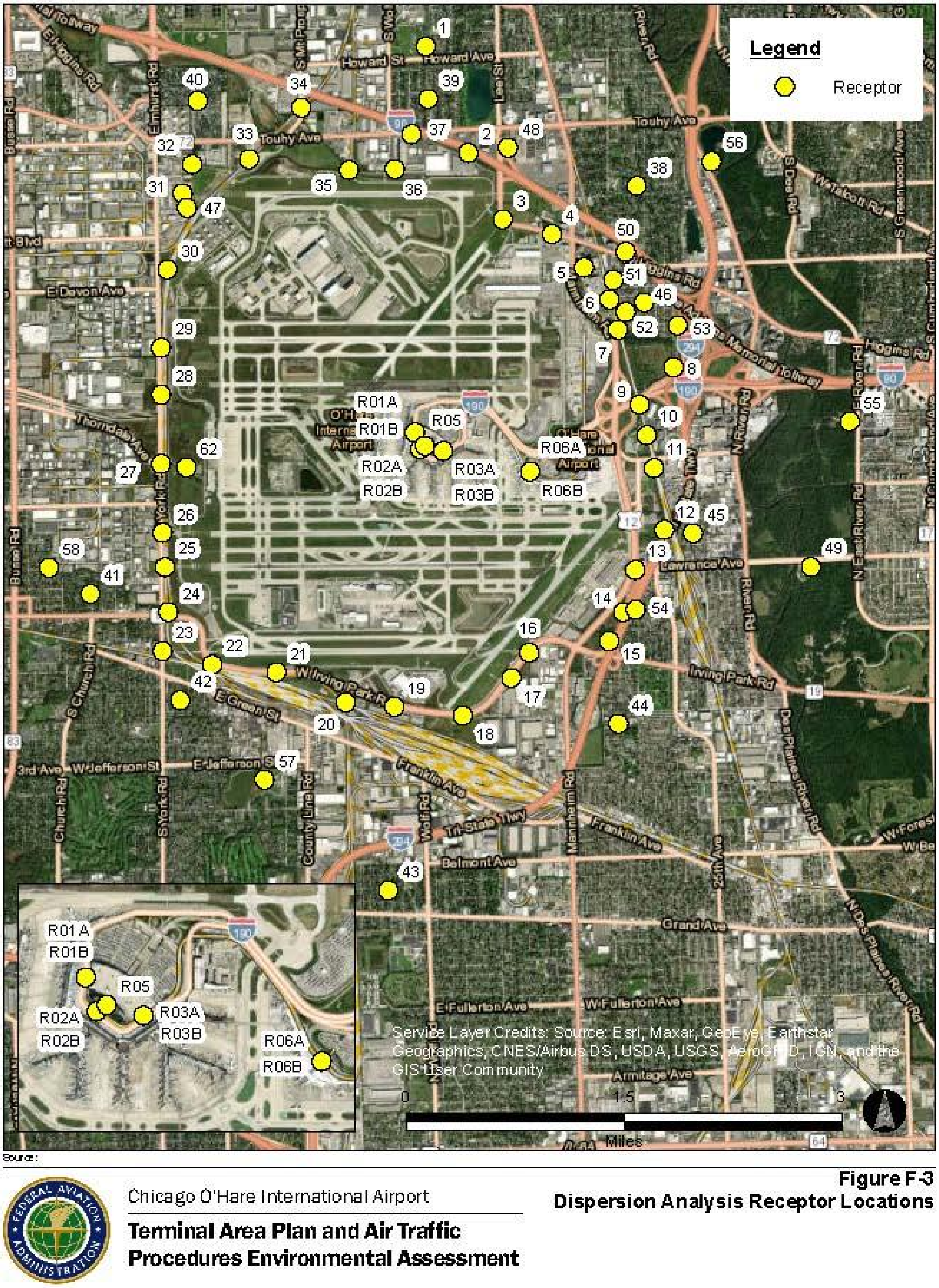
Receptor ID	Receptor Description	Receptor ID	Receptor Description
R01A	Terminal 1 Curbside (Lower)	26	Property Line (255° -RW10L)
R01B	Terminal 1 Curbside (Upper)	27	Property Line (260°)
R02A	Terminal 2 Curbside (Lower)	28	Property Line (275° - RW9R)
R02B	Terminal 2 Curbside (Upper)	29	Property Line (285° - RW9C)
R03A	Terminal 3 Curbside (Lower)	30	Property Line (300° - RW15)
R03B	Terminal 3 Curbside (Upper)	31	Property Line (310° - RW9L)
R05	Hilton Hotel Curbside	32	Touhy and Elmhurst Intersection (315°)
R06A	Terminal 5 Curbside (Lower)	33	Property Line (325°)
R06B	Terminal 5 Curbside (Upper)	34	Touhy and Mt. Prospect Intersection (335°)
1	Property Line (5°)	35	Property Line (345°)
2	Property Line (15°)	36	Property Line (355°)
3	Property Line (25° - RW27R)	37	Touhy and Wolf Intersection (355°)
4	Mannheim and Higgins Intersection (35°)	38	Northeast Residence
5	Mannheim and Zemke Intersection (45°)	39	North Residence
6	Property Line (55°)	40	Northwest Residence
7	Property Line (65° - RW27C)	41	Southwest Residence
8	Property Line (75°)	42	Southwest Residence
9	Property Line (85° - RW27L)	43	South Residence
10	Property Line (95°)	44	Southeast Residence

[20] Mixing Heights, Wind Speed, and Potential for Urban Air Pollution throughout the Contiguous United States, USEPA, January 1972

[21] The term *receptor* generically describes outdoor land uses or activities, which it can be reasonably expected that the public occupy for a period ranging from one hour to one year.

Receptor ID	Receptor Description	Receptor ID	Receptor Description
11	Property Line (105°)	45	East Residence
12	Property Line (115° - RW28R)	46	East Residence
13	Mannheim and Lawrence Intersection (125°) IEPA Monitoring Station (RW28C)	47	PP1, Elk Grove
14	Property Line (135°)	48	Sunset Park, Rosemont
15	Mannheim and Irving Park Intersection (145°)	49	Robinson Woods South, Cook County
16	Property Line (155° - RW28L)	50	Donald Stephens Park North, Cook County
17	Property Line (165°)	51	Burgermeister Park, Rosemont
18	Property Line (175°)	52	Margaret J. Lange Park, Rosemont
19	Property Line (185°)	53	Donald Stephens Athletic Complex, Cook County
20	Property Line (195°)	54	Dooley Memorial Park, Schiller Park
21	Property Line (205°)	55	Catherine Chevalier Woods, Cook County
22	Property Line (215°)	56	Chippewa Woods, Cook County
23	Property Line (225° - RW10R)	57	Redmond Park Recreational Complex, Bensenville
24	York and Irving Park Intersection (235°)	58	Mohawk Park, Bensenville
25	Property Line (245° -RW10C)	WESF	Western Employee Screening Facility (Build Out Proposed Action only)
Source: Crawford, Murphy & Tilly, Inc./RCH Group, August 2019			

FIGURE E-3
MACROSCALE DISPERSION ANALYSIS RECEPTOR LOCATIONS



Source: Crawford, Murphy & Tilly, Inc./RCH Group, August 2019

E.1.2.4 Background Concentrations

The dispersion modeling provides predicted pollutant concentrations due to emissions from airport sources and the modeled surrounding roadway network. To account for emissions generated by other sources, background concentrations were added to the model results. The background concentrations for CO, SO_2, PM_{10}, and $PM_{2.5}$ were derived from existing air monitoring data from IEPA's Northbrook monitoring station using measured data for 2016 through 2018. Because the IEPA discontinued measuring NO_2 at the Northbrook station in 2016, background concentrations of this pollutant were obtained from an air monitoring station in the City of Nilwood, per discussions with USEPA (see **Attachment E-1** of this appendix).

For the analysis of CO, three-hour SO_2, annual NO_2, and 24-hour PM_{10}, the background concentrations represent the highest (i.e., maximum) measured levels during the three-year period. The background values for one-hour NO_2, one-hour SO_2, and 24-hour $PM_{2.5}$ are not the highest measured levels because the standards for these pollutants are based on 99th, 98th, and 98th percentile values, respectively. Notably, use of the historical measured values results in conservatively high estimates of future pollutant concentrations due to the downward trend in regional pollutant concentrations. The background concentrations used in the macroscale dispersion analysis are provided in **Table E-38**.

TABLE E-38
BACKGROUND CONCENTRATIONS

Pollutant	Averaging Time	Station Selected	Note	Background Concentration
CO	1-hour	Northbrook	(a)	1.41 ppm (1,606 µg/m³)
	8-hour	Northbrook	(a)	1.10 ppm (1,222 µg/m³)
SO_2	1-hour	Northbrook	(b)	0.0034 ppm (8.89 µg/m³)
	3-hour	Northbrook	(a)	0.0046 ppm (12.0 µg/m³)
NO_2	1-hour	Nilwood	(e)	0.015 ppm (28.6 µg/m³)
	Annual	Nilwood	(f)	0.002 ppm (4.5 µg/m³)
PM_{10}	24-hour	Northbrook	(a)	53.0 µg/m³
	Annual	Northbrook	(a)	15.7 µg/m³
$PM_{2.5}$	24-hour	Northbrook	(c)	20.7 µg/m³
	Annual	Northbrook	(d)	8.30 µg/m³

Notes: ppm - parts per million
µg/m³ - micrograms per cubic meter
a) Highest value for 2016, 2017, and 2018
b) Average of the 99th percentile values for 2016, 2017, and 2018
c) Average of the 98th percentile values for 2016, 2017, and 2018
d) Average value for 2016, 2017, and 2018
e) Average of the 98th percentile values for 2018
f) Average value for 2018
Source: USEPA, Office of Air Quality Planning and Standards, AIRData – Monitor Values Reports, https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality- monitors and IEPA, Annual Air Quality Reports, https://www2.illinois.gov/epa/topics/air-quality/air-quality- reports/Pages/default.aspx

Using background concentrations without regard to the hour of the day, day of the week, or month of the year during which the highest modeled pollutant concentration occurs results in conservatively high estimates of pollutant concentrations. As stated previously, it was anticipated that predicted concentrations of NO_2 would be closest to the NAAQS. Therefore, following USEPA guidance, temporal background concentrations were derived for this pollutant and averaging time.[22] As shown in **Table E-39**, the derived one-hour NO_2 background concentrations vary by season and by time of day, with a tendency for higher concentrations during spring and fall and morning and evening periods.

TABLE E-39
ONE-HOUR NO_2 TEMPORAL BACKGROUND CONCENTRATIONS

Hour	Background Concentrations (µg/m^3)				
	Winter	Spring	Summer	Fall	Annual
1	12.6	13.5	12.6	12.8	13.7
2	23.1	17.3	16.0	14.7	17.3
3	18.6	21.6	15.2	17.7	20.7
4	16.9	20.3	15.2	13.5	16.9
5	16.5	19.7	11.3	16.7	18.8
6	14.9	17.3	13.7	15.0	17.1
7	14.9	14.3	12.6	18.2	14.9
8	13.2	12.4	10.2	13.5	13.5
9	12.8	10.2	6.2	12.2	12.2
10	10.5	10.3	8.5	9.0	10.5
11	10.0	9.2	4.7	8.1	9.6
12	10.0	9.0	6.0	10.5	9.8
13	10.0	8.8	4.5	8.1	9.0
14	9.6	7.9	3.9	10.2	9.4
15	12.6	8.3	3.9	10.5	10.7
16	11.5	8.3	4.5	9.8	10.0
17	14.1	9.8	4.9	13.7	13.4
18	16.0	10.2	9.0	14.3	14.1
19	13.0	24.8	13.4	15.0	16.4
20	13.9	19.7	14.5	15.6	17.3
21	16.9	22.9	14.9	16.4	19.2
22	17.9	22.4	17.5	13.5	18.2
23	15.8	19.7	21.3	15.2	19.4
24	19.7	17.5	22.6	14.7	21.8

[22] Additional Clarification Regarding Application of Appendix W Modeling Guidance for the one-hour NO_2 National Ambient Air Quality Standard, March 1, 2011 (https://www.epa.gov/sites/production/files/2015-07/documents/appwno2_2.pdf) and Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO_2 National Ambient Air Quality Standard, September 30, 2014 (https://www.epa.gov/sites/default/files/2020-10/documents/no2_clarification_memo-20140930.pdf)

Hour	Background Concentrations (µg/m³)				
	Winter	Spring	Summer	Fall	Annual

Notes: 98th percentile value for data for 2018
Source: USEPA, Office of Air Quality Planning and Standards, AIRData – Monitor Values Reports, https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors and IEPA, Annual Air Quality Reports, https://www2.illinois.gov/epa/topics/air-quality/air-quality-reports/Pages/default.aspx

E.1.2.5 Conversion of NO_x to NO_2

AEDT provides dispersion results for NO_x. For comparison to the NAAQS, modeled NO_x concentrations were converted to NO_2 concentrations. Prior to and while preparing the air quality analysis for the EA, the IEPA and the USEPA were provided an Air Quality Modeling Protocol (see **Attachment E-1** of this appendix). The Protocol details the analysis that was performed to confirm the best available method of converting one-hour NO_x to one-hour NO_2.

E.1.2.6 Dispersion Coefficient

When executing AERMOD, the selection of a dispersion coefficient is based on the land use within three kilometers of the source. This land use typing is based on a classification model defined by Auer [23] using pertinent U.S. Geological Survey 1:24,000 scale topographic maps of the area. If the Auer land use types of heavy industrial, light-to-moderate industrial, commercial, and compact residential account for 50 percent or more of the total area, the USEPA Guideline on Air Quality Models[24] recommends using urban dispersion coefficients; otherwise, using the appropriate rural coefficients is advised. O'Hare is in an urban area and the immediate area is characterized by large areas of pavement, low buildings, and open space. Therefore, urban dispersion coefficients were used for the air quality analysis.

E.1.2.7 Airfield Capacity and Operating Configurations

In AEDT, the capacity of the airfield, which can affect emissions via ground travel delay, is defined as the highest number of hourly departures, which can occur during the peak hour of arrivals and the highest number of hourly arrivals, which can occur during the peak hour of departures. Airfield capacity values were incorporated in AEDT per information developed by the CDA and TAAM.

Operating configurations specify the pattern of aircraft arrivals and departures on specific runways over the course of a year, depending on weather conditions and airfield capacity. Specifying configurations allows for aircraft to be assigned to runways based on aircraft size (i.e., small, large, and heavy), a similar method to that employed in an actual airport operating environment. For the air quality analysis, the west and east flow configurations were included to account for weather conditions representing westerly and easterly wind directions to model real-world conditions.

E.1.2.8 Runway Layout and Runway Use

AEDT requires that the runway layout be defined, usually in the form of points of latitude and longitude and width. For the air quality analysis, the runway layout is set up in AEDT using current runway coordinates for the existing/future runways provided by the CDA. At times, the aircraft do not begin their

[23] Auer, August H., 1978: *Correlation of Land Use and Cover with* Meteorological Anomalies. J. Appl. Meteor., 17, 636–643 http://journals.ametsoc.org/doi/pdf/10.1175/1520-0450%281978%29017%3C0636%3ACOLUAC%3E2.0.CO%3B2
[24] Appendix W to Part 51 – Guideline on Air Quality Models, http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48c032d9a39c&node=40:2.0.1.1.2.23.11.5.37&rgn=div9

departure rolls at the end of the runways, but rather at other taxiway intersections. These occurrences are referred to as intersection departures (displaced thresholds) and were employed for Runways 9R/27L and 10L/28R.

The runway use percentages for the Existing Condition were obtained from the previously mentioned ANOMS/Aerobahn databases. Runway use percentages for the Interim and Build Out Conditions were developed from TAAM (see **Appendices B and D**). This information is used to distribute aircraft arrival and departure operations to each runway end. As required by AEDT, the runway usage by aircraft size (small, large, and heavy) and wind direction flow (west and east) were used for the air quality analysis. The west and east flow runway use data for arrivals and departures, used in the air quality analysis, is provided in **Tables E-40 through E-49 f**or the Existing, Interim, and Build Out Conditions.

E.1.2.9 Aircraft Assignments to Terminal, Taxiways, and Taxipaths

The runway usage, terminal/apron assignment, and taxiway assignment define the taxipath[25] that aircraft take while traveling on the ground. AEDT uses input data to develop an aircraft taxipath and, along with aircraft travel speeds, the corresponding ground taxi times. Each aircraft is assigned a terminal/apron location to which the aircraft proceeds after landing and where servicing (e.g., baggage handling, fueling, catering, etc.) is conducted. The aircraft then departs from the same terminal/apron for a takeoff runway end. The ANOMS/Aerobahn and TAAM were used to assign aircraft to an appropriate terminal/apron based on airline lease agreements and forecast gate use strategies. For the air quality analysis, the taxiway assignments were based on the common and forecast routing paths that ground traffic controllers are known to assign and based on the TAAM.

Taxiway speeds range from: 25 knots (high-speed taxiway P between Runways 10C/28C and 10L/28R, taxiway E between Runways 9C/27C and 9R/27L, and taxiway Z south of Runway end 9L); 20 knots (taxiways C near the scenic pad, taxiways to the west of the terminal areas near the de-icing pads, and taxiway W near Runway 10R/28L); 17 knots (most other taxiways); 12 knots (taxiways circulating around the terminal area); 10 knots (near runway ends); and 7 knots (near gate/terminal entrance/exits).

E.1.2.10 Temporal Factors

Temporal factors are used to describe the relationships between different periods of time (i.e., the relationship of activity during one hour to activity in a 24-hour period). In AEDT, temporal factors were applied to represent varying activity levels as a fraction of a peak period. Using temporal factors gives the model the ability to reflect real-world conditions more accurately throughout a given time, such as one year. Temporal factors were only used for the dispersion modeling analysis.

For the Existing Condition, the temporal factors were developed using data from the FAA's Operations Network. For the Interim and Build Out Conditions, aircraft temporal factors were developed based on information within the TAAM output. Aircraft temporal factors were developed separately for arrivals, departures, and aircraft size (small, large, and heavy).

Figures E-4 through E-8 represent operational profiles for overall aircraft activity regardless of aircraft category, aircraft size, and operation type (i.e., arrivals and departures).

[25] A taxipath is an ordered list of instructions that specifies how to maneuver from a gate to a runway end (outbound) or from a runway exit to a gate (inbound).

Using data from of the surface transportation analysis for the EA, temporal factors were also developed for: on-airport roadways, off-airport roadways (e.g., Irving Park Road, York Road), the terminal curbsides, airport parking facilities, and employee busing.

TABLE E-40
WEST FLOW RUNWAY USE: EXISTING CONDITION

Aircraft Size	Percent Runway Use											
	Arrivals						Departures					
	28C	27L	27R	28R	22L	22R	22L	28R	28R (INT)	27L	28C	32L
All Aircraft	29.07	41.60	27.62	1.55	0.05	0.11	36.42	5.83	56.47	0.29	0.82	0.17
Heavy	86.51	4.27	0.10	8.82	0.22	0.08	6.65	31.87	56.74	0.22	4.31	0.21
Large	24.44	44.98	29.47	0.97	0.03	0.11	39.00	5.09	54.95	0.24	0.55	0.17
Small	24.34	25.48	49.24	0.83	0.02	0.09	24.26	6.51	65.47	3.12	0.53	0.11

Note: 28R(Int.) is the location of Intersection Departures for that runway.
Sources: ANOMS/Aerobahn Database and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-41
EAST FLOW RUNWAY USE: EXISTING CONDITION

Aircraft Size	Percent Runway Use												
	Arrivals							Departures					
	09L	09R	10L	10R	10C	04R	14R	09R	10L	10L(INT)	10C	04L	04R
All Aircraft	34.82	1.91	2.56	16.09	44.44	0.14	0.04	52.77	2.72	43.26	0.47	0.75	0.03
Heavy	0.31	0.73	6.92	0.64	91.05	0.35	0.00	16.14	30.63	48.87	3.93	0.27	0.16
Large	37.16	1.98	2.23	17.30	41.16	0.13	0.04	55.79	1.99	41.24	0.17	0.79	0.02
Small	62.74	3.13	0.75	20.06	13.04	0.14	0.14	63.24	1.64	34.12	0.27	0.68	0.05

Note: 10L(Int.) is the location of Intersection Departures for that runway.
Sources: ANOMS/Aerobahn Database and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-42
WEST FLOW RUNWAY USE: INTERIM NO ACTION

Aircraft Size	Percent Runway Use											
	Arrivals					Departures						
	27C	27R	28L	28C	28R	27L	27L(INT)	27C	28C	28R	28R(INT)	22L
All Aircraft	29.16	33.85	0.00	30.94	6.05	2.11	28.50	0.28	0.21	1.32	37.62	29.96
Heavy	37.07	0.00	0.00	51.30	11.63	22.96	28.99	3.10	2.33	11.71	30.13	0.78
Large	28.42	37.14	0.00	28.88	5.56	0.00	28.53	0.00	0.00	0.27	38.01	33.19
Small	24.65	45.72	0.00	29.21	0.42	0.00	22.37	0.00	0.00	0.00	65.47	12.16

Note: 27L(Int.) and 28R(Int.) are the locations of Intersection Departures for that runway.
Sources: Ricondo & Associates TAAM Results, August 2020 and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-43
EAST FLOW RUNWAY USE: INTERIM NO ACTION

Aircraft Size	Percent Runway Use										
	Arrivals					Departures					
	09L	09C	10L	10C	10R	09C	09R	09R(INT)	10L	10L(INT)	10C
All Aircraft	32.91	26.99	6.21	32.32	1.57	0.26	2.30	48.93	1.20	47.10	0.21
Heavy	0.00	65.81	11.92	22.16	0.11	2.81	25.15	40.85	11.57	17.29	2.33
Large	36.13	23.08	5.64	33.42	1.73	0.00	0.00	49.58	0.15	50.27	0.00
Small	42.39	23.23	5.56	28.03	0.79	0.00	0.00	61.11	0.00	38.89	0.00

Note: 09R(Int.) and 10L(Int.) are the locations of Intersection Departures for that runway.
Sources: Ricondo & Associates TAAM Results, August 2020 and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-44
WEST FLOW RUNWAY USE: INTERIM PROPOSED ACTION

	Percent Runway Use											
	Arrivals					Departures						
Aircraft Size	**27C**	**27R**	**28L**	**28C**	**28R**	**27L**	**27L(INT)**	**27C**	**28C**	**28R**	**28R(INT)**	**22L**
All Aircraft	28.60	34.25	0.00	30.90	6.25	2.07	28.62	0.28	0.21	1.26	38.26	29.30
Heavy	33.50	0.00	0.00	54.87	11.63	22.61	26.95	3.11	2.33	11.73	32.49	0.78
Large	28.17	37.55	0.00	28.49	5.79	0.00	28.96	0.00	0.00	0.21	38.38	32.46
Small	23.38	48.41	0.00	27.79	0.42	0.00	17.09	0.00	0.00	0.00	71.38	11.53

Note: 27L(Int.) and 28R(Int.) are the locations of Intersection Departures for that runway.
Sources: Ricondo & Associates TAAM Results, June 2020 and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-45
EAST FLOW RUNWAY USE: INTERIM PROPOSED ACTION

	Percent Runway Use										
	Arrivals					Departures					
Aircraft Size	**09L**	**09C**	**10L**	**10C**	**10R**	**09C**	**09R**	**09R(INT)**	**10L**	**10L(INT)**	**10C**
All Aircraft	32.16	21.80	6.27	31.85	7.92	0.28	2.35	50.59	1.13	45.44	0.21
Heavy	0.00	54.14	11.69	34.17	0.00	3.05	25.69	41.81	10.80	16.33	2.33
Large	35.28	18.61	5.73	31.72	8.66	0.00	0.00	51.34	0.15	48.51	0.00
Small	42.39	15.01	5.56	23.92	13.13	0.00	0.00	60.72	0.00	39.28	0.00

Note: 09R(Int.) and 10L(Int.) are the locations of Intersection Departures for that runway.
Sources: Ricondo & Associates TAAM Results, June 2020 and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-46
WEST FLOW RUNWAY USE: BUILD OUT NO ACTION

Aircraft Size	Percent Runway Use											
	Arrivals					Departures						
	27C	27R	28L	28C	28R	27L	27L(INT)	27C	28C	28R	28R(INT)	22L
All Aircraft	27.92	34.44	0.00	31.28	6.36	2.18	27.82	0.47	0.20	1.41	37.43	30.49
Heavy	33.36	0.00	0.00	53.58	13.06	21.97	27.47	4.73	2.03	13.53	30.22	0.05
Large	27.42	38.09	0.00	28.86	5.63	0.00	27.93	0.00	0.00	0.08	37.84	34.15
Small	20.10	46.55	0.00	27.79	5.56	0.00	22.22	0.00	0.00	0.00	66.25	11.53

Note: 27L(Int.) and 28R(Int.) are the locations of Intersection Departures for that runway.
Sources: Ricondo & Associates TAAM Results, July 2020 and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-47
EAST FLOW RUNWAY USE: BUILD OUT NO ACTION

Aircraft Size	Percent Runway Use										
	Arrivals					Departures					
	09L	09C	10L	10C	10R	09C	09R	09R(INT)	10L	10L(INT)	10C
All Aircraft	33.26	26.06	6.27	32.93	1.48	0.36	2.35	48.07	1.50	47.52	0.20
Heavy	0.00	64.36	13.75	21.79	0.10	3.60	23.66	39.67	13.78	17.26	2.03
Large	36.77	21.86	5.49	34.23	1.65	0.00	0.00	48.84	0.15	51.01	0.00
Small	42.39	25.29	3.50	28.03	0.79	0.00	0.00	60.72	0.00	39.28	0.00

Note: 09R(Int.) and 10L(Int.) are the locations of Intersection Departures for that runway.
Sources: Ricondo & Associates TAAM Results, July 2020 and Crawford, Murphy & Tilly, Inc./RCH Group

TABLE E-48
WEST FLOW RUNWAY USE: BUILD OUT PROPOSED ACTION

Aircraft Size	Percent Runway Use											
	Arrivals					Departures						
	27C	27R	28L	28C	28R	27L	27L(INT)	27C	28C	28R	28R(INT)	22L
All Aircraft	28.36	32.60	5.13	27.65	6.26	2.18	31.24	0.40	0.07	1.68	41.22	23.21
Heavy	33.98	0.00	0.00	52.80	13.22	21.97	31.66	4.06	0.68	16.25	25.38	0.00
Large	27.80	36.07	5.65	24.90	5.58	0.00	31.26	0.00	0.00	0.08	42.69	25.97
Small	24.48	40.82	7.94	26.76	0.00	0.00	26.37	0.00	0.00	0.00	62.95	10.68

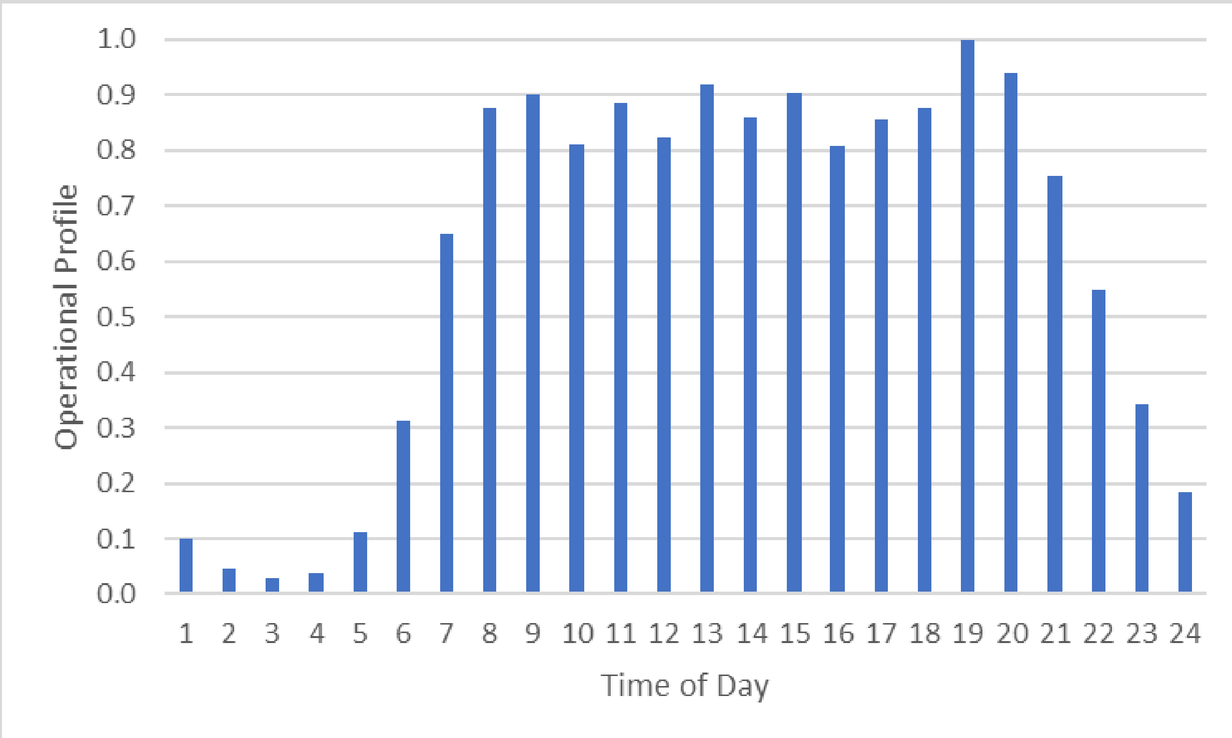
Note: 27L(Int.) and 28R(Int.) is the location of Intersection Departures for that runway.
Sources: Ricondo & Associates TAAM Results, May 2020 and Crawford, Murphy & Tilly, Inc./RCH Group.

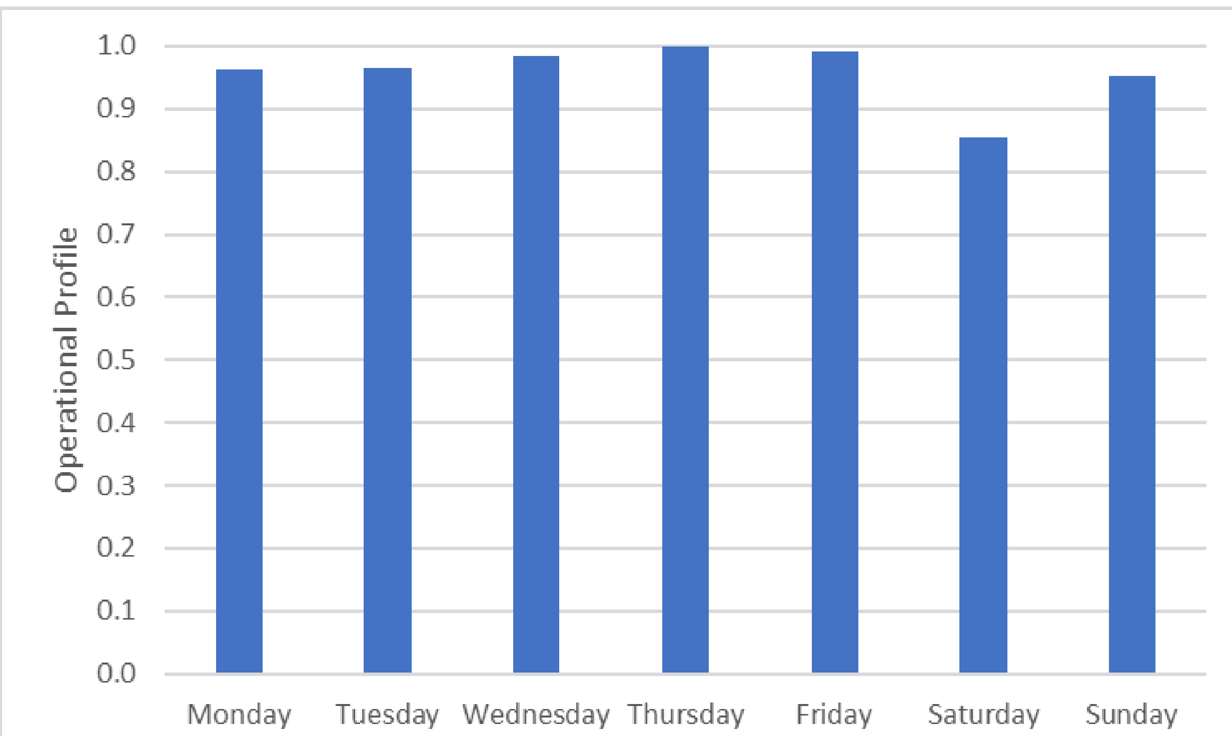
TABLE E-49
EAST FLOW RUNWAY USE: BUILD OUT PROPOSED ACTION

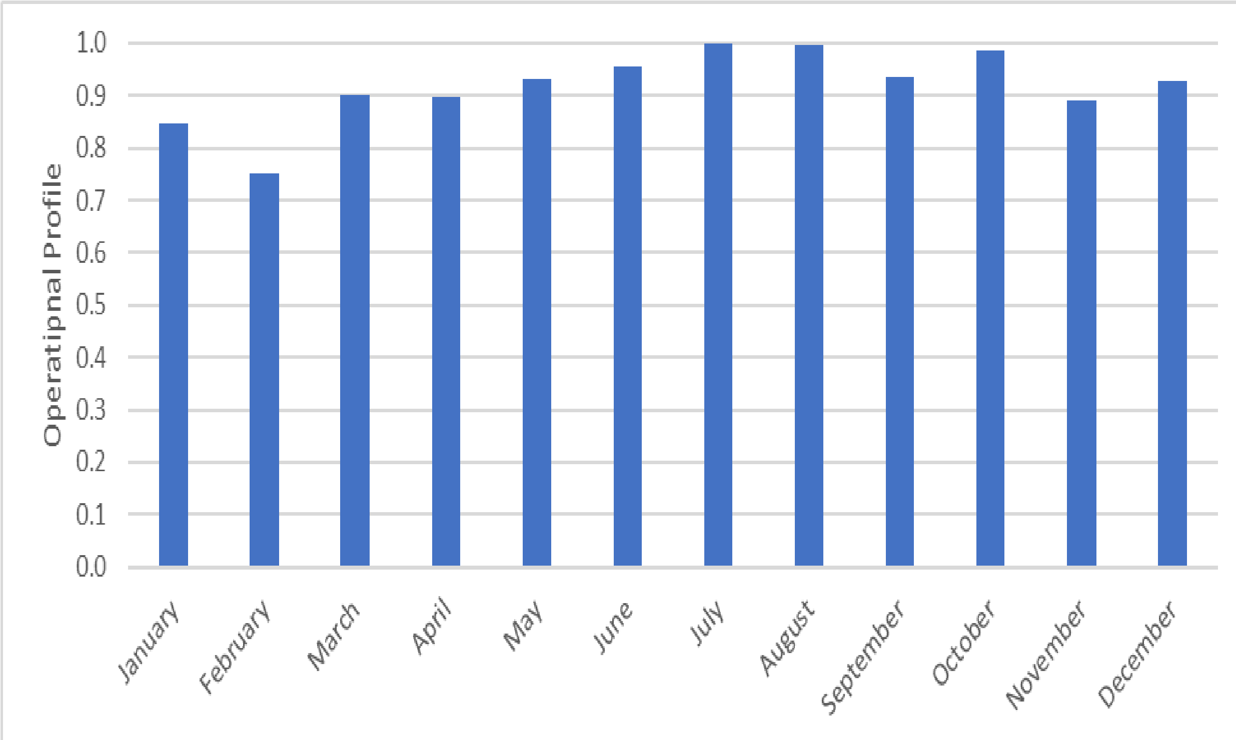
Aircraft Size	Percent Runway Use										
	Arrivals					Departures					
	09L	09C	10L	10C	10R	09C	09R	09R(INT)	10L	10L(INT)	10C
All Aircraft	31.64	19.31	6.22	30.70	12.14	0.40	2.34	47.73	1.64	47.82	0.07
Heavy	0.00	49.47	13.51	37.01	0.00	4.00	23.58	38.91	14.93	17.90	0.68
Large	35.01	16.07	5.50	30.11	13.31	0.00	0.00	48.54	0.18	51.28	0.00
Small	38.27	15.01	0.00	22.84	23.87	0.00	0.00	61.11	0.00	38.89	0.00

Note: 09R(Int.) and 10L(Int.) are the locations of Intersection Departures for that runway.
Sources: Ricondo & Associates TAAM Results, May 2020 and Crawford, Murphy & Tilly, Inc./RCH Group

FIGURE E-4
AIRCRAFT OPERATIONAL PROFILES – EXISTING CONDITION

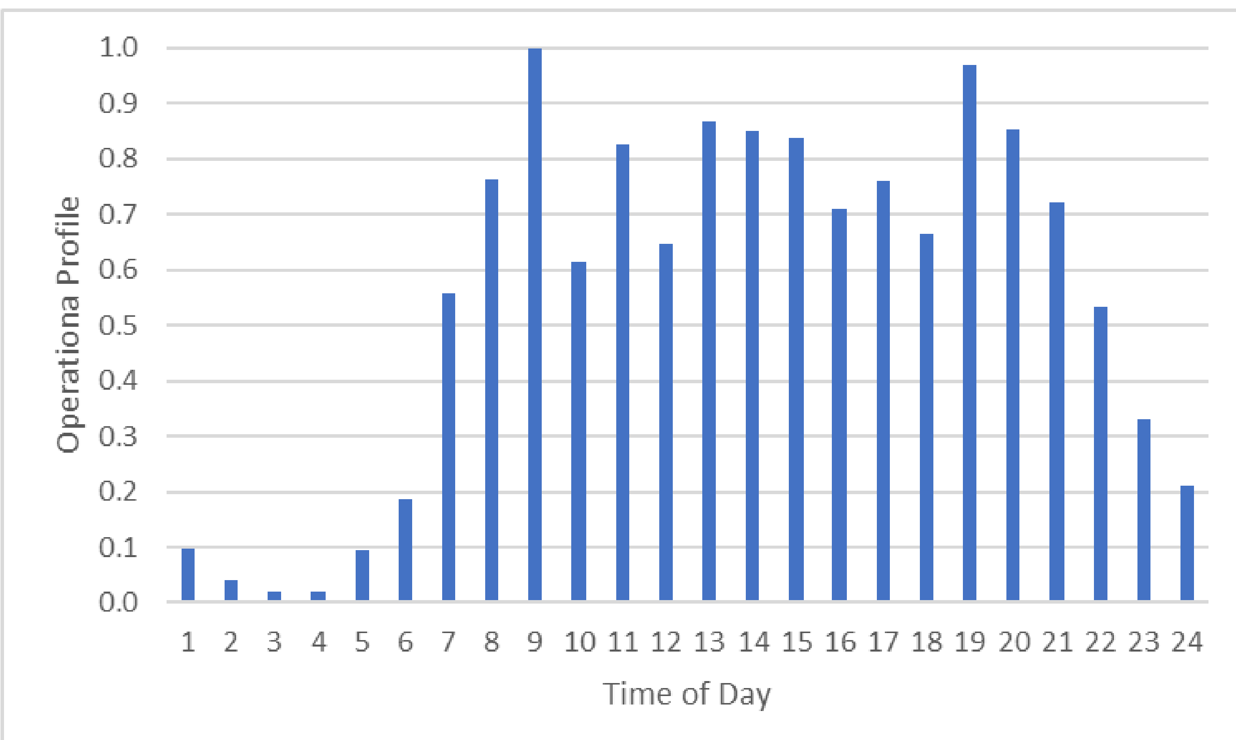


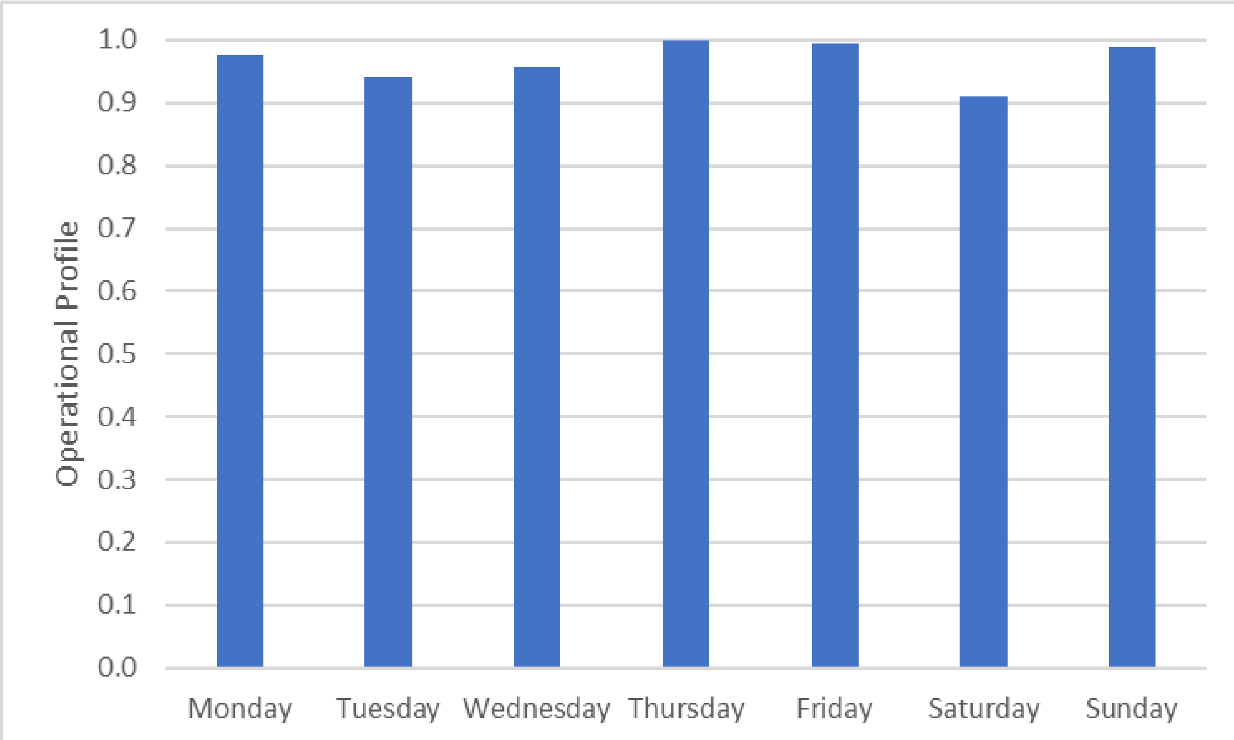


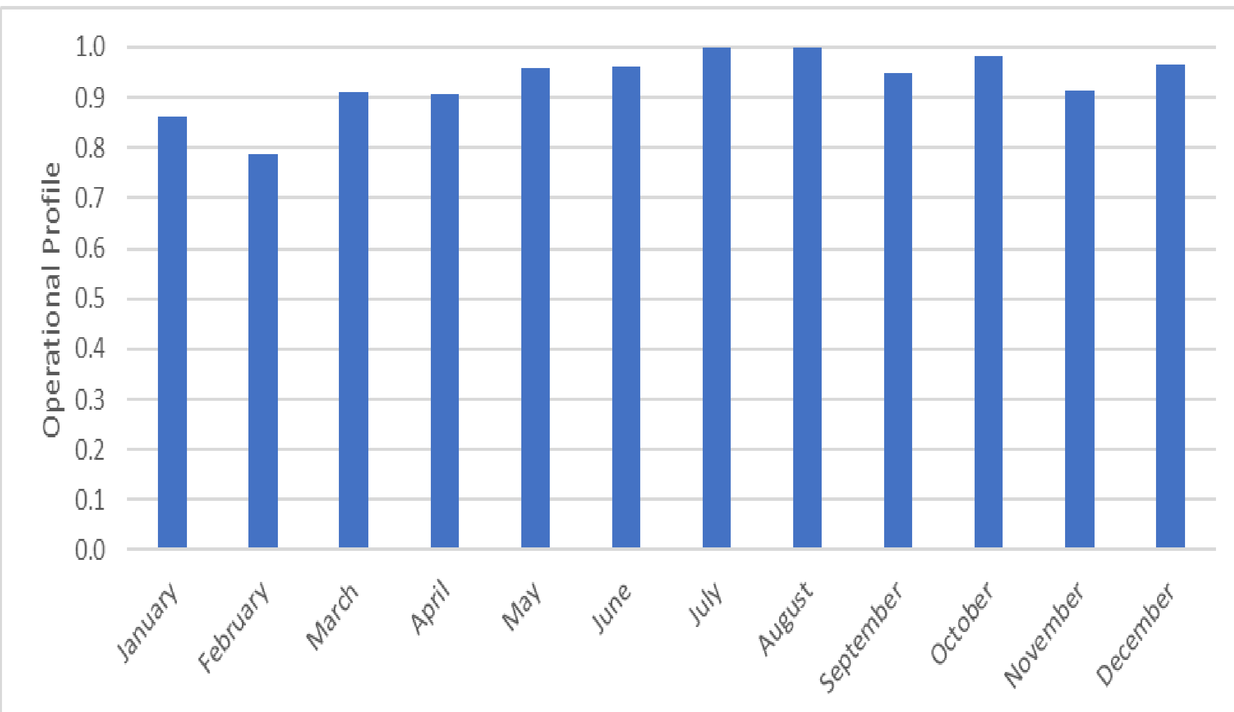


Source: FAA ASPM, 2019

FIGURE E-5
AIRCRAFT OPERATIONAL PROFILES – INTERIM NO ACTION

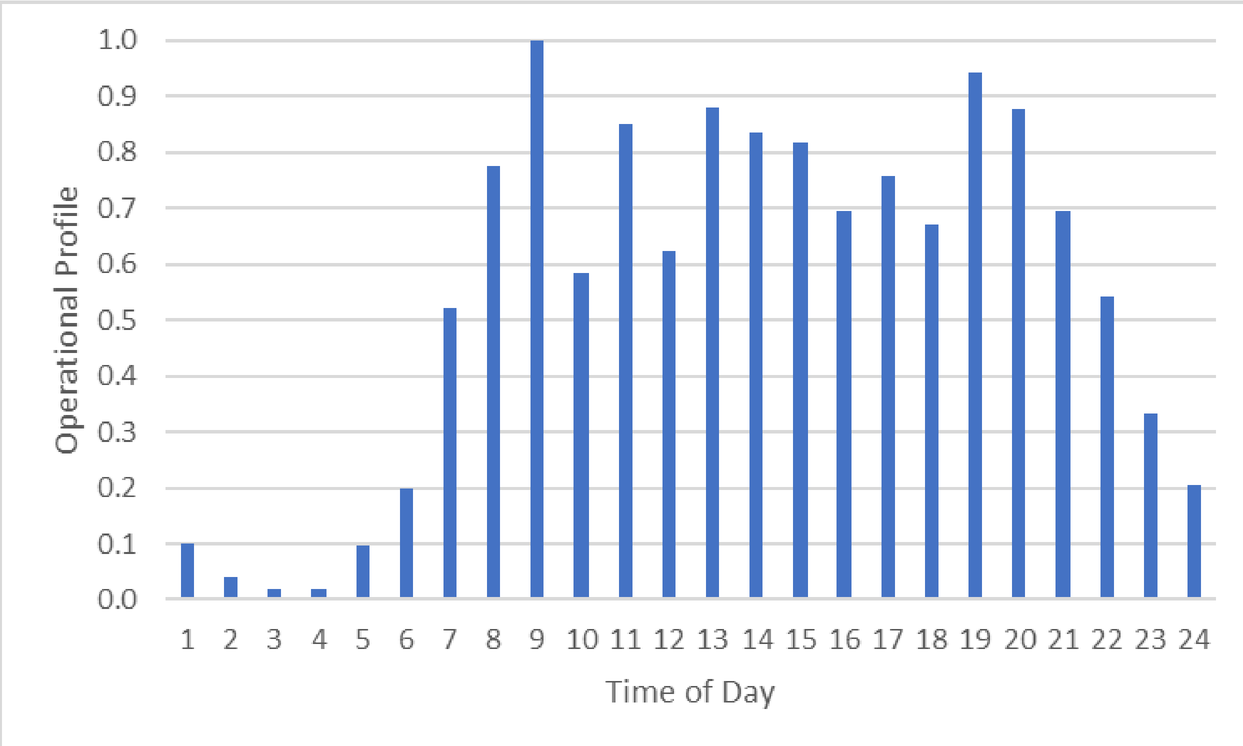


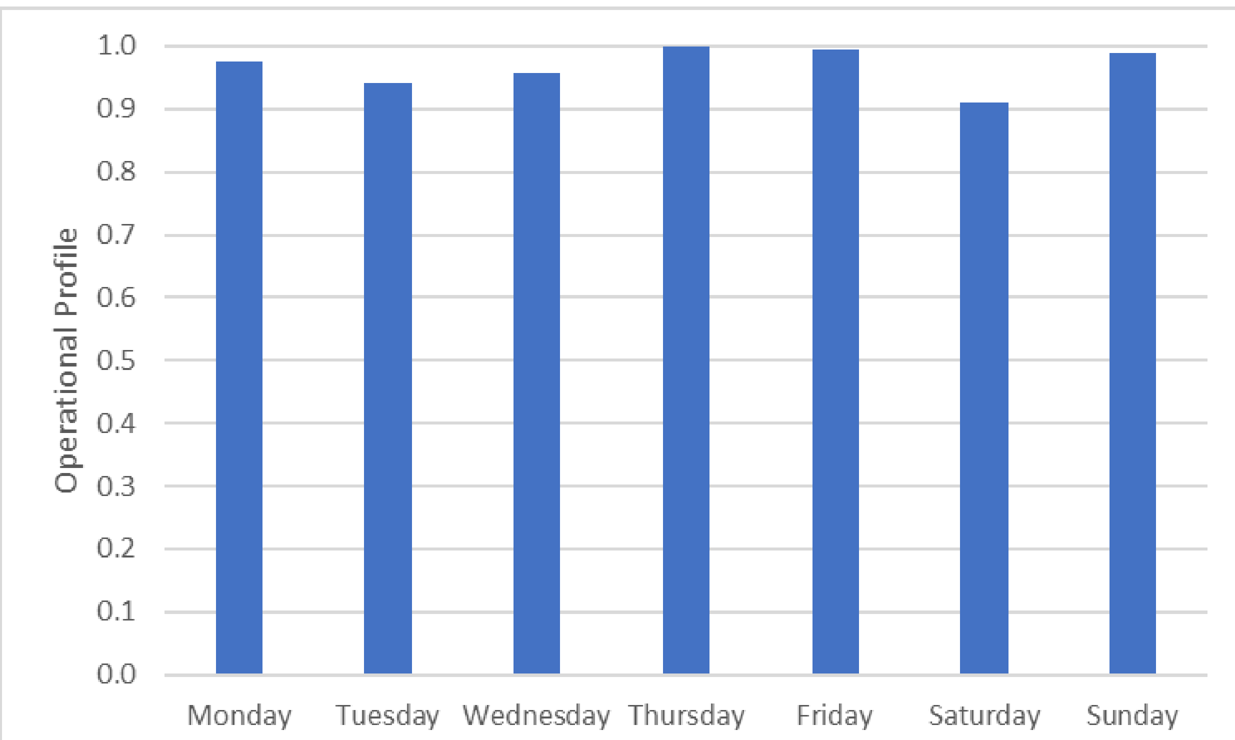


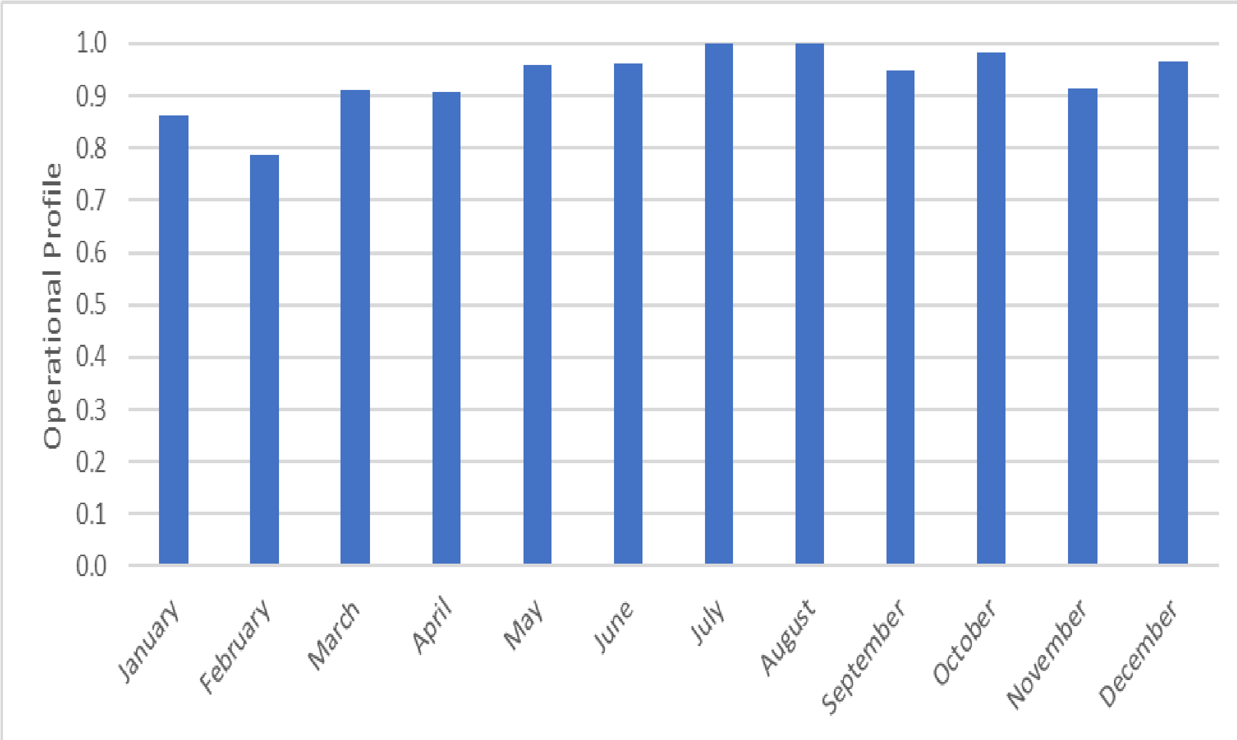


Source: Ricondo, 2020

FIGURE E-6
AIRCRAFT OPERATIONAL PROFILES – INTERIM PROPOSED ACTION

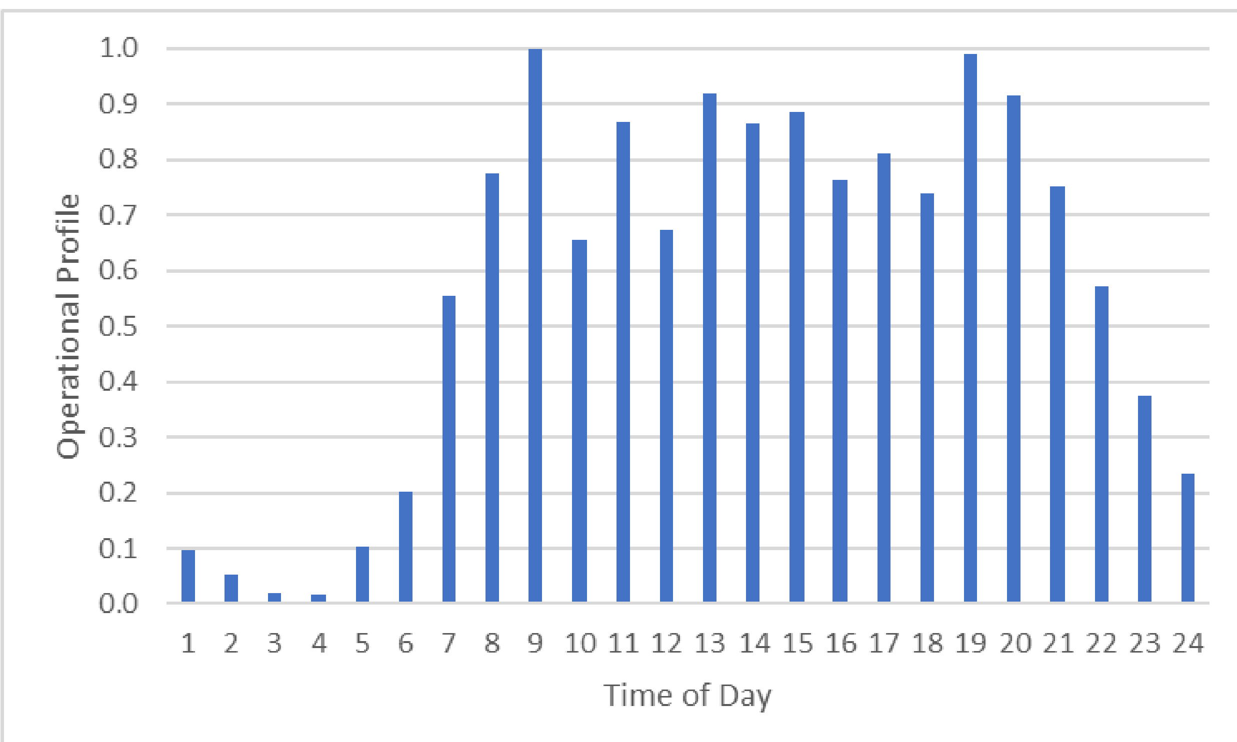


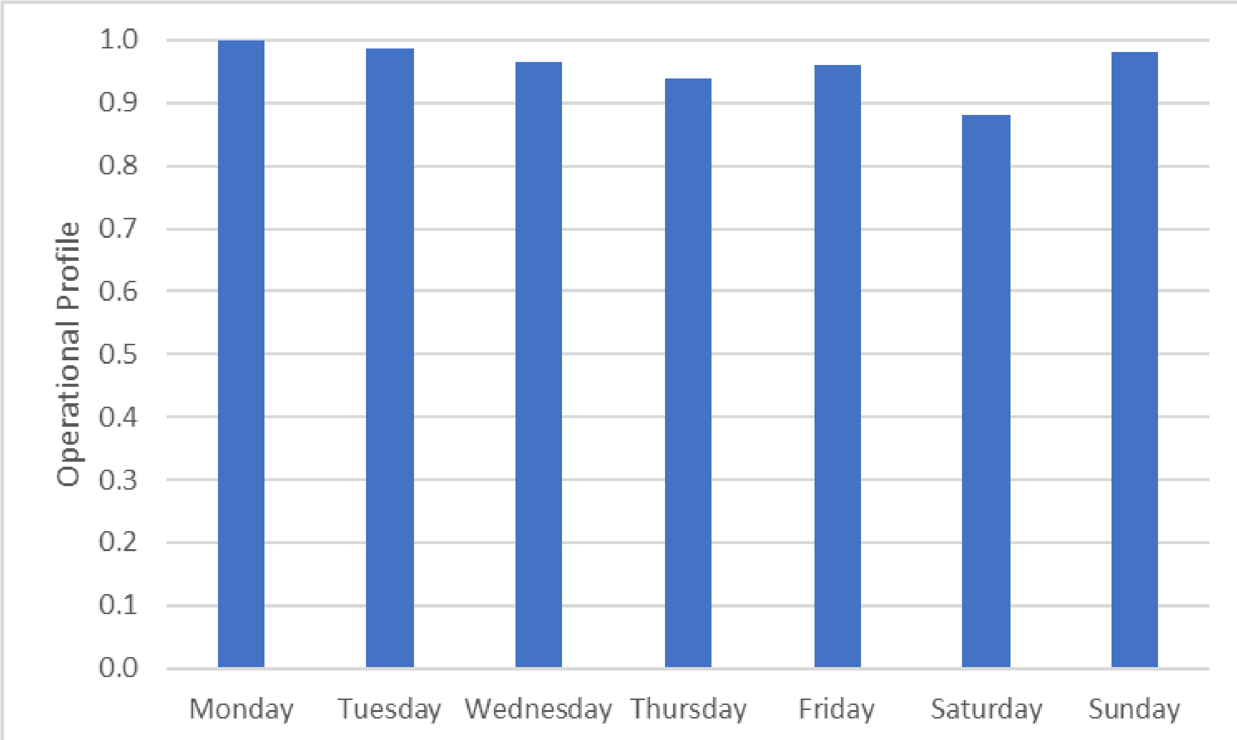


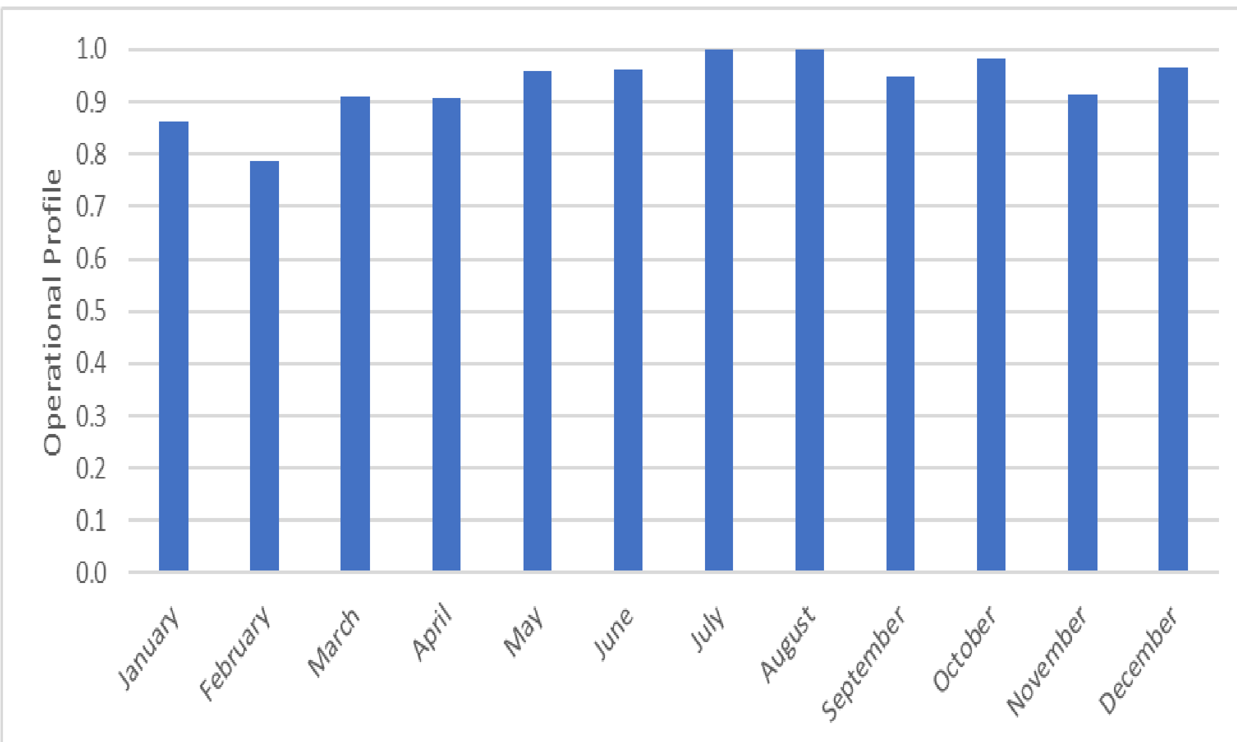


Source: Ricondo, 2020

FIGURE E-7
AIRCRAFT OPERATIONAL PROFILES – BUILD OUT NO ACTION

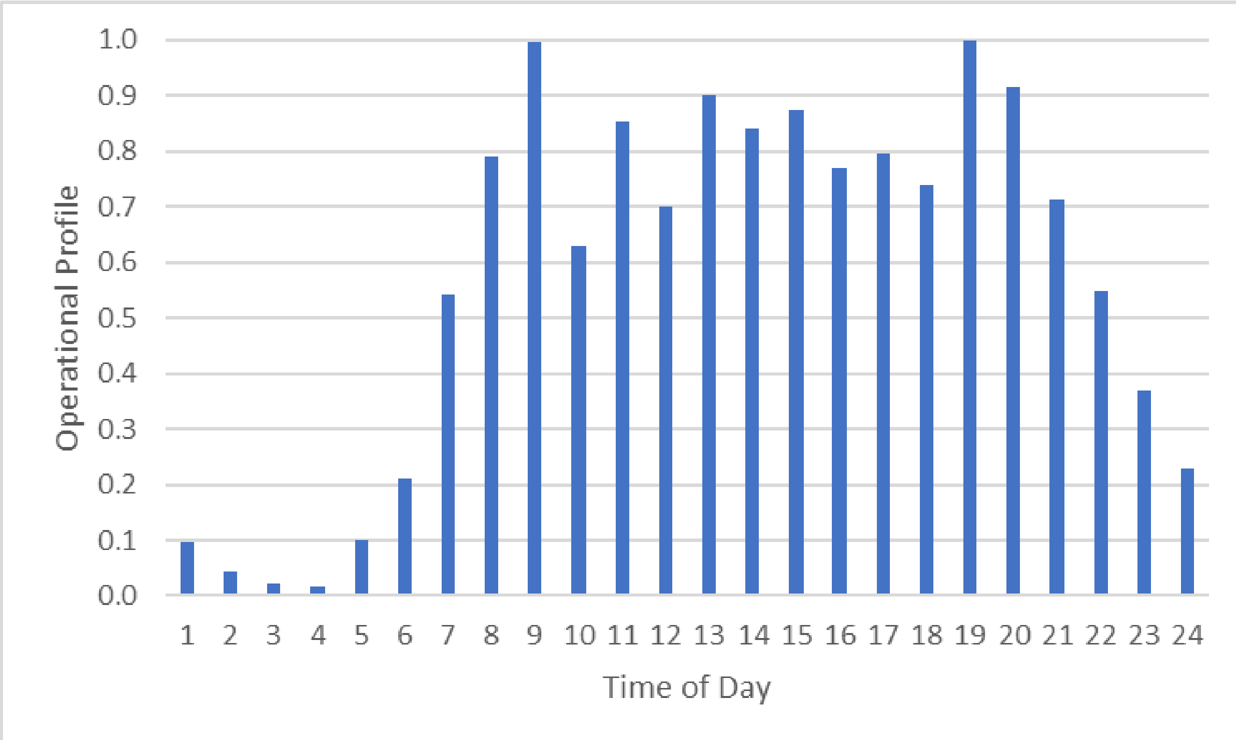


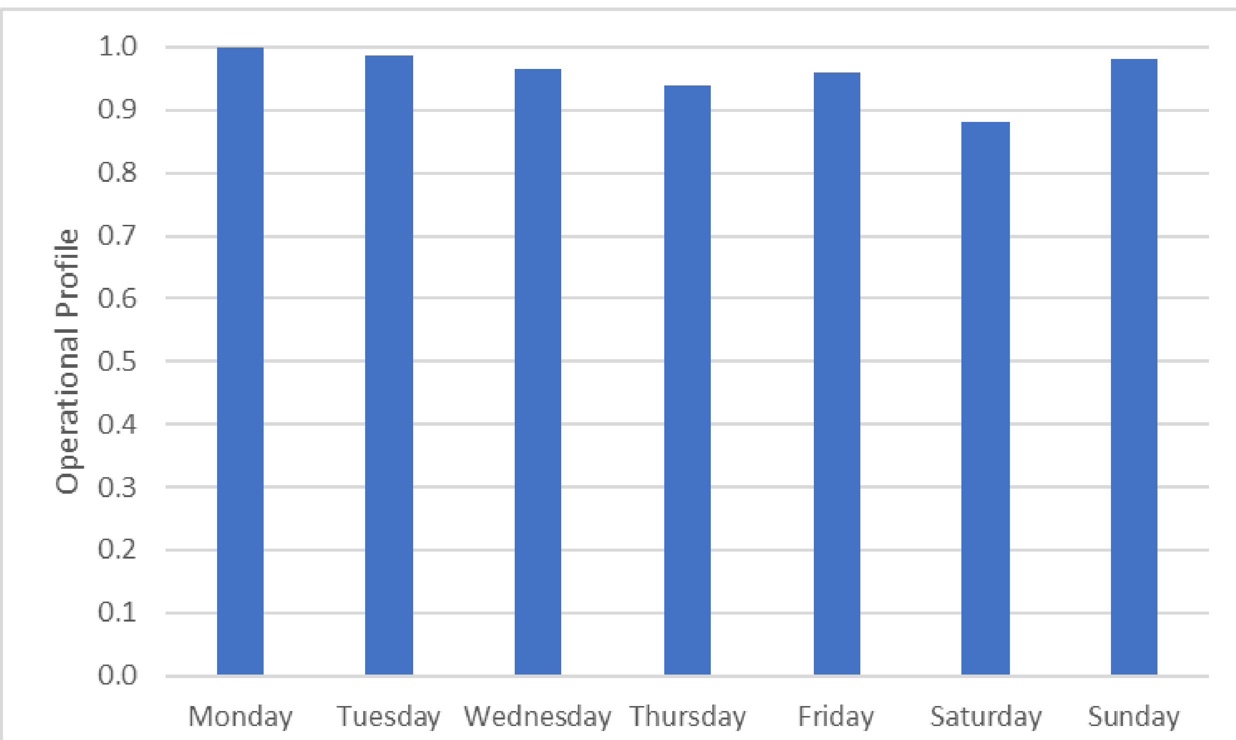


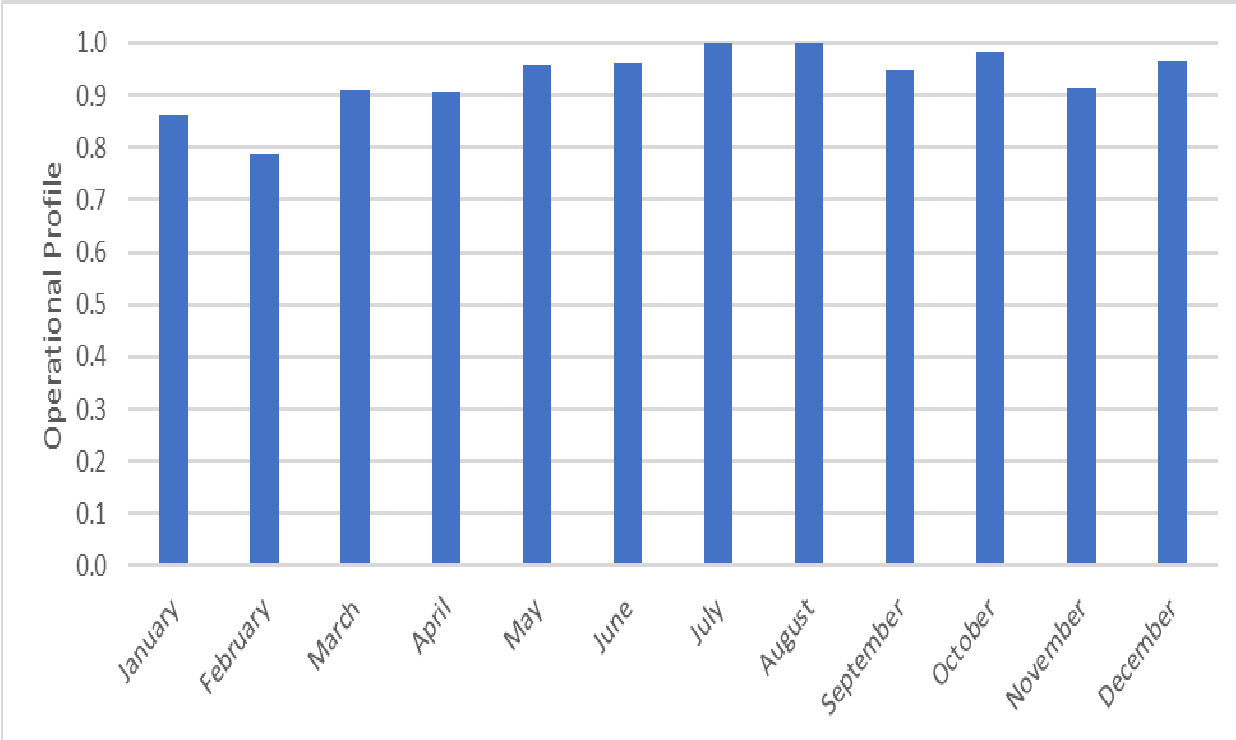


Source: Ricondo, 2020

FIGURE E-8
AIRCRAFT OPERATIONAL PROFILES – BUILD OUT PROPOSED ACTION







Source: Ricondo, 2020

E.1.2.11 Detailed Results by Receptor

Section 5.3 of the EA provides the maximum predicted pollutant concentrations of the macroscale dispersion analysis. **Tables E-50 through E-54** provide the dispersion results for each of the evaluated receptors.

TABLE E-50
MACROSCALE DISPERSION MODELING RESULTS: EXISTING CONDITION

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m³)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
1	2,065	1,453	117	8	26	29	54	21	8
2	2,524	1,580	143	18	33	33	56	22	9
3	2,353	1,566	152	14	32	32	56	22	9
4	2,274	1,547	149	15	31	34	57	23	9
5	2,346	1,565	148	13	31	33	56	22	9
6	2,370	1,565	151	12	31	34	55	22	9
7	2,453	1,667	153	14	34	36	56	22	9
8	2,446	1,572	153	11	36	32	55	22	9
9	2,581	1,670	158	14	42	40	56	22	9

Receptor ID	Maximum Predicted Pollutant Concentrations (μg/m³)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
10	2,615	1,736	159	15	48	48	56	22	9
11	2,628	1,734	162	16	56	52	56	22	9
12	2,627	1,734	**178**	17	61	57	56	22	9
13	2,911	1,684	168	23	55	49	56	22	9
14	2,540	1,646	163	16	49	49	55	22	9
15	2,684	1,655	160	14	45	41	55	22	9
16	2,739	1,616	160	16	41	37	56	22	9
17	2,531	1,610	156	14	38	33	55	22	9
18	2,400	1,570	152	13	33	34	55	22	9
19	2,442	1,575	156	13	35	32	55	22	9
20	2,362	1,545	160	11	40	35	55	22	9
21	2,393	1,635	164	17	43	40	56	22	9
22	2,452	1,618	165	15	42	41	56	22	9
23	2,444	1,557	163	17	42	39	56	22	9
24	2,513	1,591	163	16	47	45	56	22	9
25	2,772	1,766	167	15	59	55	55	22	9
26	2,833	1,795	165	15	58	61	56	22	9
27	2,318	1,523	158	15	42	35	56	22	9
28	2,293	1,461	154	13	31	32	55	22	9
29	2,278	1,437	149	12	33	30	55	21	9
30	2,277	1,491	152	9	37	31	54	21	9
31	2,151	1,410	128	9	30	28	54	21	8
32	2,081	1,409	121	9	26	27	54	21	8
33	2,141	1,458	147	10	31	28	54	21	9
34	2,147	1,393	143	11	31	26	54	21	9
35	2,218	1,465	150	10	35	37	54	21	9
36	2,157	1,488	141	11	35	40	54	21	9
37	2,640	1,599	144	20	32	34	57	22	9
38	2,135	1,444	118	9	26	28	54	21	8
39	2,185	1,512	137	10	29	31	55	22	9
40	2,036	1,422	117	9	24	24	54	21	8
41	2,495	1,603	162	9	46	42	54	21	8
42	2,247	1,532	160	10	36	37	54	21	8
43	2,045	1,372	118	7	24	24	54	21	8
44	2,429	1,447	150	9	34	31	54	21	8
45	2,500	1,651	167	14	53	50	55	22	9

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m³)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
46	2,268	1,548	148	10	31	32	55	22	9
R01A	**4,085**	**2,468**	165	**37**	58	72	**68**	26	**11**
R01B	3,226	2,013	162	28	53	69	59	24	10
R02A	3,972	2,403	167	37	69	81	67	26	11
R02B	3,287	1,990	165	29	65	77	60	24	10
R03A	3,994	2,357	167	36	65	66	68	**26**	11
R03B	3,668	1,978	166	29	60	64	61	24	10
R05	3,420	2,085	166	32	65	75	61	24	10
R06A	3,344	2,221	178	31	**94**	**93**	58	24	9
R06B	3,196	2,128	172	28	87	87	57	23	9
47	2,202	1,426	134	9	31	29	54	21	8
48	2,378	1,598	150	13	30	27	56	22	9
49	2,166	1,470	156	10	33	33	54	21	8
50	2,239	1,488	139	10	27	31	55	22	9
51	2,310	1,527	146	11	30	33	55	22	9
52	2,325	1,582	151	12	32	34	55	22	9
53	2,296	1,556	149	10	31	29	55	21	9
54	2,529	1,602	162	16	48	47	55	22	9
55	2,125	1,445	150	8	30	29	54	21	8
56	2,093	1,394	108	8	23	26	54	21	8
57	2,140	1,453	156	8	31	28	54	21	8
58	2,384	1,548	156	9	38	41	54	21	8

Values reflect rounding.
BOLD values represent maximum concentrations.
Source: Crawford, Murphy & Tilly, Inc./RCH Group, 2021

TABLE E-51
MACROSCALE DISPERSION MODELING RESULTS: INTERIM NO ACTION

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m³)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
1	2,093	1,482	149	8	31	29	54	21	8
2	2,312	1,520	156	16	39	35	55	22	9
3	2,287	1,530	160	14	45	39	56	21	9
4	2,453	1,561	160	15	46	42	56	22	9
5	2,510	1,636	159	13	46	42	55	22	9

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m³)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
6	2,390	1,653	161	13	48	41	55	22	9
7	2,494	1,707	162	15	50	46	56	22	9
8	2,326	1,569	157	13	39	39	55	21	8
9	2,565	1,718	162	17	50	47	56	22	9
10	2,451	1,722	162	17	49	49	56	22	9
11	2,563	1,723	162	17	54	53	56	22	9
12	2,529	1,677	178	17	63	52	55	22	9
13	2,557	1,632	168	20	54	47	56	22	9
14	2,453	1,648	162	15	52	48	55	22	9
15	2,471	1,606	161	13	51	44	55	22	8
16	2,665	1,608	161	14	47	44	55	22	9
17	2,499	1,573	159	12	48	39	55	22	9
18	2,430	1,590	157	11	41	37	55	22	9
19	2,431	1,590	159	11	43	40	55	21	9
20	2,340	1,555	162	10	49	41	54	21	8
21	2,438	1,629	166	14	52	44	55	22	9
22	2,420	1,619	166	13	50	46	55	22	9
23	2,408	1,565	165	15	48	41	57	22	9
24	2,514	1,590	167	15	55	49	56	21	9
25	2,726	1,694	168	15	59	52	55	21	9
26	2,690	1,670	166	15	59	52	56	22	9
27	2,426	1,582	169	16	52	47	56	22	9
28	2,633	1,621	185	14	62	48	55	21	9
29	2,715	1,639	170	11	64	47	55	21	9
30	2,496	1,572	162	10	54	43	54	21	8
31	2,162	1,454	160	9	39	36	54	21	8
32	2,132	1,445	156	9	38	32	54	21	8
33	2,239	1,466	161	10	45	34	54	21	8
34	2,171	1,453	157	10	38	37	54	21	9
35	2,250	1,514	157	10	44	37	54	21	8
36	2,231	1,487	156	11	39	35	54	21	8
37	2,362	1,525	155	16	36	33	56	22	9
38	2,200	1,471	155	10	36	30	54	21	8
39	2,231	1,549	153	10	34	31	54	21	8
40	2,138	1,433	155	9	34	28	54	21	8
41	2,431	1,549	160	10	44	41	54	21	8
42	2,295	1,530	164	10	43	40	54	21	8
43	2,033	1,386	151	7	31	29	54	21	8
44	2,362	1,483	157	9	39	35	54	21	8

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m³)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
45	2,419	1,613	167	15	56	46	55	22	8
46	2,332	1,594	158	12	43	39	55	21	8
R01A	3,483	2,144	166	**30**	73	63	64	24	10
R01B	3,007	1,899	165	25	70	59	58	23	9
R02A	3,563	**2,160**	166	29	81	72	63	24	10
R02B	3,208	1,923	165	26	78	68	58	23	9
R03A	**3,701**	2,133	165	29	73	68	**66**	**24**	**10**
R03B	3,460	1,844	163	26	70	64	60	23	9
R05	3,238	1,954	165	27	77	69	59	23	9
R06A	3,148	2,130	174	28	**84**	**76**	57	23	9
R06B	3,028	2,009	169	26	74	70	56	23	9
47	2,209	1,468	161	9	41	38	54	21	8
48	2,317	1,564	158	13	36	31	55	22	9
49	2,134	1,481	156	10	36	33	54	21	8
50	2,238	1,535	157	11	39	36	54	21	8
51	2,320	1,610	160	12	44	36	55	22	8
52	2,392	1,630	159	13	47	41	55	22	9
53	2,300	1,569	157	11	40	38	55	21	8
54	2,348	1,617	161	15	50	47	55	22	8
55	2,096	1,438	149	9	31	31	54	21	8
56	2,068	1,411	148	8	29	28	54	21	8
57	2,160	1,443	159	8	37	30	54	21	8
58	2,212	1,514	159	10	38	35	54	21	8

Values reflect rounding.
BOLD values represent maximum concentrations.
Source: Crawford, Murphy & Tilly, Inc./RCH Group, 2021

TABLE E-52
MACROSCALE DISPERSION MODELING RESULTS: INTERIM PROPOSED ACTION

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m3)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
1	2,088	1,482	151	8	32	29	54	21	8
2	2,273	1,523	156	15	41	37	55	21	9
3	2,374	1,539	160	15	48	41	56	21	9
4	2,473	1,567	160	15	51	40	56	22	9
5	2,442	1,656	159	14	46	41	55	22	9
6	2,440	1,690	161	14	52	41	55	22	9
7	2,608	1,699	161	16	52	42	56	22	9

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m3)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
8	2,324	1,576	158	13	42	40	55	22	8
9	2,576	1,717	161	17	46	46	56	22	9
10	2,504	1,747	161	17	51	48	56	22	9
11	2,587	1,734	160	17	56	54	56	22	9
12	2,566	1,693	176	17	64	55	55	22	9
13	2,603	1,652	168	21	63	50	56	22	9
14	2,492	1,664	163	15	52	50	55	22	9
15	2,562	1,624	160	13	55	46	55	22	9
16	2,756	1,614	161	14	50	44	56	22	9
17	2,620	1,575	159	12	50	38	55	22	9
18	2,390	1,577	157	11	41	38	55	22	9
19	2,480	1,597	160	11	46	43	55	21	9
20	2,421	1,538	164	10	51	43	54	21	8
21	2,486	1,623	166	14	50	44	55	22	9
22	2,470	1,626	166	14	51	46	55	22	9
23	2,380	1,586	165	15	49	42	57	22	9
24	2,651	1,607	167	15	57	51	56	22	9
25	2,685	1,716	167	15	60	53	55	21	9
26	2,694	1,726	167	16	59	53	56	22	9
27	2,526	1,627	170	16	58	51	56	22	9
28	2,632	1,622	**185**	14	62	47	55	22	9
29	2,773	1,630	168	11	67	51	55	21	9
30	2,528	1,568	163	10	54	44	54	21	8
31	2,219	1,464	158	9	42	38	54	21	8
32	2,198	1,468	159	9	41	34	54	21	8
33	2,191	1,484	161	10	43	34	54	21	8
34	2,124	1,452	157	10	38	35	54	21	8
35	2,159	1,511	158	10	43	37	54	21	8
36	2,166	1,494	158	11	41	36	54	21	8
37	2,327	1,528	156	16	35	34	56	22	9
38	2,148	1,473	153	10	35	31	54	21	8
39	2,223	1,545	154	10	35	33	54	21	8
40	2,119	1,444	156	8	36	29	54	21	8
41	2,405	1,569	161	11	45	41	54	21	8
42	2,305	1,528	163	11	45	40	54	21	8
43	2,082	1,378	152	7	32	28	54	21	8
44	2,409	1,490	158	9	41	36	54	21	8
45	2,447	1,628	167	15	57	49	55	22	9
46	2,421	1,616	158	12	47	37	55	22	8
R01A	3,743	**2,193**	167	**32**	73	62	**66**	**25**	**10**
R01B	3,187	1,939	166	28	69	57	59	23	9
R02A	3,442	2,147	168	31	71	60	62	24	10
R02B	3,083	1,930	167	27	66	56	58	23	9
R03A	**3,757**	2,117	165	30	70	60	64	24	10

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m3)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
R03B	3,363	1,862	164	26	68	57	59	23	9
R05	3,139	1,938	167	28	69	58	59	23	10
R06A	3,142	2,161	171	29	**94**	**83**	57	23	9
R06B	3,015	2,036	166	26	85	77	56	23	9
47	2,244	1,473	159	9	44	40	54	21	8
48	2,325	1,566	158	13	40	35	55	22	9
49	2,173	1,477	155	10	38	33	54	21	8
50	2,253	1,557	158	11	42	36	55	21	8
51	2,339	1,631	160	13	48	38	55	22	9
52	2,487	1,657	160	13	50	40	55	22	9
53	2,361	1,572	157	12	42	37	55	22	8
54	2,450	1,618	162	15	51	48	55	22	9
55	2,125	1,452	147	9	32	33	54	21	8
56	2,075	1,427	148	8	31	28	54	21	8
57	2,178	1,446	159	9	36	30	54	21	8
58	2,274	1,564	160	10	39	38	54	21	8

Values reflect rounding.
BOLD values represent maximum concentrations.
Source: Crawford, Murphy & Tilly, Inc./RCH Group, 2021

TABLE E-53
MACROSCALE DISPERSION MODELING RESULTS: BUILD OUT NO ACTION

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m³)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
1	2,052	1,437	150	8	32	30	54	21	8
2	2,199	1,503	157	13	41	36	55	21	9
3	2,331	1,542	160	14	47	42	55	21	9
4	2,455	1,569	161	14	53	46	55	21	9
5	2,378	1,616	160	13	47	45	55	21	9
6	2,371	1,644	164	14	51	43	55	22	8
7	2,513	1,646	162	15	51	46	55	22	9
8	2,244	1,548	159	14	40	41	55	21	8
9	2,439	1,667	162	17	46	45	55	22	9
10	2,404	1,681	162	18	50	47	55	22	9
11	2,546	1,707	164	18	58	54	55	22	9
12	2,397	1,647	181	19	66	55	55	22	9
13	2,560	1,609	179	21	60	53	55	22	9
14	2,449	1,628	165	16	57	50	55	22	8

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m³)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
15	2,512	1,609	162	13	53	46	55	22	8
16	2,599	1,595	162	13	51	47	55	22	9
17	2,452	1,549	161	11	47	39	55	21	8
18	2,334	1,530	159	9	43	37	55	21	8
19	2,320	1,538	160	10	45	43	54	21	8
20	2,312	1,540	165	10	52	43	54	21	8
21	2,371	1,580	167	13	54	46	55	21	9
22	2,362	1,579	167	13	52	48	55	21	8
23	2,363	1,567	166	13	51	43	56	21	9
24	2,473	1,592	167	14	60	51	56	21	9
25	2,683	1,731	169	15	62	59	55	21	9
26	2,666	1,722	172	15	60	55	55	21	9
27	2,528	1,602	171	15	57	49	55	21	9
28	2,754	1,620	**209**	13	66	56	55	21	9
29	2,734	1,644	172	11	70	52	54	21	9
30	2,419	1,561	166	11	55	45	55	21	9
31	2,215	1,470	162	9	45	37	54	21	8
32	2,243	1,466	161	10	41	33	55	21	8
33	2,222	1,471	160	10	44	35	54	21	8
34	2,131	1,457	157	10	40	34	54	21	8
35	2,188	1,486	158	10	43	36	54	21	8
36	2,138	1,470	158	11	41	36	54	21	8
37	2,176	1,470	157	13	37	34	56	21	9
38	2,160	1,455	155	10	36	33	54	21	8
39	2,149	1,479	156	10	34	33	54	21	8
40	2,130	1,413	156	8	35	30	54	21	8
41	2,389	1,563	163	11	47	45	54	21	8
42	2,237	1,522	166	11	46	41	54	21	8
43	2,037	1,377	156	7	32	28	54	21	8
44	2,287	1,479	159	9	42	35	54	21	8
45	2,294	1,591	166	16	57	47	55	22	8
46	2,369	1,585	160	13	45	40	55	21	8
R01A	3,203	2,110	173	28	71	62	66	24	10
R01B	2,813	1,898	171	25	68	58	59	23	9
R02A	3,180	**2,118**	168	28	**86**	72	64	24	10
R02B	2,891	1,909	168	25	81	68	58	23	9
R03A	**3,361**	2,105	169	28	80	69	**69**	**24**	**10**
R03B	3,171	1,855	166	26	76	65	60	23	9
R05	2,981	1,941	168	27	81	69	59	23	9

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m³)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
R06A	3,135	2,050	173	**30**	83	**75**	57	23	9
R06B	2,982	1,934	167	27	75	69	56	22	9
47	2,271	1,505	162	11	47	39	55	21	9
48	2,328	1,529	159	12	39	34	55	21	9
49	2,079	1,462	157	11	39	34	54	21	8
50	2,227	1,532	158	12	42	38	54	21	8
51	2,312	1,599	161	13	49	39	55	21	8
52	2,416	1,618	160	14	48	42	55	21	8
53	2,272	1,541	160	12	41	41	54	21	8
54	2,415	1,608	165	16	55	49	55	22	8
55	2,085	1,429	153	9	32	32	54	21	8
56	2,062	1,409	149	9	31	30	54	21	8
57	2,133	1,451	163	9	40	33	54	21	8
58	2,226	1,547	163	10	40	39	54	21	8

Values reflect rounding.
BOLD values represent maximum concentrations.
Source: Crawford, Murphy & Tilly, Inc./RCH Group, 2021

TABLE E-54
MACROSCALE DISPERSION MODELING RESULTS: BUILD OUT PROPOSED ACTION

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m3)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
1	2,054	1,485	151	9	32	30	54	21	8
2	2,247	1,569	158	14	45	40	55	21	9
3	2,347	1,579	162	15	54	47	55	21	9
4	2,577	1,614	161	15	55	48	55	22	9
5	2,528	1,709	162	15	53	46	55	22	9
6	2,511	1,665	163	15	58	46	55	22	9
7	2,630	1,720	163	17	60	54	55	22	9
8	2,451	1,604	160	15	47	44	55	22	8
9	2,525	1,724	166	20	52	49	55	22	9
10	2,508	1,755	164	20	57	50	56	22	9
11	2,553	1,762	164	20	62	55	56	22	9
12	2,403	1,751	178	20	66	59	56	22	9
13	2,594	1,710	175	23	66	57	56	22	9

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m3)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
14	2,542	1,681	163	18	58	50	55	22	9
15	2,690	1,635	161	15	52	46	55	22	9
16	2,468	1,656	161	16	53	49	56	22	9
17	2,354	1,592	161	13	50	45	55	22	9
18	2,247	1,545	160	11	44	43	55	21	8
19	2,252	1,575	160	11	46	45	54	21	8
20	2,204	1,555	162	11	48	44	54	21	8
21	2,289	1,631	165	15	54	44	55	21	9
22	2,361	1,587	165	14	52	43	55	21	8
23	2,252	1,546	162	14	47	39	56	21	9
24	2,395	1,686	164	15	56	48	56	22	9
25	2,610	1,803	166	15	68	65	55	22	9
26	2,590	1,772	168	15	63	53	55	22	9
27	2,378	1,639	167	15	47	42	55	22	9
28	2,351	1,649	**182**	14	55	47	55	22	9
29	2,468	1,689	165	12	59	50	55	21	9
30	2,334	1,555	165	12	57	46	55	21	9
31	2,127	1,484	160	10	42	37	54	21	8
32	2,074	1,473	160	10	38	33	55	21	8
33	2,159	1,481	158	11	41	34	54	21	8
34	2,133	1,440	156	10	36	33	54	21	8
35	2,213	1,470	158	11	45	35	54	21	8
36	2,138	1,504	158	12	40	35	54	21	8
37	2,107	1,500	157	14	37	35	56	21	9
38	2,188	1,517	157	11	35	34	54	21	8
39	2,145	1,529	156	11	35	33	54	21	8
40	2,021	1,435	156	9	32	31	54	21	8
41	2,329	1,619	160	11	51	49	55	21	8
42	2,211	1,505	159	12	43	38	54	21	8
43	1,979	1,397	151	7	31	28	54	21	8
44	2,255	1,498	158	11	44	34	54	21	8
45	2,294	1,685	167	17	57	52	55	22	9
46	2,473	1,612	160	14	51	47	55	22	8
R01A	3,483	2,015	169	31	68	56	**66**	24	10
R01B	3,077	1,854	168	28	65	53	59	23	9

Receptor ID	Maximum Predicted Pollutant Concentrations (µg/m3)								
	CO		NO_2		SO_2		PM_{10}	$PM_{2.5}$	
	1-hour	8-hour	1-hour	Annual	1-hour	3-hour	24-Hour	24-Hour	Annual
R02A	3,348	1,998	170	30	75	61	62	23	10
R02B	3,114	1,820	168	28	72	58	58	23	9
R03A	3,155	2,097	168	31	74	57	65	**24**	**10**
R03B	3,011	1,881	166	28	69	54	59	23	9
R05	3,109	1,865	170	29	72	59	59	23	9
R06A	**3,542**	**2,237**	181	**34**	**124**	**95**	58	23	9
R06B	3,345	2,093	176	32	115	86	57	23	9
47	2,236	1,530	161	12	44	39	55	21	9
48	2,327	1,543	159	13	44	35	55	21	9
49	2,056	1,520	158	12	39	36	54	21	8
50	2,216	1,598	160	13	44	38	54	21	8
51	2,396	1,652	161	14	50	43	55	22	8
52	2,544	1,647	161	15	55	50	55	22	9
53	2,422	1,599	160	14	46	43	55	22	8
54	2,378	1,644	165	17	56	48	55	22	9
55	2,055	1,460	151	10	34	33	54	21	8
56	2,044	1,453	154	9	32	29	54	21	8
57	2,047	1,435	159	10	39	33	54	21	8
58	2,201	1,571	157	10	41	40	54	21	8
WESF1	2,730	1,732	166	20	74	50	56	22	9
WESF2	2,685	1,692	166	19	71	48	55	22	9

Values reflect rounding.
BOLD values represent maximum concentrations.
Source: Crawford, Murphy & Tilly, Inc./RCH Group, 2021

E.1.3 Microscale Dispersion Analysis

Microscale intersection analyses (referred to as hot-spot analyses) were performed to evaluate concentrations of CO and $PM_{2.5}$ from motor vehicles on roadways in the vicinity of O'Hare. These analyses were conducted in accordance with the following USEPA guidelines and documents:

- Guideline for Modeling Carbon Monoxide from Roadway Intersections, http://www.epa.gov/scram001/guidance/guide/coguide.pdfNovember 1992;[26]
- Using MOVES2014 in Project-Level Carbon Monoxide Analyses, March 2015; [27]and

[26] USEPA, Guideline for Modeling Carbon Monoxide from Roadway Intersections, November 1992, https://www.epa.gov/sites/default/files/2020-10/documents/coguide.pdf
[27] USEPA, Using MOVES2014 in Project-Level Carbon Monoxide Analyses, March 2015, https://nepis.epa.gov/Exe/ZyPdf.cgi?Dockey=P100M2FB.pdf

- Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas, November 2015.[28]

E.1.3.1 Carbon Monoxide (CO)

A screening analysis was performed to determine the locations at which the greatest predicted concentrations of CO would be expected to occur. The analysis considered intersections within the study area that are forecast to operate at Level of Service (LOS) D, E, or F, as well as intersections for which the LOS is forecast to deteriorate to LOS D, E, or F due to increased traffic volumes resulting from changes in the traffic pattern that would be associated with the Proposed Action. The five intersections with a combination of the greatest traffic volume and forecast delay in the Interim and Build Out Conditions are listed in **Tables E-55** and **E-56**. **Appendix K** provides data related to surface transportation and intersections.

TABLE E-55
MICROSCALE DISPERSION ANALYSIS INTERSECTIONS: INTERIM CONDITON

Intersection	Peak Hour	Alternative			
		No Action		Proposed Action	
		LOS	Volume	LOS	Volume
York Road and Irving Park Road	PM	E	5,865	E	5,815
Mannheim Road and Irving Park Road	AM	D	6,375	D	7,135
Mannheim Road and Higgins Road	AM	D	4,725	E	6,715
Mannheim Road and Zemke Boulevard	AM	C	3,355	D	5,175
Higgins Road/Lee Street and I-90 EB Ramps	AM	C	3,410	F	5,140
Sources: Mead & Hunt and Crawford, Murphy & Tilly Inc., 2021					

TABLE E-56
MICROSCALE DISPERSION ANALYSIS INTERSECTIONS: BUILD OUT CONDITION

Intersection	Peak Hour	Alternative			
		No Action		Proposed Action	
		LOS	Volume	LOS	Volume
York Road and Irving Park Road	PM	D	4,710	E	5,055
Mannheim Road and Irving Park Road	AM	D	5,705	D	6,160
Mannheim Road and Higgins Road	AM	C	2,860	C	3,850
Mannheim Road and Zemke Boulevard	AM	C	2,350	C	2,715
Higgins Road/Lee Street and I-90 EB Ramps	AM	C	2,450	C	3,210
Sources: Mead & Hunt and Crawford, Murphy & Tilly Inc., 2021					

[28] USEPA, Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM10 Nonattainment and Maintenance Areas, November 2015

Methodology

The CO microscale analysis was performed using the USEPA-approved CAL3QHC model.[29] CAL3QHC, a micro-scale atmospheric dispersion model, combines roadway design, operational parameters, motor vehicle emission rates, and meteorological conditions to provide estimates of CO concentrations at receptors along roadways, interchanges, or intersections.

For the EA, roadway links were developed based on aerial interpretation and design plans to represent the geometry of each modeled intersection. Each link identified features such as the link length and location, number of lanes, lane width, and motor vehicle speed. Project-specific data, including intersection approach volumes, signal timing cycles, and queue delays, were obtained from the surface transportation analysis.

Meteorological Data

The meteorological conditions that result in worst-case CO concentrations (morning and winter) were used in the analysis. The conditions that provided worst-case concentrations are listed in **Table E-57**.

TABLE E-57
CAL3QHC METEOROLOGICAL INPUTS

Parameter	Input Data
Atmospheric Stability Class	D (Neutral)
Wind Speed	1 meter per second (m/s)
Wind Direction	360 degrees in 1-degree increments
Mixing Height	1,000 meters (m)
Surface Roughness	175 centimeters (cm)
Source: Crawford, Murphy & Tilly Inc., 2021	

Emission Factors

Motor vehicle emission rates were obtained from the USEPA's MOVES model. The rates were based on project-specific data and input parameters specific to Cook County that were provided by the IEPA. **Table E-58** summarizes the MOVES inputs used to obtain the emission rates for the CO hot-spot analysis.

TABLE E-58
MICROSCALE DISPERSION ANALYSIS: MOVES INPUT

Parameter	Input Data
Location	Cook County
Evaluation Months	January (winter)
Days	Weekdays

[29] USEPA, User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations near Roadway Intersections, September 1995

Parameter	Input Data
Evaluation Hour	January 7AM – 8AM
Links	Developed based on aerial imagery and future intersection geometry
Link Source Type	The link source type for passenger vehicles was developed assuming vehicles are evenly divided between cars (MOVES Code 21) and trucks (MOVES Code 31). The percentages of heavy vehicles/trucks (MOVES Code 52) are provided in **Tables E-59 through E-62**.
Link Speeds	Turn lane speeds were assumed half the posted speed limit, queue link speeds were assigned a speed of 0 mph, and through lanes had speeds up to 50 mph.
Roadway Type	Urban Unrestricted (e.g., freeway/interstates/ramps)
Coldest Winter Temperature	18.1 degrees F
Relative Humidity	80.8 percent
Vehicle Age Distribution	Provided by IEPA
I/M Programs	
Fuel Data	
Source: Mead & Hunt and Crawford, Murphy & Tilly Inc., 2021	

Tables E-59 through E-62 present the vehicle mix assumed for the evaluated intersections. To obtain emission rates from MOVES, heavy vehicles were assumed to be diesel single-unit short-haul trucks and light vehicles were assumed to be gasoline-fueled passenger cars and light-duty trucks.[30] Single-unit short-haul trucks were assumed to represent heavy vehicles; should multi-trailer heavy trucks use the roadways in the study area, the percentage of these vehicles among the total heavy vehicles would be very small.

TABLE E-59
MOTOR VEHICLE FLEET MIX: INTERIM NO ACTION

Intersection	Movement	Hourly Traffic Volume	Percentage of Vehicles			
			Gas		Diesel Heavy Vehicles/ Trucks	Total
			Passenger Cars	Passenger Trucks		
Mannheim Road and Higgins Road	SB	755	49	49	2	100
	WB	855	48	48	4	100
	NB	1,725	49	49	2	100
	EB	1,390	48	48	4	100
Mannheim Road and Irving Park Road	SB	1,645	48	48	5	100
	WB	1,355	47	47	6	100
	NB	1,860	48	48	5	100
	EB	1,515	49	49	3	100
Mannheim Road and Zemke Boulevard	SB	1,135	49	49	2	100
	WB	150	49	49	2	100
	NB	1,725	49	49	2	100
	EB	200	49	49	2	100

30 Gasoline vehicles emit greater CO emissions than do diesel vehicles, thus all passenger cars and trucks are conservatively assumed to use gasoline.

Intersection	Movement	Hourly Traffic Volume	Percentage of Vehicles				
			Gas		Diesel Heavy Vehicles/ Trucks	Total
			Passenger Cars	Passenger Trucks		
Higgins Road/Lee Street and Interstate 90 EB Ramps	SB	1,435	49	49	2	100
	WB	1,080	49	49	3	100
	NB	890	48	48	4	100
	EB	720	49	49	3	100
York Road and Irving Park Road	SB	1,740	47	47	6	100
	WB	1,825	47	47	6	100
	NB	1,135	47	47	6	100
	EB	1,165	47	47	6	100

Values reflect rounding.
NB – Northbound, SB – Southbound, EB – Eastbound, WB - Westbound
Sources: Mead & Hunt and Crawford, Murphy & Tilly Inc., 2021

TABLE E-60
MOTOR VEHICLE FLEET MIX: INTERIM PROPOSED ACTION

Intersection	Movement	Hourly Traffic Volume	Percentage of Vehicles			
			Gas		Diesel Heavy Vehicle	Total
			Passenger Cars	Passenger Trucks		
Mannheim Road and Higgins Road	SB	805	49	49	2	100
	WB	1,315	48	48	4	100
	NB	2,290	49	49	2	100
	EB	2,305	48	48	4	100
Mannheim Road and Irving Park Road	SB	2075	48	48	5	100
	WB	1,425	49	49	3	100
	NB	2,065	48	48	5	100
	EB	1570	47	47	6	100
Mannheim Road and Zemke Boulevard	SB	1,930	49	49	2	100
	WB	195	49	49	2	100
	NB	2,655	49	49	2	100
	EB	395	49	49	2	100
Higgins Road/Lee Street and Interstate 90EB Ramps	SB	1,890	49	49	2	100
	WB	2,465	49	49	3	100
	NB	1,615	48	48	4	100
	EB	1,140	49	49	3	100
York Road and Irving Park Road	SB	1,675	47	47	6	100
	WB	1,755	47	47	6	100
	NB	1,175	47	47	6	100

Intersection	Movement	Hourly Traffic Volume	Percentage of Vehicles: Gas: Passenger Cars	Gas: Passenger Trucks	Diesel Heavy Vehicle	Total
	EB	1,210	47	47	6	100

Values reflect rounding.
NB – Northbound, SB – Southbound, EB – Eastbound, WB - Westbound
Sources: Mead & Hunt and Crawford, Murphy & Tilly Inc., 2021

TABLE E-61
MOTOR VEHICLE FLEET MIX: BUILD OUT NO ACTION

Intersection	Movement	Hourly Traffic Volume	Percentage of Vehicles: Gas: Passenger Cars	Gas: Passenger Trucks	Diesel Heavy Vehicle	Total
Mannheim Road and Higgins Road	SB	675	49	49	2	100
	WB	530	48	48	4	100
	NB	755	49	49	2	100
	EB	900	48	48	4	100
Mannheim Road and Irving Park Road	SB	1650	48	48	5	100
	WB	1,135	47	47	6	100
	NB	1,935	48	48	5	100
	EB	985	47	47	6	100
Mannheim Road and Zemke Boulevard	SB	625	49	49	2	100
	WB	185	49	49	2	100
	NB	965	49	49	2	100
	EB	575	49	49	2	100
Higgins Road/Lee Street and Interstate 90 EB Ramps	SB	1,235	49	49	2	100
	WB	580	49	49	2	100
	NB	535	48	48	4	100
	EB	680	49	49	2	100
York Road and Irving Park Road	SB	1,235	47	47	6	100
	WB	1,645	47	47	6	100
	NB	530	47	47	6	100
	EB	1,300	47	47	6	100

Values reflect rounding.
NB – Northbound, SB – Southbound, EB – Eastbound, WB - Westbound
Sources: Mead & Hunt and Crawford, Murphy & Tilly Inc., 2021

TABLE E-62
MOTOR VEHICLE FLEET MIX: BUILD OUT PROPOSED ACTION

Intersection	Movement	Hourly Traffic Volume	Percentage of Vehicles: Gas: Passenger Cars	Percentage of Vehicles: Gas: Passenger Trucks	Percentage of Vehicles: Diesel Heavy Vehicle	Percentage of Vehicles: Total
Mannheim Road and Higgins Road	SB	815	49	49	2	100
	WB	510	48	48	4	100
	NB	1,010	49	49	2	100
	EB	1,515	48	48	4	100
Mannheim Road and Irving Park Road	SB	1260	48	48	5	100
	WB	1,155	49	49	3	100
	NB	2,050	48	48	5	100
	EB	1695	49	49	3	100
Mannheim Road and Zemke Boulevard	SB	885	49	49	2	100
	WB	170	49	49	2	100
	NB	1,310	49	49	2	100
	EB	270	49	49	2	100
Higgins Road/Lee Street and Interstate 90 EB Ramps	SB	1,630	49	49	2	100
	WB	405	49	49	2	100
	NB	805	48	48	4	100
	EB	645	49	49	2	100
York Road and Irving Park Road	SB	1,270	47	47	6	100
	WB	1,895	49	49	3	100
	NB	590	47	47	6	100
	EB	1,300	49	49	3	100

Values reflect rounding.
NB – Northbound, SB – Southbound, EB – Eastbound, WB - Westbound
Sources: Mead & Hunt and Crawford, Murphy & Tilly Inc., 2021

Receptors

Following USEPA guidance, receptors were evaluated three meters (approximately 10 feet) from the roadway travel lane at a height of 1.8 meters (6 feet) and 25, 50, and 75 meters (approximately 82, 164, and 246 feet) from each intersection cross street.

Conversion of One-Hour to Eight-Hour Concentrations

The CAL3QHC model estimates CO concentrations for a one-hour averaging period. For the EA analysis, the one-hour concentrations were converted to eight-hour averaging periods using USEPA's default persistence factor of 0.7. This factor accounts for the variability in both traffic and meteorological conditions over an eight-hour period.

Background Concentrations

Background concentrations representing non-modeled local sources of CO were based on ambient air monitoring data obtained from the Northbrook air monitoring site. The maximum measured CO concentration from recent years (i.e., 2016 through 2018) was conservatively used to represent future CO background concentrations. The one-hour and eight-hour background concentrations used in the EA analysis were 1.4 and 1.1 parts per million (ppm), respectively.

E.1.3.2 Particulate Matter 2.5 Micrometers or Less in Diameter (PM2.5)

Because of the greater emission rates of $PM_{2.5}$ from diesel-fueled vehicles, the microscale analysis for $PM_{2.5}$ is typically performed for the intersection(s) at which there is a combination of the greatest number of diesel vehicles and the greatest delay (i.e., operating at LOS D, E, or F). The intersection with the greatest volume of trucks when comparing the No Action and Proposed Action Alternatives is at Mannheim Road and Irving Park Road. To be conservative, it was assumed that all trucks forecast to approach/depart each intersection/interchange would be diesel-fueled.

Methodology

The $PM_{2.5}$ hot-spot analysis was performed using MOVES and AERMOD. The same roadway links developed for the CO hot-spot analysis were used in the $PM_{2.5}$ hot-spot analysis. Roadway temporal profiles, developed in support of the surface transportation analysis for the EA, were used to estimate hourly, daily, and monthly vehicle activities.

Meteorological Data

The same meteorological data—hourly meteorological data collected at O'Hare—that was used for the macroscale dispersion analysis performed with AEDT was used for the $PM_{2.5}$ hot-spot analysis.

Emission Factors

The $PM_{2.5}$ emission factors were developed using MOVES. Meteorological data provided by the IEPA for MOVES was used to calculate seasonal (i.e., morning summer and winter and afternoon summer and winter) emission rates. The same vehicle mix used for the CO hot-spot analysis was also used for the $PM_{2.5}$ hot-spot analysis. **Table E-63** summarizes the MOVES input.

TABLE E-63
MICROSCALE DISPERSION ANALYSIS-PM2.5: MOVES INPUT

Parameter	Input Data
Location	Cook County
Evaluation Months	November (winter) and May (summer)
Days	Weekdays
Evaluation Hours	Winter 6AM – 7AM and Summer 11AM – 12PM
Links	Developed based on aerial imagery and future intersection geometry

Parameter	Input Data
Link Source Type	The link source type for passenger vehicles was developed assuming vehicles are evenly divided between cars (MOVES Code 21) and trucks (MOVES Code 31). The percentages of heavy vehicles/trucks (MOVES Code 52) are provided in **Tables E-49 through E-62**.
Link Speeds	Turn lane speeds were assumed half the posted speed limit, queue link speeds were assigned a speed of 0 mph, and through lanes had speeds up to 50 mph.
Roadway Type	Urban Unrestricted (e.g., freeway/interstates/ramps)
Seasonal Average Temperature	Winter: 35.3 degrees F and Summer: 65.6 degrees F
Seasonal Average Relative Humidity	Winter: 77.4 percent and Summer: 55.6 percent
Vehicle Age Distribution	Provided by IEPA
I/M Programs	
Fuel Data	

Notes:
Months represent seasonal average.
Evaluation hours represent seasonal averages for winter and summer.
Source: Crawford, Murphy & Tilly Inc., 2021

Receptors

Receptors were evaluated in accordance with Section 93.123(c)(1) of the transportation conformity rule, which requires $PM_{2.5}$ hot-spot analyses to estimate air quality concentrations at "appropriate receptor locations in the area substantially affected by the project." An "appropriate receptor location" is one suitable for comparison to the relevant $PM_{2.5}$ NAAQS.[31]

Background Concentrations

Background concentrations used to represent non-modeled local sources of $PM_{2.5}$ are based on three years (i.e., 2016-18) of seasonal average concentrations from IEPA's Northbrook air quality monitoring station. The 24-hour seasonal and annual background concentrations were developed using USEPA's guidance.[32] The derived background concentrations are presented in **Table E-64.** These values were added to modeled $PM_{2.5}$ concentrations for comparison to the NAAQS.

TABLE E-64
MICROSCALE DISPERSION ANALYSIS-$PM_{2.5}$: BACKGROUND CONCENTRATIONS

Monitor	Background Concentrations (µg/m³)				
	Winter	Spring	Summer	Fall	Annual
Northbrook	20.6	16.9	17.8	18.8	8.3

Sources: IEPA and Crawford, Murphy & Tilly Inc., 2021

31 CAA section 176(c)(1)(B) requires that transportation activities do not cause or contribute to new NAAQS violations, worsen existing NAAQS violations, or delay timely attainment of the NAAQS or interim milestones in the project area. USEPA interprets "NAAQS" in this provision to mean the specific NAAQS that has been established through rulemaking.

32 USEPA, Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM2.5 and PM10 Nonattainment and Maintenance Areas, November 2015

ATTACHMENT E-1

CHICAGO O'HARE INTERNATIONAL AIRPORT ENVIRONMENTAL ASSESSMENT AIR QUALITY MODELING PROTOCOL

Chicago O'Hare International Airport
Terminal Area Plan and Air Traffic Procedures
Environmental Assessment
Air Quality Modeling Protocol

Prepared for:

City of Chicago Department of Aviation
and
Federal Aviation Administration

Prepared by:

RCH Group
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June 29, 2021

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ATTACHMENTS

1. INTRODUCTION

The Federal Aviation Administration (FAA) is preparing an Environmental Assessment (EA) for the Terminal Area Plan (TAP or Projects) and Air Traffic Procedures at Chicago O'Hare International Airport (O'Hare). The TAP and Air Traffic Procedures would result in new passenger terminal space and changes to airfield and air traffic operating procedures. Prepared in accordance with the National Environmental Policy Act (NEPA), the EA will address the potential impacts to environmental factors associated with the Project, including potential impacts to air quality.

This *Air Quality Modeling Protocol* describes the technical approach for conducting the air quality analysis in support of the EA. A draft of the document was submitted to the United States Environmental Protection Agency (USEPA) and Illinois Environmental Protection Agency (IEPA). Where appropriate, the document was revised based on the comments received from the agencies. The coordination with USEPA and IEPA ensures that the air quality analysis is prepared in a manner which complies with applicable federal, state and local air quality regulations. Notably, the information provided in this *Protocol* is a synopsis of the technical approach to the air quality analysis, which will be expanded upon in the EA and supporting documentation.

The air quality analysis will evaluate the potential for air quality impacts in accordance with FAA's Order 1050.1F, *Environmental Impacts: Policies and Procedures*; Order 5050.4B, *NEPA Implementing Instructions for Airport Actions*; and the FAA's *Aviation Emissions and Air Quality Handbook*[1] and other applicable guidance. The analysis will be performed using the FAA's *Aviation Environmental Design Tool* (AEDT, Version 2d Service Pack 2),[2] USEPA's American Meteorological Society/USEPA Regulatory Model (AERMOD), and other approved models.

FAA Order 1050.1F directs agency personnel to ensure that an air quality analysis prepared under NEPA includes an analysis and summary conclusions of a project's impacts on air quality and, when a NEPA analysis is warranted, an assessment of the Proposed Action may be required to evaluate the impact on the National Ambient Air Quality Standards (NAAQS). FAA Order 5050.4B provides the basis for delineating the scope of the FAA's assessment of air quality impacts under NEPA and the Clean Air Act (CAA), and contains guiding criteria for determining the scope of an air quality analysis.

The focus of the air quality analysis for the EA will be the air pollutants for which there are NAAQS and for which there are reasonable methods of deriving predicted concentrations of the pollutants. These air pollutants are carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter less than 10 micrometers (coarse particulate or PM_{10}), and particulate matter less than 2.5 micrometers (fine particulate or $PM_{2.5}$). Because ozone (O_3) is a regional pollutant and emissions and concentrations of O_3 cannot be computed directly using conventional models, volatile organic compounds (VOC) and nitrogen oxides (NO_x), the primary precursors to O_3 formation, will be used as surrogates for this pollutant. Emissions of lead (Pb) will not be evaluated because less than one percent of the total aircraft operations at O'Hare are a result of piston aircraft; the aircraft that use aviation fuel that contains Pb (i.e., Avgas/100LL). Because the number of operations by piston aircraft at O'Hare is minimal (i.e., approximately two dozen operations per year), total O'Hare-related Pb emissions would be minimal (less than 0.1 tons). Hazardous air pollutant (HAP) and greenhouse gas (GHG) emissions attributable to the Projects will also be disclosed.

[1] FAA, *Aviation Emissions and Air Quality Handbook Version 3 Update 1, January 2015,* https://www.faa.gov/regulations_policies/policy_guidance/envir_policy/airquality_handbook/

[2] FAA, *Aviation Environmental Design Tool (AEDT) Users Guide*, September 2017, https://aedt.faa.gov/. AEDT 2d, Service Park 2 was released on September 5, 2019

Impact Analysis Overview

To evaluate the potential impacts of the change in conditions at O'Hare that would result from the Projects, the following alternatives will be analyzed:

- No Action
- With Project

Three timeframes will be evaluated:

- The Existing condition (2018)
- An Interim condition (e.g., 2023)
- The Build Out condition one year after physical completion of the TAP (e.g., 2030)

Both the No Action and the With Project alternatives are presumed to have the same number of aircraft operations, aircraft fleet mix, number of passenger enplanements, and volume of ground access vehicles (i.e., motor vehicles) on- or off-airport roadways. However, the number and position of aircraft gating, runway use percentages, and aircraft taxi times as well as the ground access vehicle traffic patterns are presumed to be different between the No Action and the With Project alternatives.

2. REGULATORY BACKGROUND

This section describes existing air quality conditions in the Chicago metropolitan area and identifies the regulatory criteria that will be applied to the results of the air quality analysis.

Attainment / Nonattainment Designations

O'Hare is located within Cook and DuPage counties. Based on air monitoring data, these two counties, along with six other counties and the Townships of Aux Sable and Goose Lake in Grundy County and the Oswego Township in Kendall County, are currently designated by the USEPA to be a moderate nonattainment area for the eight-hour NAAQS for O_3. These areas are collectively referred to as the "Chicago-Naperville, Illinois, Indiana, Wisconsin" nonattainment area. On September 23, 2019, the "Chicago-Naperville, Illinois, Indiana, Wisconsin" nonattainment area was reclassified to serious nonattainment for the 2008 ozone NAAQS.[3] Information from the USEPA indicates that both Cook and DuPage counties are currently designated as being in attainment of the NAAQS for the other criteria air pollutants (CO, NO_2, SO_2, PM_{10}, $PM_{2.5}$, and Pb).

Regulatory Standards and Criteria for Air Quality

The regulatory standards and criteria that are relevant to the air quality analysis are discussed in the following sections of this Protocol.

Federal and State Standards

Under the federal CAA, the USEPA promulgated the NAAQS as shown in **Table 1**. The levels of the NAAQS are established to protect public health (primary standards) and public welfare (secondary standards). The IEPA has adopted these standards.

[3] Determinations of Attainment by the Attainment Date, Extensions of the Attainment Date, and Reclassification of Several Areas Classified as Moderate for the 2008 Ozone National Ambient Air Quality Standards https://www.govinfo.gov/content/pkg/FR-2019-08-23/pdf/2019-17796.pdf?utm_source=federalregister.gov&utm_medium=email&utm_campaign=subscription+mailing+list

Table 1: National Ambient Air Quality Standards

Pollutant	Averaging Time	Design Value	Primary Standards	Secondary Standards
Carbon monoxide	1-hour	Not to be exceeded more than once per year	35 ppm (40 mg/m^3)	--
	8-hour		9 ppm (10 mg/m^3)	--
Nitrogen dioxide	1-hour	98th percentile of 1-hour daily maximum, averaged over 3 years	0.10 ppm (188 µg/m^3)	--
	Annual	Annual mean	0.053 ppm (100 µg/m^3)	0.053 ppm (100 µg/m^3)
Sulfur dioxide	1-hour	99th percentile of 1-hour daily maximum, averaged over 3 years	0.075 ppm (196 µg/m^3)	--
	3-hour	Not to be exceeded more than once per year	--	0.5 ppm (1,300 µg/m^3)
Particulate Matter 10 micrometer or less in size	24-hour	Not to be exceeded more than once per year on average over 3 years	150 µg/m^3	150 µg/m^3
Particulate Matter 2.5 micrometer or less in size	24-hour	98th percentile, averaged over 3 years	35 µg/m^3	35 µg/m^3
	Annual	Annual mean, averaged over 3 years	12 µg/m^3	15 µg/m^3
Ozone[a]	8-hour	Annual 4th highest daily maximum, averaged over 3 years	0.070 ppm (137 µg/m^3)	0.070 ppm (137 µg/m^3)
Lead	3-month rolling average	Not to be exceeded	0.15 µg/m^3	0.15 µg/m^3

Source: USEPA, https://www.epa.gov/criteria-air-pollutants/naaqs-table

ppm = parts per million, µg/m^3 = micrograms/cubic meter, mg/m^3 = milligrams/cubic meter

[a] Referred to as the year 2015 standard.

General Conformity Requirements

Within areas designated nonattainment, and for the pollutant(s) for which the designation is relevant (e.g., the air pollutant O_3 in both Cook and DuPage County), the General Conformity Rule of the CAA prohibits federal agencies (including the FAA) from permitting or funding projects or actions that do not conform to an applicable State Implementation Plan (SIP). SIPs are developed/used by state agencies to bring an area into compliance with the NAAQS.

An applicability analysis will be performed to determine whether or not project-related emissions are subject to the General Conformity Rule. If the General Conformity Rule is applicable, a formal conformity determination will be conducted. While the General Conformity Rule is separate from NEPA, the two analyses will be performed concurrently. Because O'Hare is located within an area that USEPA re-designated as nonattainment/serious with respect to the 2008 ozone NAAQS, the ***de-minimis*** levels for VOC and NOx, O_3 precursors, are 50 tons per year and will be used in the applicability analysis for the EA, as shown in **Table 2**.[4]

Table 2: General Conformity Rule Applicability Analysis *De-minimis* Emission Thresholds

Pollutant	***De-minimis*** Thresholds (tons/year)
Ozone	50 (VOC) 50 (NOx)

Source: General Conformity Rule (40 CFR Part 93, Subpart B).

[4] Federal Register, Volume 84, No. 164, Environmental Protection Agency, 40 CFR Pats 52 and 81, August 23, 2019.

3. AIR QUALITY ASSESSMENT METHODOLOGY

The air quality documentation for the EA will be assembled, analyzed, and presented in accordance with the FAA's Order 1050.1F, *Environmental Impacts: Policies and Procedures*;[5] FAA's Order 5050.4B, *NEPA Implementing Instructions for Airport Actions*;[6] and the FAA's *Aviation Emissions and Air Quality Handbook*[7] and other applicable guidance. FAA also provides guidance in the *An Environmental Desk Reference for Airport Actions*[8], which summarizes applicable special purpose laws. The guidance in the *Desk Reference* helps FAA integrate the compliance of NEPA and applicable special purpose laws, including those pertaining to air quality. The technical analysis will be accomplished using the FAA's AEDT in conjunction with USEPA's AERMOD (Version 19191) dispersion model and other approved models.

Implementation of the TAP would result in both short-term and long-term air quality impacts. Over the short-term, local air quality conditions could be temporarily affected due to construction activities. Over the long-term, implementation has the potential to affect air quality due to changes in aircraft taxi and motor vehicle circulation patterns as well as airport support activities. To evaluate the effect of these changes on local and regional air quality conditions, two types of air quality analyses will be performed - emission inventories and dispersion modeling. The emission inventories provide an indication of the change in the amount of air pollutant and pollutant precursor emissions that will be produced with the project. Dispersion modeling provides predicted concentrations of ambient pollutant levels that can be directly compared to the NAAQS.

Study Area

Generally, the air quality study area is bounded by Irving Park Road on the south side, West/East Touhy Avenue and I-90 on the north side, North York Road/South Elmhurst Road on the west side and North Mannheim Road on the east.

The aircraft activities comprising a landing/take-off cycle (LTO) consist of both ground-based emission sources (i.e., ground taxi/idle) as well as emissions above ground level (i.e., approach, climbout, and takeoff). For this purpose, the air quality study area described in the previous paragraph extends a few miles beyond the airport boundary to capture emissions associated with off-airport roadways and aircraft activity above ground level (within approach and takeoff/climbout) at which most aircraft reach the atmospheric mixing height (which is 2,510 feet above ground level for the Chicago area).[9]

Emission and Dispersion Models

AEDT is a software system that dynamically models aircraft performance to compute emissions, fuel burn, and noise and assess their interdependencies. The FAA-requires that the AEDT be used to assess the potential for airport-related air quality impacts. The AEDT will be used to prepare emissions inventories of CO, NOx, SO_2, PM_{10}, $PM_{2.5}$, and VOC. The sources of O'Hare-related emissions that will be included in AEDT are aircraft, auxiliary power units (APUs), ground support equipment (GSE), ground access vehicles (on and off airport), and various stationary sources (e.g., boilers, generators, etc.).

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[5] FAA, Order 1050.1F, *Environmental Impacts: Policies and Procedures*, July 16, 2015 https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.current/documentnumber/1050.1

[6] FAA, *NEPA Implementing Instructions for Airport Actions, April 2006,* *https://www.faa.gov/airports/resources/publications/orders/environmental_5050_4/*

[7] FAA, *Aviation Emissions and Air Quality Handbook Version 3 Update 1, January 2015,* https://www.faa.gov/regulations_policies/policy_guidance/envir_policy/airquality_handbook/

[8] FAA, *An Environmental Desk Reference for Airport Actions, October 2007,* *https://www.faa.gov/airports/environmental/environmental_desk_ref/*

[9] Mixing Heights, Wind Speed, and Potential for Urban Air Pollution throughout the Contiguous United States, U.S. Environmental Protection Agency, January 1972.

Other models that will be used to evaluate the Projects include the USEPA's AERMOD dispersion model for macroscale air pollutant concentrations. [10, 11] *Motor Vehicle Emissions Simulator* (MOVES, Version 2014b)[12], the NONROAD emission factor model for construction-related emissions[13], CAL3QHC roadway intersection dispersion model for hot-spot CO, and AERMOD dispersion model for intersection hot-spot $PM_{2.5}$ concentrations.[14],[15]

AERMOD is an atmospheric dispersion model which simulates point, area, volume, and line sources and has the capability to include simple, intermediate, and complex terrains. It also predicts both short-term (1 to 24 hours) and long-term (quarterly or annual) average concentrations of air pollutants. AERMOD is commonly executed to yield one-hour, 24-hour, and annual average concentrations (in micrograms per cubic meter or $\mu g/m^3$) at designated receptors.

MOVES is the emission modeling system developed by USEPA to compute emissions for mobile sources. MOVES provides emission rates for on-road vehicles including passenger cars and trucks, commercial trucks and buses, and motorcycles. Because requirements that effect emissions from on-road vehicles vary by state/area (i.e., inspection/maintenance emission testing), MOVES provides estimates of exhaust and evaporative emissions, as well as brake and tire wear emissions, that vary by state/area. MOVES also has the capability to compute non-road vehicle emissions.

NONROAD is a database developed by the USEPA for the purpose of preparing emission inventories for the nonroad category of emission sources This category includes agricultural and construction equipment, airport GSE, all-terrain recreational vehicles, marine equipment, lawn and garden equipment, and a variety of other off-road vehicles and equipment. For airport applications, NONROAD is used primarily for the estimation of emissions from GSE and construction-related equipment.

CAL3QHC is a computer model developed by the USEPA for the purpose of predicting hourly CO concentrations from motor vehicles at roadway intersections. The model has the capability, with the use of various concentration-averaging algorithms, to predict 1-hour, 8-hour, 24-hour, and annual concentrations, compared with only the maximum hourly average computed by CAL3QHC. AERMOD is the USEPA-recommended model for $PM_{2.5}$ hot-spot modeling for highway and roadway intersection projects.

Emissions Inventory

In general terms, an emissions inventory is a quantification of the amount, or weight, of pollutants emitted from a source (or combination of sources) over a period of time. The outcome is a product of source activity levels (i.e., aircraft operations) combined with appropriate emission factors (i.e., grams of pollutant per operation). The results are segregated by pollutant type (i.e., CO, NO_x, SO2, PM_{10}, $PM_{2.5}$, and VOC), emission source, and project milestone year. Emission inventory results are commonly reported in units of tons per year.

Using AEDT, emission inventories will be prepared for each EA alternative. The aircraft fleet mix, annual operations, runway assignment, gate assignment, taxipath and other modeling parameters used to prepare

[10] USEPA Preferred/Recommended Models, *AERMOD Modeling System*, https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models

[11] Title 40 CFR Part 51, *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule,* http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf

[12] USEPA, *Motor Vehicle Emissions Simulator (MOVES) User Guide for MOVES2014b*, December 2018, https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves

[13] USEPA, NONROAD Model, https://19january2017snapshot.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles_.html and USEPA, *Non-Road Model Worksheet*, December 2008.

[14] USEPA, *User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections*, November 1992, http://www.epa.gov/ttn/scram/userg/regmod/cal3qhcug.pdf

[15] USEPA requires the use of AERMOD for $PM_{2.5}$ hot-spot analysis initiated after January 20, 2020Revisions to the Guideline on Air Quality Models: Enhancements to the AERMOD Dispersion Modeling System and Incorporation of Approaches To Address Ozone and Fine Particulate Matter, January 17, 2017, https://www.epa.gov/sites/production/files/2020-09/documents/appw_17.pdf

the inventories will be consistent with the data generated for the Total Airspace and Airport Modeler (TAAM) and noise analyses that are also being prepared in support of the EA.

The emission inventories will be prepared to estimate emissions for the following O'Hare and Project-related sources:

- Aircraft (arrivals, departures, ground taxi, and engine startup)
- APUs
- GSE
- Stationary sources
- Ground access vehicles
- Construction activities

Emission estimates for ground access vehicles include motor vehicle activity both on- and off-airport roadways, in on-airport parking facilities, and at terminal curbsides. Other airport-related sources include aircraft run-up engine testing, fuel storage and handling facilities, deicing, training fires, and on-site stationary combustion sources (e.g., the Airport's heating and refrigeration plant), miscellaneous boiler units, emergency turbine, and standby/emergency generators. The following highlight certain assumptions and/or methodologies that will be used to prepare the emission inventories.

Aircraft

AEDT contains emissions factors for the vast majority of the aircraft operating in the United States. The factors are provided by aircraft engine type and operational mode (i.e., take-off, climbout, approach, and taxi/idle). [16]

Ground Support Equipment (GSE)/Auxiliary Power Units (APUs)

GSE is a term used to describe the equipment and vehicles that service aircraft after arrival and before departure at an airport. Emissions from these sources are based on the number and type of equipment used to service each aircraft along with the amount of time the equipment is in use per aircraft LTO and the fuel type. GSE are comprised of aircraft tugs, baggage tugs, belt loaders, fuel trucks, food trucks, cargo trailers, hydrant carts, lavatory trucks, cabin service, and cargo loaders as well as deicers, forklifts, and ground power units (GPUs). The number, types of GSE, fuel types (e.g., gasoline, diesel, electric), and operating times that are used to service each category of aircraft will be based on O'Hare specific information or available technical guidance. Therefore, hydrant carts are used within the terminal area instead of fuel trucks. Aircraft tug activities associated with movements to maintenance hangers, remain overnight, and between terminals are also included.

APUs are small turbine engines used by commercial jet aircraft to start the main engines; provide electrical power to aircraft radios, lights, and other equipment; and to power the onboard air conditioning (heating and cooling) system. When an aircraft arrives at a terminal gate, the pilot has the option of shutting off power to the main jet engines and operating the onboard APU, which is fueled by the aircraft's jet fuel. Alternately, an aircraft can receive electrical power and pre-conditioned air (PCA) from a mobile GPU and air conditioning equipment, or receive electrical power (400 Hertz (Hz) and PCA from connections at the

[16] For the purposes of the emissions inventories, a landing and take-off cycle is comprised of the following AEDT operational mode categories:

- *Descend Below Mixing Height*: The modes in this category are associated with an aircraft's arrival, beginning at the atmospheric mixing height and including descend emissions below 1,000 feet, the landing ground roll, and arrival taxi (i.e., taxi-in) emissions.
- *Climb Below Mixing Height:* The modes in this category are associated with an aircraft's departure, beginning with startup and including climb taxi (i.e., taxi-out), takeoff ground roll, climb below 1,000 feet and climb to the atmospheric mixing height.

gate. Where available, gate power connections are built into the passenger loading bridge used to connect the terminal building to the aircraft for loading and unloading passengers.

Use of a GPU or gate connections eliminates the need for aircraft to use their own power at the gate except for short periods of time during engine start-up and shut-down. Terminal gates without PCA/ground power typically assume an APU operating time of 26 minutes (13 minutes during taxi in and 13 minutes during taxi out). Terminal gates with PCA/ground power typically assume an APU operating time of seven minutes (3.5 minutes during taxi in and 3.5 minutes during taxi out).[17] All of the terminal gates at O'Hare provide PCA and power to aircraft. Therefore, for the EA, APU operating times will be assumed to be seven minutes at all terminal gates. Operations involving cargo or general aviation aircraft will be assumed to require an APU run time of 26 minutes, where applicable.

Ground Access Vehicles

Ground access vehicles include privately owned vehicles (e.g., cars, vans, trucks, cabs, rental cars, etc.), mass transit vehicles (e.g., buses and vans), government vehicles, and cargo-related vehicles (e.g., trucks). Emissions factors for this airport source will be obtained from the MOVES emission factor model. Input data for MOVES that is specific to the Chicago metropolitan area, such as the fleet mix and parameters affecting emissions (e.g., ambient temperature and humidity), were obtained from the IEPA.

The air quality analysis will include contributions from vehicles on major arterials in the vicinity of the Airport such as Interstate 190, Interstate 90, Bessie Coleman Drive, Elmhurst Road, Irving Park Road, Touhy Avenue, York Road, Thorndale Avenue, and Mannheim Road. Terminal area motor vehicle curbside queues will also be included in the roadway network. Parking facilities such as public parking garages and surface lots (i.e., terminal area, international, economy, and stalls at O'Hare's Consolidated Car Rental Facility (CONRAC)) and terminal curbsides will also be included in the emission inventories and dispersion analyses.

Stationary Sources

As previously stated, stationary sources include boilers, generators, training fires, and fuel storage facilities. These sources are subject to an operating permit and typically make up only a small portion of overall airport emissions. Emissions for stationary sources will be based on the amount of fuel or material consumed for the year 2018 and emission factors within the operating permit. Depending on the type of source, emissions will be calculated for some or all of the following pollutants: CO, NO_x, SO_x, PM_{10}, $PM_{2.5}$, and VOC Emission factors for stationary sources will be obtained from the City of Chicago's Department of Aviation's (CDA's) CAA Permit Program Permit Application.[18]

The sources of VOC emissions from the storage and handling of fuel include breathing and working losses for storage tanks, and losses from the filling of tanker trucks. Jet A and Av-gas fuel throughputs for the Projects will be based on CDA records for the year 2018. Per the Title V permit, training of fire and rescue staff at O'Hare includes burning propane, Jet A, and/or gasoline fuel to simulate fires from burning aircraft during an emergency. Annual fuel usage data consumed in training fires will be based on operating permit limits. O'Hare has an emergency turbine for backup power. This turbine uses diesel fuel and is located at the heating and refrigeration plant. Annual fuel usage data for diesel fuel consumed by the turbine will also be obtained from CDA records for the year 2018.

The stationary source exhaust release parameters (i.e., stack height, diameter, exit velocity, and temperature) used in the dispersion modeling analysis will be consistent with the CAA Permit Program

[17] FAA, *Aviation Emissions and Air Quality Handbook Version 3 Update 1, January 2015,* https://www.faa.gov/regulations_policies/policy_guidance/envir_policy/airquality_handbook/

[18] Illinois Environmental Protection Agency, Title V – CAAPP Permit, City of Chicago Department of Aviation, O'Hare International Airport, I.D. No. 031600FQP, Permit 95110002, November 17, 2017.

Permit Application. Additional stationary sources associated with new terminal and other facilities within the Projects will also be included in the emissions inventory and dispersion modeling analysis.

Construction

A detailed construction plan listing numbers and types of equipment and expected usage during the construction projects is being prepared. The construction emissions inventory will evaluate an eight to ten year construction period that will include project elements such as passenger terminal development, airfield improvements, landside infrastructure, and commercial development.

Construction-related emissions will result from use of heavy equipment (e.g., dozers, scrapers, and backhoes), construction vehicles (e.g., haul trucks, and worker vehicles), batch plants (e.g., asphalt), and fugitive dust (e.g., travel on unpaved surfaces, earthmoving). The emissions inventory will be prepared for CO, NO_x, SO_2, PM_{10}, $PM_{2.5}$, and VOC for each year of construction, and each project element. Fugitive dust and entrained roadway dust emissions will also be inventoried. Construction activities would also include demolition/removal of facilities within the existing airport location and proposed airports facilities such as aprons, terminals, utilities, access roadways, parking lots, and other support facilities. Measures to reduce construction-period air emissions, consistent with regulatory practices and policies, will be identified.

The construction-related emission estimates will be prepared using equipment/vehicle activity levels, the types and sizes of equipment, estimation of disturbed area, and the construction duration and emission rates obtained from the USEPA's MOVES and NONROAD.

4. DISPERSION MODELING

Atmospheric dispersion modeling will be conducted to predict the effects of the Projects on local air quality conditions. The dispersion modeling analysis will be completed in accordance with the FAA's *Aviation Emissions and Air Quality Handbook*[19] and USEPA's *Guideline on Air Quality Models*[20].

A dispersion analysis will be performed to predict ambient (i.e., outdoor) pollutant concentrations of CO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$ both on and off the airport (i.e., public access) for each alternative. The results of the dispersion analysis will be used to indicate whether airport-related emissions would cause or contribute to violations of the NAAQS for these pollutants. The analysis will be performed using USEPA's AERMOD dispersion model for the following pollutants and averaging times:

- CO – 1-hour and 8-hour
- NO_2 – 1-hour and annual
- SO_2 – 1-hour and 3-hour
- PM_{10} – 24-hour
- $PM_{2.5}$ – 24-hour and annual

All standard approaches to the dispersion modeling will be used except where project-specific conditions and inputs are more appropriate and allowable under FAA and IEPA guidance. Because O_3 is a regional pollutant and emissions and concentrations of O_3 cannot be computed directly using AEDT, AERMOD, or other conventional models[21], VOC and NO_x (the primary precursors to O_3 formation) will be used as

[19] FAA, *Aviation Emissions and Air Quality Handbook Version 3 Update 1, January 2015,* https://www.faa.gov/regulations_policies/policy_guidance/envir_policy/airquality_handbook/
[20] USEPA, 40 CFR Part 51 Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule, November 9, 2005, https://www3.epa.gov/scram001/guidance/guide/appw_05.pdf
[21] The complexity of O_3 formation and the health implications of O_3 warrant evaluation on a regional basis using a regional model and cannot be meaningfully addressed on a project-specific level.

surrogates for this pollutant. Specifically, the results of the emissions inventories for VOC and NO_x will be compared to the appropriate emission thresholds.

American Meteorological Society/USEPA Regulatory Model (AERMOD) Options

AERMOD is an atmospheric dispersion model that simulates point, area, volume, and line emissions sources. The model is capable of considering simple, intermediate, and complex terrain along with meteorological conditions and multiple receptor locations.[22] The model also predicts both short-term (one to 24 hours) and long-term (annual) average concentrations. AERMOD will be executed using the regulatory default options (e.g., stack-tip downwash, elevated terrain effects, calm wind speeds processing routine, missing data processing routine, buoyancy-induced dispersion, and final plume rise), default wind speed profile categories, default potential temperature gradients, and, with the exception of the NO_x to NO_2 analysis, no pollutant decay. AERMOD is the appropriate model for this analysis based on the model's coverage of simple (i.e., flat), intermediate, and complex (i.e., above emission-source elevation) terrain. For this evaluation, the terrain will be assumed to be flat.

When executing AERMOD, the selection of appropriate dispersion coefficients depends on the land use within three kilometers (km) of a source. This land-use typing is based on a classification method defined by Auer,[23] using pertinent U.S. Geological Survey (USGS) 1:24,000 scale (7.5 minute) topographic maps of the area. If the Auer land use types of heavy industrial, light-to-moderate industrial, commercial, and compact residential account for 50 percent or more of the total area, the USEPA Guideline on Air Quality Models[24] recommends using urban dispersion coefficients; otherwise, using the appropriate rural coefficients is advised. O'Hare is in an urban area, therefore, urban dispersion coefficients will be used for this analysis.

Background Concentrations

Because the dispersion modeling will address emissions from airport-related sources and the surrounding roadway network only, background concentrations are added to the results to account for air pollutants originating from outside the study area. These background concentrations were derived from existing air monitoring data collected by the IEPA. IEPA considers the Northbrook monitoring station to be a representative background concentration for the O'Hare area. For CO, SO_2, PM_{10}, and $PM_{2.5}$, background concentrations from pollutant measurements during 2016 through 2018 from the air monitoring station located approximately 12 miles north-northeast of the Airport in the City of Northbrook will be used. However, because the IEPA discontinued monitoring NO_2 at the Northbrook monitoring station, other stations within Cook County were reviewed to determine if data from one of the stations was appropriate for use in the analysis. Notably, while there is an air monitoring station on the east side of O'Hare (in Schiller Park) at which IEPA measures NO_2, use of data from this monitoring station is not appropriate to derive background concentrations because:

- The monitor is located in close proximity to O'Hare and therefore airport-related sources of NO_2 contribute to the measurements at the station (i.e., use of data from this station would be "double counting" the contribution of O'Hare to modeled NO_2 totals).
- The AEDT input files include airport-related activity within the property boundary of O'Hare and airport and non-airport-related motor vehicle traffic outside of the property boundary. Most notably, the input file includes motor vehicle traffic on Mannheim Road, a heavily traveled roadway between O'Hare and the Schiller Park monitoring station.

[22] Title 40 CFR Part 51, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule, http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf

[23] Auer, August H., 1978: *Correlation of Land Use and Cover with Meteorological Anomalies*. J. Appl. Meteor., 17, 636–643 http://journals.ametsoc.org/doi/pdf/10.1175/1520-0450%281978%29017%3C0636%3ACOLUAC%3E2.0.CO%3B2

[24] Appendix W to Part 51 – Guideline on Air Quality Models, http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48c032d9a39c&node=40:2.0.1.1.2.23.11.5.37&rgn=div9

To determine from what other air monitoring stations an appropriate background concentration might be obtained, the IEPA's monitoring objectives for other regional NO_2 monitors were reviewed.[25] The objectives, are provided in **Table 3**. As shown, of the five monitors evaluated, either the primary or secondary objective of the monitor was to record highest concentrations of NO_2 as such data from these monitors is not appropriate for use in deriving background NO_2 concentrations. Of the remaining two monitors, one has a measurement scale designated as being "neighborhood" and the other a measurement scale of "regional". The definition of these two measurement scales are provided below:

- Neighborhood – Uniform pollutant concentrations ranging from 0.5 to 4 kilometers
- Regional – Uniform pollutant concentrations ranging from tens to hundreds of kilometers.

Table 3: Regional NO_2 Monitoring Stations

Site ID	Address	Distance from ORD (miles/ kilometers)	Measurement Scale	NO_2 Monitoring Objective		Monitoring Type
				Primary	Secondary	
17-031-0219	Kennedy Expressway West, Chicago	13 / 21	Micro	Highest concentration	Source	Near road
17-031-0119	Kingery Expressway & Torrence Avenue, Lansing	33 / 53	Micro	Highest concentration	Source	Near road
17-031-4002	1820 S. 51st Avenue, Cicero	11 / 18	Neighborhood	Population	Highest Concentration	Area wide
17-031-0076	7801 Lawndale, Chicago	19 / 31	Neighborhood	Population	None	Area wide
17-117-0002	Heaton & Dubois, Nilwood	202 / 325	Regional	Background	Population	Area wide

Sources: USEPA Airdata (Extracted 7-23-20) and Illinois Ambient Air Monitoring 2020 Network Plan (https://www2.illinois.gov/epa/topics/air-quality/outdoor-air/air-monitoring/Documents/2020%20Network%20Plan%20%28For%20Comment%20Period%29.pdf

Based on these definitions, as well as the distance of the monitors from O'Hare, measured data from the Nilwood monitoring station was determined to be the most suitable monitor from which to derive background concentrations for NO_2. It is notable that the primary monitoring objective of the Nilwood station is to provide regional background concentrations of this pollutant.

For the analysis of CO, three-hour SO_2, annual NO_2, and 24-hour PM_{10}, the background concentrations represent the highest (i.e., maximum) measured levels during the three-year period. The background values for one-hour NO_2, SO_2 and $PM_{2.5}$ are not the highest measured levels because the standards for these pollutants are based on 99th, 98th, and 98th percentile values, respectively. Use of these background values will result in conservatively high estimates of total pollutant concentrations due to a downward trend in regional pollutant concentrations within the area. The estimated background concentrations for the EA are listed in **Table 4**. All background concentrations are below the NAAQS.

[25] *Illinois Ambient Air Monitoring 2020 Network Plan*, https://www2.illinois.gov/epa/topics/air-quality/outdoor-air/air-monitoring/Documents/2020%20Network%20Plan%20%28For%20Comment%20Period%29.pdf

Table 4: Background Concentrations

Pollutant	Averaging Time	Station Selected	Note	Background Concentration	Percent of Standard
Carbon Monoxide	1-hour	Northbrook	(a)	1.41 ppm (1,606 µg/m^3)	4
	8-hour	Northbrook	(a)	1.10 ppm (1,222 µg/m^3)	12
Nitrogen Dixode	1-hour	Nilwood	(e)	0.015 ppm (28.6 µg/m^3)	15
	Annual	Nilwood	(f)	0.002 ppm (4.5 µg/m^3)	5
Sulfur Dioxide	1-hour	Northbrook	(b)	0.0034 ppm (8.89 µg/m^3)	5
	3-hour	Northbrook	(a)	0.0046 ppm (12.0 µg/m^3)	1
Particulate Matter 10 micrometer or less in size	24-hour	Northbrook	(a)	53.0 µg/m^3	35
	Annual	Northbrook	(a)	15.7 µg/m^3	31
Particulate Matter 2.5 micrometer or less in size	24-hour	Northbrook	(c)	20.7 µg/m^3	59
	Annual	Northbrook	(d)	8.30 µg/m^3	69

Notes: ppm - parts per million
µg/m^3 - micrograms per cubic meter
a) Highest value for 2016, 2017, and 2018.
b) Average of the 99th percentile values for 2016, 2017, and 2018.
c) Average of the 98th percentile values for 2016, 2017, and 2018.
d) Average value for 2016, 2017, and 2018.
e) Average of the 98th percentile values for 2018
f) Average value for 2018.
Source: USEPA, *AIRData – Monitor Values Reports*, http://www.epa.gov/air/data/index.html, and IEPA, *Annual Air Quality Reports*, http://www.epa.illinois.gov/topics/air-quality/air-quality-reports/index

To account for the variance in background concentrations over time, seasonal background concentrations of $PM_{2.5}$ from the Northbrook monitoring station from 2016 through 2018 were derived following USEPA guidance. For the 24-hour $PM_{2.5}$ hot-spot analysis, three-year average seasonal values of 18.8 µg/m^3 (fall), 16.9 µg/m^3 (spring), 17.8 µg/m^3 (summer), and 20.6 µg/m^3 (winter) will be used. For the analysis of annual concentrations, a background concentration of 8.30 µg/m^3 (**Table 4**) will be used.

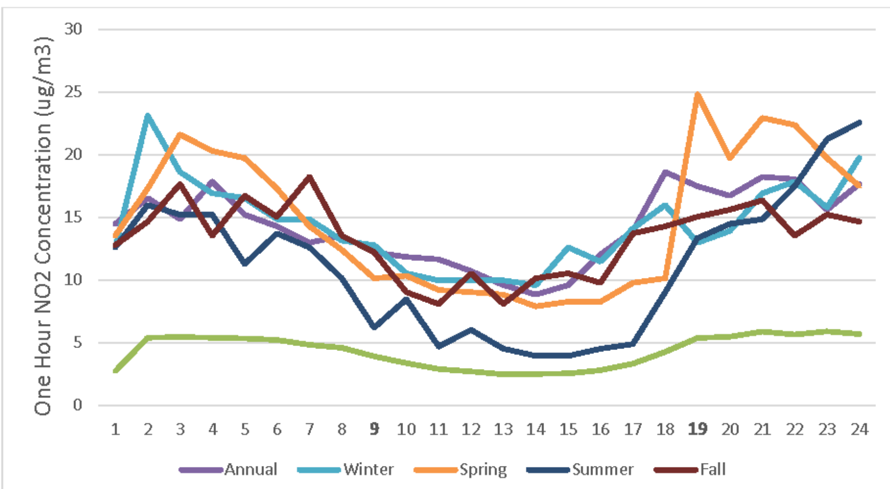
To account for the variance in background NO_2 concentrations over time, seasonal/temporal background concentrations for NO_2 from the Nilwood monitoring station from 2018 were derived following USEPA guidance. As shown in **Table 5** and **Figure 1**, the estimated NO_2 one-hour background concentrations vary by season and by time of day with a tendency for higher concentrations during spring and nighttime periods. These seasonal/temporal NO_2 background concentrations will be used for the one-hour NO_2 dispersion analysis. **Attachment A** provides further information regarding meteorological data processing and the development of NO_2 background concentrations.

Table 5: One-Hour NO_2 Temporal Background Concentrations (µg/m^3) for Nilwood

Hour	Winter	Spring	Summer	Fall	Annual
1	12.6	13.5	12.6	12.8	13.7
2	23.1	17.3	16.0	14.7	17.3
3	18.6	21.6	15.2	17.7	20.7
4	16.9	20.3	15.2	13.5	16.9
5	16.5	19.7	11.3	16.7	18.8
6	14.9	17.3	13.7	15.0	17.1
7	14.9	14.3	12.6	18.2	14.9
8	13.2	12.4	10.2	13.5	13.5
9	12.8	10.2	6.2	12.2	12.2
10	10.5	10.3	8.5	9.0	10.5
11	10.0	9.2	4.7	8.1	9.6
12	10.0	9.0	6.0	10.5	9.8
13	10.0	8.8	4.5	8.1	9.0
14	9.6	7.9	3.9	10.2	9.4
15	12.6	8.3	3.9	10.5	10.7
16	11.5	8.3	4.5	9.8	10.0
17	14.1	9.8	4.9	13.7	13.4
18	16.0	10.2	9.0	14.3	14.1
19	13.0	24.8	13.4	15.0	16.4
20	13.9	19.7	14.5	15.6	17.3
21	16.9	22.9	14.9	16.4	19.2
22	17.9	22.4	17.5	13.5	18.2
23	15.8	19.7	21.3	15.2	19.4
24	19.7	17.5	22.6	14.7	21.8

Notes: 98th percentile values
Source: KB Environmental Science/RCH Group analysis of USEPA ambient monitoring data (*AIRData – Monitor Values Reports*, http://www.epa.gov/air/data/index.html), 2020.

Figure 1: One-Hour NO_2 Temporal Background Concentrations (µg/m^3) for Nilwood



Source: KB Environmental Science/RCH Group analysis of USEPA ambient monitoring data (*AIRData – Monitor Values Reports*, http://www.epa.gov/air/data/index.html), 2020.

Meteorological Data

Air pollutant concentrations are a function of the rate and location of pollutant emissions, meteorological conditions and topographic features that affect pollutant movement and dispersal. The NAAQS pertain to air pollutant levels in the lower part of the atmosphere (referred to as the planetary boundary layer). The planetary boundary layer is defined as "the region in which the atmosphere experiences surface effects through vertical exchanges of momentum, heat, and moisture."[26] Within this atmospheric layer the concentration of an air pollutant is based on the amount of pollutant emitted (or developed) and the degree to which the pollutant is diluted and dispersed.

AERMOD uses both surface and upper air[27] meteorological conditions. The data used in the evaluation of the EA was obtained from the National Climatic Data Center. The dispersion modeling analysis will use hourly meteorological data collected at O'Hare by the National Weather Service for a three-year period (2016 through 2018). **Figure 2** provides the wind rose for this time period. As shown, the wind direction was predominately from the south, southwest, and west with a low frequency of calm and low wind conditions and the average annual wind speed was 10.4 miles per hour. Based on the data, a value of 2,510 feet will be used for the mixing height.[28] Notably, the mixing height is used by AEDT in the calculation of air pollutant/pollutant precursor emissions inventories. The mixing height value is not specifically used within the AERMOD dispersion model.

AERSURFACE was used to determine the surface characteristics for input to AERMET meteorological processor. AERSURFACE[29] was also used to assess the land use cover and determine the appropriate surface roughness length[30], Bowen ratio[31], and albedo[32] based on land use cover, soil moisture, and seasonal conditions. The appropriate monthly surface roughness length, Bowen ratio, and albedo for the analysis were estimated with AERSURFACE, within twelve directional sectors, with calculated values of 0.12 to 0.23 meters, 0.79 to 1.03, and 0.17 to 0.18, respectively, indicative of land use designations containing urban/recreational grasses/commercial/industrial/transportation within and surrounding the airport.[33]

A screening analysis will be conducted to determine which year of meteorological data will result in the greatest predicted pollutant concentrations. Because it is anticipated that the predicted concentrations of NO_2 will be closest to the NAAQS for this pollutant, the screening analysis will be performed for the Proposed Action Buildout and No Action Buildout for both the determination of the one-hour and annual NO_2 concentrations. The meteorological year resulting in the highest NO_2 concentrations will then be used

[26] Panofsky H.A., Dutton J.A., 1984: Atmospheric turbulence, models and methods for engineering applications, John Wiley and Sons, New York.

[27] Peoria, Illinois.

[28] Mixing Heights, Wind Speed, and Potential for Urban Air Pollution throughout the Contiguous United States, U.S. Environmental Protection Agency, January 1972.

[29] AERSURFACE is a tool that processes land cover data to determine the surface characteristics for use in AERMET.

[30] The roughness length is approximately one-tenth of the height of the surface roughness elements. For example, short grass of height 0.01m has a roughness length of approximately 0.001m. Surfaces are rougher if they have more protrusions. Forests have much larger roughness lengths than tundra, for example. Roughness length is an important concept in urban meteorology as the building of tall structures, such as skyscrapers, has an effect on roughness length and wind patterns.

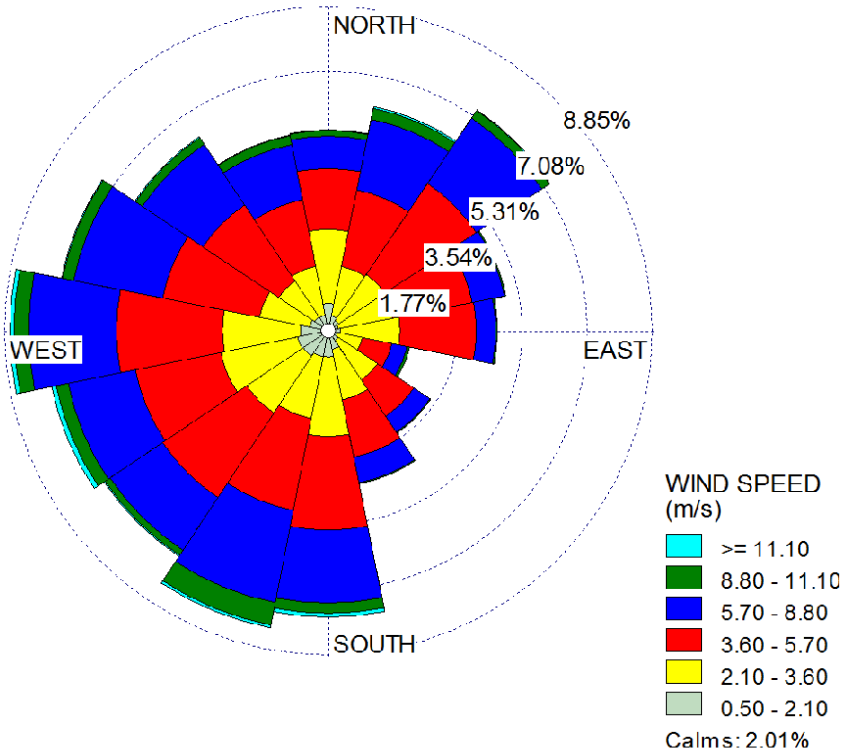
[31] The Bowen ratio is used to describe the type of heat transfer in a water body. The Bowen ratio is the mathematical method generally used to calculate heat lost (or gained) in a substance; it is the ratio of energy fluxes from one state to another by sensible and latent heating respectively.

[32] The ratio of reflected radiation from the surface to incident radiation upon it or reflecting power of a surface. Albedo values range from 0.1 for thick deciduous forests to 0.9 for fresh snow.

[33] AERMOD is more sensitive to surface roughness, which tends to be higher in urban environments due to greater obstructions and thus, greater turbulence. Bowen ratio has little effect on the AERMOD results, while albedo can have a slight effect on the results. Higher surface roughness lengths may produce lower concentrations for surface-based emissions but higher concentrations for elevated emission sources.

to evaluate all other pollutants/averaging periods and No Action/Project alternatives.[34] Attachment A provides further information regarding meteorological data processing and NO_2 background concentrations.

Figure 2: Windrose for 2016 through 2018



Source: KB Environmental Science/RCH Group analysis of National Climatic Data Center meteorological data, 2019.

[34] The emission distribution for NOx will be similar to the emission distribution for CO, SO_2, PM_{10}, and $PM_{2.5}$ because the majority of the emissions result from aircraft and the temporal operational profiles for aircraft are the same regardless of pollutant. It is also anticipated that both the 1-hour and annual NO_2 concentration will be worst-case for the same meteorological year. As such, the worst-case concentrations of CO, SO_2, PM_{10}, and $PM_{2.5}$ for both short- and long-term averaging periods would occur in the same year. Of note, based on experience, the percentage of the airport/project contribution to the total concentration (airport/project plus background) will be highest for NO_2 and the closest to the NAAQS compared to the other pollutants. Therefore, it is unlikely that use of a different year of meteorological data would substantially change the resulting conclusions for CO, SO_2, PM_{10}, or $PM_{2.5}$.

Receptors

For the air quality dispersion analysis, concentrations will be predicted at a sufficient number of locations (referred to as receptors)[35] to identify maximum concentrations. Because the AEDT/AERMOD run time is significant when a large number of receptors are evaluated, a strategy will be developed to balance the number of receptors while optimizing the fidelity of the results. The following lists the types of receptors that will be evaluated:

- **Boundary receptors —** Boundary receptors will be located in areas along the Airport boundary at a spacing of approximately 10 degrees. The boundary receptor spacing is approximately 600 meters (2,000 feet). This distribution of receptors is standard when conducting an airport air quality assessment. [36]
- **Sensitive receptors —** Sensitive receptors will include schools, parks, residential areas and health-/day-care centers located in the vicinity of the Airport.
- **Worst-case receptors —** Worst-case receptors will be selected in close proximity to air emissions sources such as near runway ends, terminal area access/egress roads, and off-site intersections. These receptors represent sites where the pollutant concentrations are expected to be the highest and the public would reasonably be expected to occupy the area for a period of one hour or more.

Additional receptors will be added to represent the Projects, including the western transportation facility. The height of each receptor will be assumed to be 1.8 meters above ground (average breathing height) consistent with USEPA modeling guidance. Receptors will also be evaluated at terminal curbsides and in the public/employee parking facilities. **Figure 3** illustrates receptor locations that will be evaluated in the dispersion modeling analysis.

Operational Profile

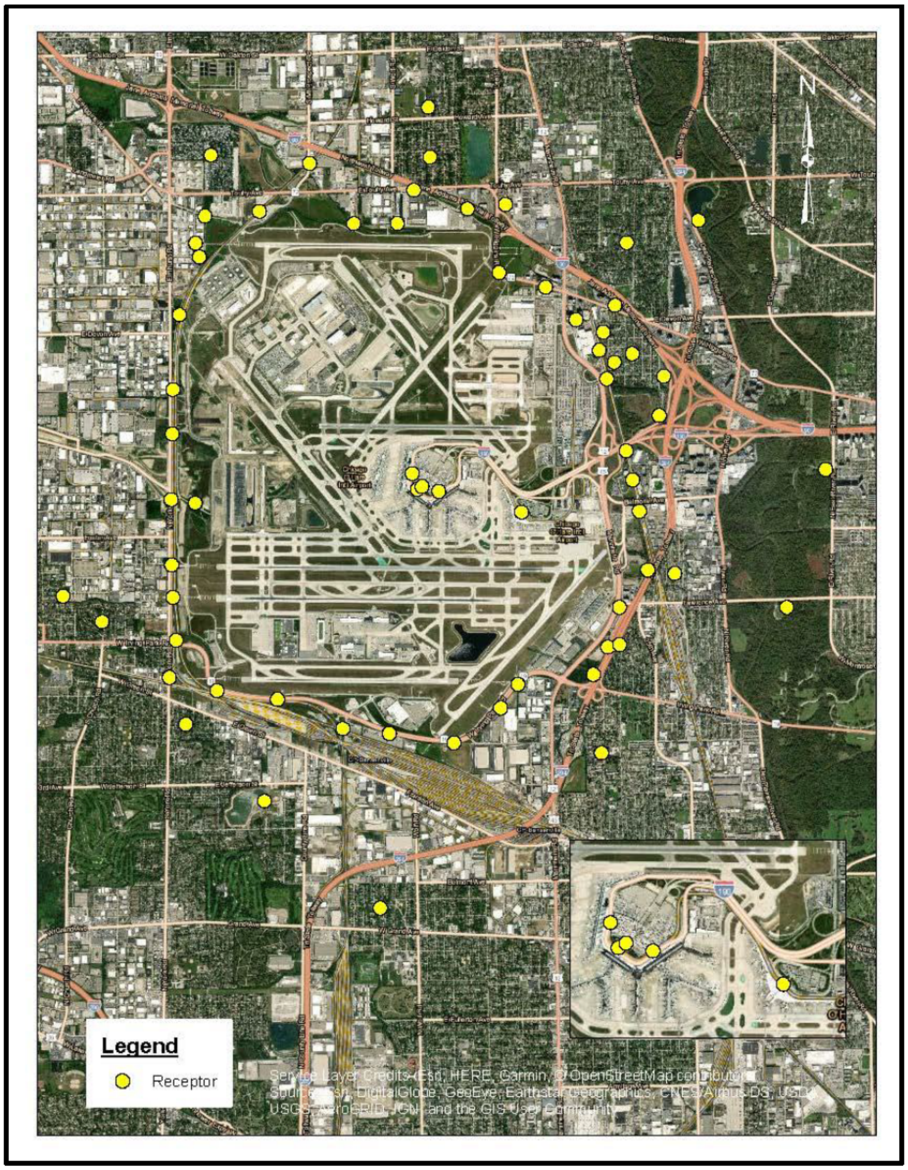
An operational profile, which is comprised of temporal factors, will be used to describe the relationship of one period of time to another period of time (i.e., the relationship of the activity during one-hour to the activity during a 24-hour period). In AEDT, temporal factors are applied to represent varying levels of activity as a fraction of a peak hour. The use of temporal factors gives the model the ability to more accurately reflect real world conditions.

To represent actual aircraft activity at the Airport throughout the entire calendar year, hour-of-day, day-of-week, and month-of-year operational profiles will be used in the analysis. These profiles will be used by AEDT in its dispersion mode to calculate concentrations for each hour of the evaluated years at receptor locations. The hour of the day, day of the week, and monthly operational profiles for the Existing Condition were developed using O'Hare-specific activity data from FAA's Operations and Performance Data (OPSNET) for the year 2018 (**Table 6**). Future year temporal factors will be developed from the TAAM airfield simulation modeling. Based on data for the year 2018, the majority (i.e., peak) of the aircraft activity occurs from 6 to 7 pm on a Thursday during July. **Figure 4** illustrates the hour of the day, day of the week, and month of the year aircraft operational profiles for 2018. Temporal factors for deicing (based on monthly CDA Deicing Season Report), boiler usage (based on monthly CDA fuel usage records), and monthly passenger counts will also be used. Temporal factors for motor vehicle activities will be based on the operational profiles for aircraft operations and/or available information associated with surface transportation volumes.

[35] The term *receptor* generically describes outdoor land uses or activities which it can be reasonably expected that the public would occupy for a period ranging from one hour to one year.

[36] The boundary receptor spacing is approximately 600 meters (2,000 feet). This distribution of receptors is standard when conducting an airport air quality assessment.

Figure 3: Dispersion Modeling Receptors



Source: KB Environmental Science/RCH Group

Table 6: Aircraft Operational Profiles for 2018

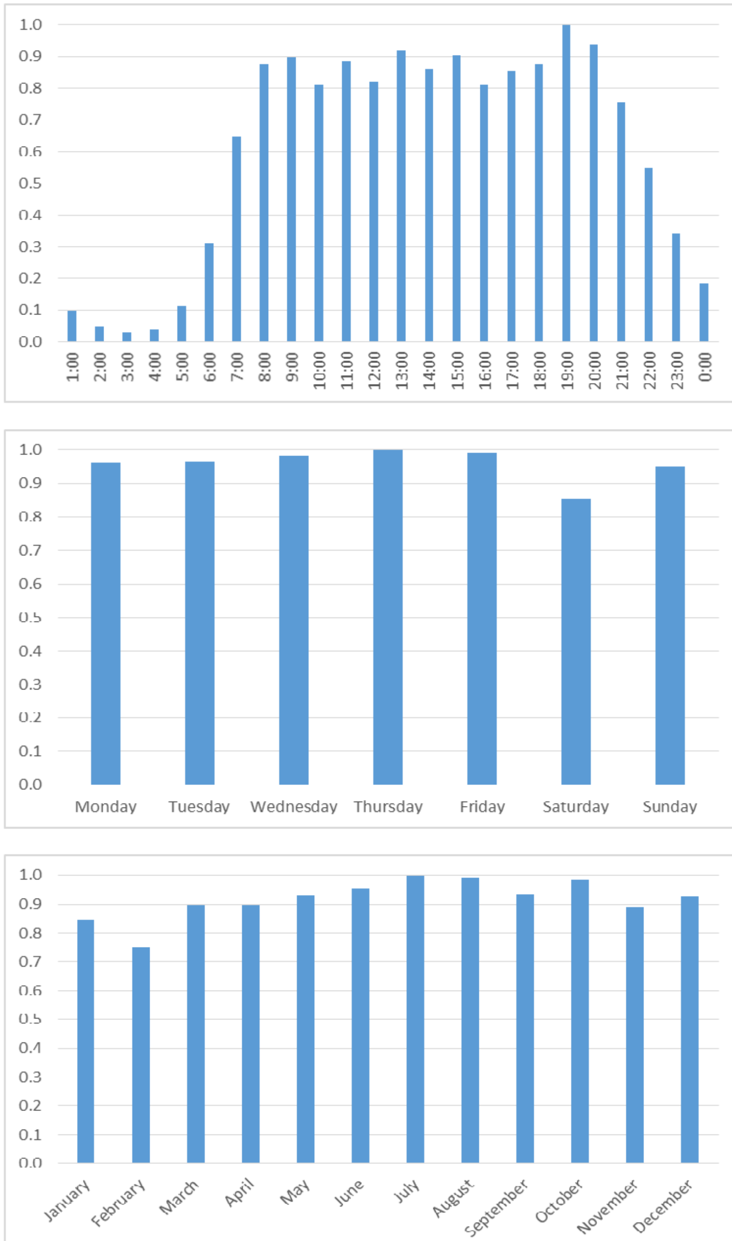
Hour Ending	Profile
1	0.1000
2	0.0475
3	0.0280
4	0.0372
5	0.1119
6	0.3120
7	0.6487
8	0.8772
9	0.8997
10	0.8101
11	0.8856
Noon	0.8225
1	0.9202
2	0.8607
3	0.9041
4	0.8091
5	0.8551
6	0.8766
7	**1.0000**
8	0.9390
9	0.7552
10	0.5492
11	0.3423
Midnight	0.1834

Day	Profile
Monday	0.9624
Tuesday	0.9655
Wednesday	0.9830
Thursday	**1.0000**
Friday	0.9907
Saturday	0.8556
Sunday	0.9528

Month	Profile
January	0.8460
February	0.7503
March	0.8998
April	0.8959
May	0.9322
June	0.9551
July	**1.0000**
August	0.9950
September	0.9343
October	0.9856
November	0.8899
December	0.9299

Source: FAA Operation and Performance Data, 2018.

Figure 4: Aircraft Operational Profiles for 2018



Source: FAA Operation and Performance Data, 2018.

Nitrogen Oxides (NO_x) to Nitrogen Dioxide (NO_2) Conversion

The results of the dispersion modeling will provide predicted concentrations of NO_x which, for comparison to the NAAQS, will be converted to concentrations of NO_2. While AERMOD is generally considered a non-chemistry model, it offers three methods for modeling NO_2 formation from NO_x emissions: (i) the Ambient Ratio Method (ARM-2), (ii) the Ozone Limiting Method (OLM), and (iii) the Plume Volume Molar Ratio Method (PVMRM). As discussed in USEPA's Appendix W, PVMRM is most appropriate for analyses with relatively isolated and elevated sources. OLM is more appropriate for analyses with area sources, near-surface releases, or where plume overlap from multiple sources will occur. Moreover, USEPA's *Guideline on Air Quality Models*[37], recommends a three-tiered screening approach to estimate ambient concentrations of NO_2:

- *Tier 1* – Assumes complete (100 percent) conversion of all emitted NO_x to NO_2 based on application of an appropriate refined modeling technique under *Section 4.2.2 of Appendix W* (of the USEPA's Guideline) to estimate ambient NO_x concentrations.
- *Tier 2* – Ambient Ratio Method (ARM-2), where model predicted NO_x concentrations are multiplied by a NO_2/NO_x ambient ratio, derived from ambient monitoring data.

  ARM-2 incorporates a variable ambient ratio that is a function of model predicted one-hour NO_x concentration, based on an analysis of nationwide hourly ambient NO_x monitoring data from approximately 580 stations over the period 2001 through 2010.
- *Tier 3* – Performs a detailed analysis on a case-by-case basis by employing the OLM or PVMRM. These methods require the most detailed level of analysis and produce the least conservative, and presumably the most representative results. Tier 3 requires information such as in stack NO_2/NO_x ratio and ambient ozone concentrations.

An evaluation will be conducted using the full (100 percent) conversion, ARM-2, OLM with default NO_2 to NO_x emission ratios, OLM with aircraft-related NO_2 to NO_x emission ratios (see **Table 6**), PVMRM with default NO_2 to NO_x emission ratios, and PVMRM with aircraft-related NO_2 to NO_x ratios to determine one-hour and annual NO_2 concentrations for comparison to the NAAQS. Concentrations for NO_2 are available from the Schiller Park monitoring station for 2016 through 2018, located near the end of Runway 28R, east of the airport. The predicted one-hour NO_2 concentrations from each method will then be compared to ambient monitored data obtained from the Schiller Park monitoring station, to select the most appropriate method of converting NO_x to NO_2. A statistical analysis (e.g., mean square error, robust high concentration) will be performed to determine the best performing method compared to the ambient monitoring data for the same time period. For the evaluation of the OLM and PVMRM, hourly ozone concentrations from the Chicago area (Elgin monitoring station) will be used.

For Tier 3 screening (OLM and PVMRM), the USEPA guidance recommends source-specific information for NO_x/NO_2 emission ratios and in the absence of the source-specific data a default value of 0.5 may be used. Extensive emission testing has been conducted on a wide range of aircraft engines in the last decade. This research has shown that the aircraft-related NO_2/NO_x emission ratio differs markedly from most other NO_x sources.[38] For aircraft, the NO_2 fraction of NO_x decreases with power, from over 98 percent at the lowest power setting (four percent rated thrust or taxi/idle) to under 10 percent at higher power settings (65 to 100 percent rated thrust for climbout/takeoff).[39] Overall, the amount of NO_x emissions emitted by aircraft

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[37] Appendix W to Part 51 – Guideline on Air Quality Models, http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48c032d9a39c&node=40:2.0.1.1.2.23.11.5.37&rgn=div9.

[38] Aircraft Particulate Emissions eXperiment – APEX (2004), JETS-APEX2 (2005), and APEX3 (2005).

[39] Wormhoudt, Joda, Scott Herndon, Paul Yelvington, Richard Miake-Lye, and Changlie Wey. *Nitrogen Oxide (NO/NO2/HONO) Emissions Measurements in Aircraft Exhausts*. Journal of Propulsion and Power 23, no. 5 (2007): 906-11.

was assumed to be 3.3 kilogram (kg) per engine per LTO, of which 0.8 kg is emitted in the form of NO_2.[40] **Table 7** lists the NO_2 to NO_x ratios for each aircraft operating mode. The OLM and PVMRM will be performed using the aircraft NO_2 to NO_x emission ratios presented in **Table 7**.

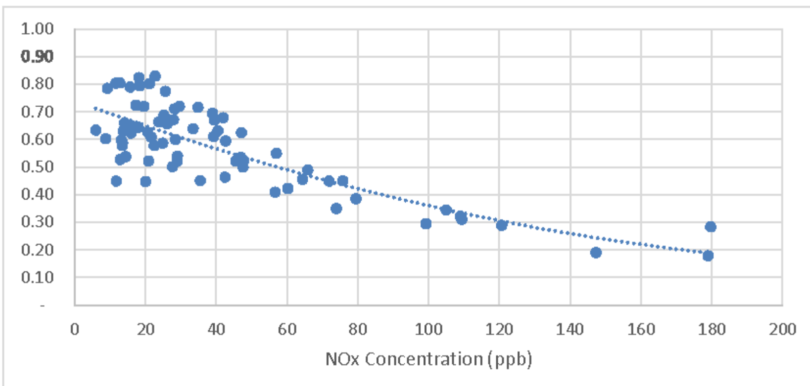
Table 7: Aircraft NO_2 to NO_x Emission Ratios

Operating Mode	NO_2/NOx Ratio (kg/kg)	NO_2 Emissions (kg)	NOx Emissions (kg)
Idle	0.914	0.53	0.58
Approach	0.155	0.08	0.49
Takeoff	0.081	0.06	0.70
Climbout	0.088	0.13	1.53

Source: Wood, Ezra, Scott Herndon, Michael Timko, Paul Yelvington, and Richard Miake-Lye. *Speciation and Chemical Evolution of Nitrogen Oxides in Aircraft Exhaust Near Airports.* Environmental Science & Technology, 2008, 42, 1884-1891.

For ARM-2, the dispersion modeling will be performed using the USEPA default NO_2 to NOx ambient ratios of 0.5 to 0.9. The dispersion modeling will also be performed using site-specific NO_2 to NOx ambient ratios of 0.186[41] to 0.717 per **Figure 5**, which is based on monitoring data at Schiller Park and a sample size of 8,523 hours. **Attachment B** provides further information on the NO_2 conversion methodologies evaluation.

Figure 5: One-Hour NO_2 to NOx Ambient Ratio at Schiller Park



Source: KB Environmental Science/RCH Group analysis of USEPA ambient monitoring data (*AIRData – Monitor Values Reports*, http://www.epa.gov/air/data/index.html), 2019.

Increment Methodology for NO_2 Concentrations

An increment methodology is being used because AEDT/AERMOD over predicts one-hour NO_2 concentrations and reporting the modeled concentrations in the EA would be a misrepresentation of levels that are currently being measured near O'Hare.

As previously noted, the IEPA owns/operates the Schiller Park air monitoring station, located approximately 0.8 miles east of ORD's Runway 28C. Air monitoring data from the Schiller Park monitoring

[40] Wood, Ezra, Scott Herndon, Michael Timko, Paul Yelvington, and Richard Miake-Lye. *Speciation and Chemical Evolution of Nitrogen Oxides in Aircraft Exhaust Near Airports.* Environmental Science & Technology, 2008, 42, 1884-1891.

[41] Adjusted to 0.228; **Attachment D** provides further information regarding minimum NO_2 to NOx ambient ratio.

station shows that measured levels of NO_2 in the vicinity of O'Hare have not exceeded the one-hour NO_2 NAAQS since the IEPA began monitoring at this location in 1998.

For example, in 2018 the measured 98th percentile one-hour NO_2 concentration at Schiller Park was 115 micrograms per cubic meter ($\mu g/m^3$) and the recent three-year average was 105 $\mu g/m^3$ - both well below the 188 $\mu g/m^3$ NAAQS. Additionally, the monitoring data has shown a decrease and then leveling off of NO_2 concentrations over time with a measured level of 166 $\mu g/m^3$ in 2002, 141 $\mu g/m^3$ in 2007, 118 $\mu g/m^3$ in 2013, and 115 $\mu g/m^3$ in 2018, measured concentrations of one-hour NO_2 have been/are well below the NAAQS.

Importantly, NO_2 dispersion modeling for O'Hare has previously demonstrated that the greatest predicted concentrations of this pollutant occur at a modeling receptor placed at the Schiller Park monitoring station. This is expected to occur again with the Terminal Area Plan and Air Traffic Actions EA because the monitoring station and receptor would be located due east of the ends of two of O'Hare's frequently used departure runways (Runway 28R and Runway 22L), and dispersion modeling typically indicates that airport-related NO_2 concentrations are highest near the departure end (i.e., where aircraft start their takeoff roll) of runways.

Therefore, given that the Schiller Park monitoring location likely represents the highest ambient concentrations in the vicinity of the airport and the modeled values are likely to also greatly over predict the measured values at the Schiller Park monitoring station (by approximately two to three times the measured values), the use of an increment method to assess project impacts is proposed to demonstrate compliance with the NAAQS. The proposed method is described as follow:

Firstly, the average measured 98th percentile one-hour NO_2 concentration over the last three years (105 $\mu g/m^3$) will be used to represent the existing condition:

Existing Concentration = Measured Existing Concentration at Schiller Park

Secondly, the following formulas will be used to derive estimated NO_2 concentrations for future conditions (for the No Action Interim/Build Out and With Project Interim/Build Out alternatives):

Estimated Interim With Project Concentration = (Modeled AEDT/AERMOD Interim With Project Concentration – Modeled AEDT/AERMOD Existing Concentration) + Measured Existing Concentration at Schiller Park

Estimated Build Out With Project Concentration = (Modeled AEDT/AERMOD Build Out With Project Concentration – Modeled AEDT/AERMOD Existing Concentration) + Measured Existing Concentration at Schiller Park

Estimated Interim No Action Concentration = (Modeled AEDT/AERMOD Interim No Action Concentration – Modeled AEDT/AERMOD Existing Concentration) + Measured Existing Concentration at Schiller Park

Estimated Build Out No Action Concentration = (Modeled AEDT/AERMOD Build Out No Action Concentration – Modeled AEDT/AERMOD Existing Concentration) + Measured Existing Concentration at Schiller Park

The modeled future With Project concentration minus the modeled existing concentration represents the estimated future contribution of the airport-related sources relative to the existing condition or Project Increment. For the calculation of No Action and With Project-related one-hour NO_2 concentrations, the measured existing concentration will be obtained from the air monitoring station located at Schiller Park and be added to the increment value. Notably, the Project Increment plus the measured concentration from Schiller Park would likely represent a conservative estimate of the future one-hour NO_2 concentration.

To account for the variance in measured existing concentrations over time (i.e., hourly, day of the week, monthly, and season), seasonal/temporal existing concentrations for NO_2 from the Schiller Park monitoring station from 2016 through 2018 were derived following USEPA guidance and will be used in the analysis.[42] As shown in **Table 7** and **Figure 6**, the estimated NO_2 one-hour existing concentrations vary by season and by time of day with a tendency for higher concentrations during winter and fall and morning and evening periods. For the Increment Method, these seasonal/temporal NO_2 existing concentrations will be used for the one-hour NO_2 dispersion analysis.

Lastly, these calculations 1) account for the "change" in airport-related emissions that would occur over time, 2) allow a comparison of the No Action and With Project NO_2 concentrations to the NAAQS, and 3) provide the predicted change in concentrations of the pollutant as a result of the Project (i.e., discloses the environmental impact of the Project). **Attachment C** provides further information regarding the Increment Method for NO_2 concentrations.

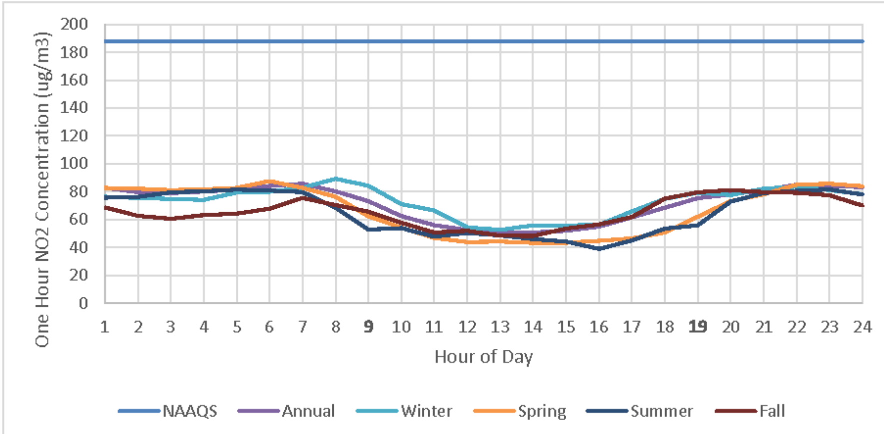
Table 7: One-Hour NO_2 Temporal Existing Concentrations (µg/m^3) for Schiller Park

Hour	Winter	Spring	Summer	Fall	Annual
1	51.1	55.4	50.7	46.0	55.4
2	50.6	55.0	51.0	42.0	53.3
3	50.1	54.3	53.3	40.5	52.9
4	49.7	54.7	53.7	42.4	53.6
5	53.2	55.4	54.5	43.0	54.6
6	53.5	58.7	54.0	45.4	56.3
7	55.6	55.4	53.4	50.6	57.4
8	59.7	51.2	45.8	47.2	53.7
9	56.4	41.7	35.3	44.0	49.1
10	47.6	36.3	36.1	38.6	41.8
11	44.6	31.4	32.0	34.0	37.6
12	36.4	29.4	33.7	34.8	35.1
13	35.2	29.6	32.6	32.4	33.8
14	37.4	29.0	30.8	32.3	34.0
15	37.3	29.0	29.6	35.8	34.8
16	37.6	30.0	26.1	37.8	36.8
17	44.1	31.1	30.0	41.4	41.2
18	50.1	34.0	35.8	50.2	45.9
19	53.0	41.5	37.4	53.2	50.4
20	51.9	49.1	48.8	54.3	52.2
21	55.1	52.3	52.9	53.3	54.3
22	56.0	56.9	54.0	53.0	56.9
23	54.4	57.4	54.6	51.8	56.3
24	52.3	56.2	52.2	46.9	55.8

Notes: 98th percentile values
Source: KB Environmental Science/RCH Group analysis of USEPA ambient monitoring data (*AIRData – Monitor Values Reports*, http://www.epa.gov/air/data/index.html), 2020.

[42] Additional Clarification Regarding Application of Appendix W Modeling Guidance for the one-hour NO_2 _National Ambient Air Quality Standard, dated March 1, 2011 and Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO_2 National Ambient Air Quality Standard, dated September 30, 2014

Figure 6: One-Hour NO_2 Temporal Existing Concentrations (µg/m³) for Schiller Park



Source: KB Environmental Science/RCH Group analysis of USEPA ambient monitoring data (*AIRData – Monitor Values Reports*, http://www.epa.gov/air/data/index.html), 2020.

Gate Assignments, Runways, Taxiways, Taxipaths, Airfield Capacity, and Operating Configurations

AEDT uses a variety of input data to develop an aircraft taxipath[43] and subsequently a ground taxi duration. Each aircraft is assigned a terminal gate location to which the aircraft proceeds after landing and at which servicing (e.g., baggage handling, fueling, catering, etc.) is conducted. The aircraft is also assumed to depart from the same terminal gate for departure. Each aircraft is also assigned runway ends for arrival and departure.

Operating configurations specify the pattern of aircraft arrivals and departures on specific runways over the course of a year depending on the weather and airport capacity. Specifying configurations allows for the assignment of aircraft to runways based on aircraft weight categories that are similar to those employed in an actual airport operating environment (e.g., based on airfield data for 2018, approximately 17.5 percent of departure of heavy aircraft are from Runway 28R and 23.6 percent of the departures of large aircraft are from Runway 09R). Airfield operational west and east flow configurations, as well as airfield capacity values, will be included in the air quality analysis. Airfield capacity for the west and east flow configurations will also be included in the air quality analysis.[44]

The assignments for taxiways, taxipaths, airfield capacity levels, taxiway speeds, and runway utilization for each alternative will be based on the results of the TAAM airfield simulation modeling. AEDT's Delay and Sequence Module uses this airport-specific input along with aircraft operational schedules, runway configurations, and the ground movement delays associated with airport capacity to derive aircraft taxi times.

[43] A taxipath is an ordered list of instructions which specify how to maneuver from a gate to a runway end (outbound) or from a runway exit to a gate (inbound).

[44] Airfield capacity is defined as the highest number of hourly departures which can occur during the peak hour of arrivals and the highest number of hourly arrivals which can occur during the peak hour of departures.

Roadway Intersection Dispersion Analysis

A roadway intersection analysis will be conducted to assess project-related impacts to ambient levels of CO and $PM_{2.5}$ using the USEPA's recommended CAL3QHC and AERMOD model, respectively.[45] The criteria that will be used to determine which intersections will be evaluated are:

- CO - Intersections that are forecast to operate at Level-of-Service D, E, or F with Project or for which the Level-of-Service will degrade to D, E, or F with the Project.
- $PM_{2.5}$ - Intersections that are forecast to operate at Level-of-Service D, E, or F with Project and for which there would be a significant number of diesel vehicles or for which the Level-of-Service would degrade to D, E, or F and there would be a significant number of diesel vehicles with the Project.

Up to five of the top intersections within the defined study area that meet the above criteria with regard to traffic volume, delay, and the worst level of service will be evaluated.

For the intersection analysis, receptors will be located where the maximum project concentrations are likely to occur and where the general public is likely to have access (i.e., along sidewalks, in vacant lots, residences, businesses, parks, etc.). In the absence of an area(s) in which the general public would have access, receptors will be located three meters from each intersecting roadway and at distances up to at least 50 meters from the intersection. The height of the receptors will be 1.8 meters (i.e., breathing height).

As a screening for CO, worst case meteorological conditions will be modeled (i.e., one meter per second wind speed, wind directions every 10 degrees from 0 to 360, neutral atmospheric stability, a mixing height of 1,000 meters, and a surface roughness length of 175 centimeters). CO concentrations will be estimated for a one-hour averaging period and adjusted to an eight-hour averaging period based on a factor of 0.7.[46] For $PM_{2.5}$, three years of hourly meteorological data will be used. $PM_{2.5}$ concentrations will be estimated for the 24-hour and annual averaging period.

5. GENERAL CONFORMITY

The General Conformity Rule of the federal CAA prohibits federal agencies (including the FAA) from permitting or funding projects or actions within non-attainment areas that do not conform to an applicable SIP. In an O_3 nonattainment area, if a proposed project results in project-related emissions greater than the applicable ***de-minimis*** levels for VOC and NOx, then a formal General Conformity Determination is required. If required, a project is determined to conform to a SIP if one or more of the following is demonstrated:

- The total direct and indirect emissions from the action are specifically identified and accounted in the applicable federally-approved SIP; or,
- All direct and indirect emissions (not just the portion exceeding *de-minimis* threshold(s)) are fully offset such that there is no net increase in emissions of the pollutant or its precursors; or,
- It is demonstrated that the action would not cause or contribute to a new NAAQS violation in the area based on area-wide or local air quality modeling, nor would the action increase the frequency or severity of any existing violation; or,
- State/local air quality governance agree to revise the SIP to accommodate the action's emissions.

If a General Conformity Determination is required for the purpose of demonstrating conformance with the applicable Illinois O_3 SIP, it will be assumed that O'Hare-related construction emissions (ongoing and

[45] USEPA, *User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations near Roadway Intersections*, September 1995, https://www3.epa.gov/scram001/userg/regmod/cal3qhcug.pdf
[46] USEPA, Screening Procedures for Estimating the Air Quality Impact of Stationary Sources Revised, October 1992.

project-related) are/will be included in the IEPA's regional emission estimates for this source of air pollutants. Notably, this same assumption was made, and approved by the IEPA, at the time the Environmental Impact Statement (EIS) was prepared for the O'Hare Modernization Program (2005) and for subsequent Re-evaluations including the recently published (July 2019) Chicago O'Hare Interim Fly Quiet EIS Re-Evaluation.

6. HAZARDOUS AIR POLLUTANTS

HAPs comprise gaseous organic and inorganic chemicals and particulate matter with known or suspected potential to cause cancer (carcinogenic) or other serious health effects (non-carcinogenic). They are commonly emitted by a wide range of airport and non-airport sources, including aircraft, ground support equipment, motor vehicles, home furnaces, evaporating fuel and paints, wood burning, carpets, dry-cleaning of clothing, and industrial facilities.

HAP are pollutants for which there are no NAAQS, but the pollutants are still regulated under the federal CAA because of their potentially adverse effects on human health and the environment. For most airport emission inventories, formaldehyde occurs in the greatest amounts followed by acetaldehyde, acrolein, and 1,3-butadiene. These compounds are emitted in the exhaust of aircraft, APUs, GSE, and ground access vehicles and, to a lesser extent, from boilers, fuel facilities, and other stationary sources. Compounds such as benzene, ethylbenzene, naphthalene, toluene, hexane, styrene, and xylene also occur, but in far lesser amounts.

The USEPA and the FAA developed organic gas speciation profiles and best practices for use in HAP emission inventories of aircraft equipped with turbofan, turbojet, and turboprop engines fueled with kerosene-based jet-A fuel. The development of these profiles and guidance was the combined work of both agencies, taking into account the most recent data and information available.

- *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines.*[47]

  The aircraft-related speciation profile developed from this initiative was used to update the organic gas profile for aircraft in the USEPA SPECIATE database – the agency's multi-sector repository for such data. In this application, a ***speciation profile*** is the amount of organic gases emitted based on the amount of VOC emitted by an emission source.

The FAA also published a document providing an approach to, and technical guidance for, preparing speciated organic gas emission inventories for airport sources.

- *Guidance for Quantifying Speciated Organic Gas Emissions from Airport Sources.*[48]

  This guidance is intended to help ensure that OG/HAPs emission inventories prepared in support of environmental documents prepared by, or on behalf of, the FAA under NEPA are done so consistently. Importantly, it points out that emission inventories of aviation-related organic gases; which include the organic gases identified by the USEPA to be HAP and the organic gases listed in the USEPA's Integrated Risk Information System, are not required by current USEPA regulations. However, in those cases where it is necessary to prepare such an aviation-related HAP emissions inventory, the inventory must be prepared following this guidance and using AEDT.

AEDT calculates emissions for approximately 400 different air toxics. Of these air toxics approximately 45 compounds are classified as HAPs by the USEPA. Annual emissions of air toxic compounds in tons per

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[47] **FAA and USEPA,** *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines (Version 1.0)*, **May 2009,** http://www.epa.gov/nonroad/aviation/420r09901.pdf

[48] **FAA,** *Guidance for Quantifying Speciated Organic Gas Emissions from Airport Sources,* **Version 1, September 2, 2009,** http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/Guidance%20for%20Quantifying%20Speciated%20Organic%20Gas%20Emissions%20from%20Airport%20Sources.pdf

year will be estimated and reported from all airport-related activities including ground access vehicles on the major roadways in the vicinity of the airport and construction activities.

7. GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE

Although there are no federal standards for aviation-related GHG emissions, it is well established that GHG emissions can affect climate.[49] Following procedures detailed in FAA's 1050.1F Desk Reference, FAA's policy is that GHG emissions should be quantified in a NEPA document when there is a reason to quantify emissions for air quality purposes or when changes in the amount of aircraft fuel used are computed/reported. GHG are emitted principally from the combustion of fossil fuels, decomposition of waste materials, and deforestation and are linked to an increase in the earth's average temperature by means of a phenomenon called the "greenhouse effect."

The Council on Environmental Quality (CEQ) has indicated that climate should be considered in NEPA analyses. As noted by CEQ, however, "it is not currently useful for the NEPA analysis to attempt to link specific climatological changes, or the environmental impacts thereof, to the particular project or emissions; as such direct linkage is difficult to isolate and to understand".[50]

GHG emissions associated with aviation are principally in the form of CO_2 and are generated by aircraft, APU, GSE, motor vehicles and an assortment of stationary sources. For the most part, CO_2 emissions from these sources arise from the combustion of fossil fuels (e.g., jet fuel, Av-gas, diesel, gasoline, compressed natural gas) and are emitted as by-products contained in the engine exhausts. Other GHG associated with airport operations include methane (CH_4) and nitric oxides (N_2O), water vapor (H_2O), soot, and sulfates - but are emitted by airports to a far lesser extent than CO_2.

Fuel burn and GHG emissions will be calculated in much the same way as criteria air pollutants. Input data included activity levels or material throughput (i.e., fuel use, vehicle miles traveled, electrical consumption, etc.). Appropriate emission factors will be applied to the input data (i.e., in units of GHG emissions per gallon of fuel). GHG will be inventoried in accordance with Airport Cooperative Research Program *Guidebook on Preparing Airport Greenhouse Gas Emission Inventories* (ACRP Report 11).[51]

49 Massachusetts v. USEPA, 549 U.S. 497, 508-10, 521-23 (2007).

50 FAA, Order 1050.1F, Environmental Impacts: Policies and Procedures, July 16, 2015, https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.current/documentnumber/1050.1

51 Transportation Research Board, Airport Cooperative Research Panel Report 11, *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*, 2009, http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_011.pdf

Attachment A

Meteorological Data Processing and Nitrogen Dioxide Background Concentration for the Terminal Area Plan and Air Traffic Procedures Environmental Assessment for Chicago O'Hare International Airport Memo

KB Environmental Sciences

MEMO

Date: August 7, 2020

To: Amy Hanson, Federal Aviation Administration (FAA)

From: Carrol Fowler and Justin Godin, KB Environmental Sciences, Inc. (KBE)
Mike Ratte, RCH Group

Cc: Diana Wasiuk, Harris Miller & Hanson, Inc.
Ralph Iovinelli, FAA
Mohammed Majeed, FAA
Thomas Cuddy, FAA

Subject: **Meteorological Data Processing and Nitrogen Dioxide Background Concentration for the Terminal Area Plan (TAP) and Air Traffic Procedures Environmental Assessment (EA) for Chicago O'Hare International Airport (O'Hare)**

In support of the TAP EA, air pollutant dispersion modeling is being performed using the FAA's *Aviation Environmental Design Tool* (AEDT, Version 2d Service Pack 2),[1] and United States Environmental Protection Agency's (USEPA)'s American Meteorological Society/Regulatory Model (AERMOD Version 19191)[2]. The more recent versions of AEDT, Versions 3b and 3c, were not used for the assessment because the analysis was initiated before these versions of the model were released. A review of the updates and revisions that resulted in Versions 3b and 3c of AEDT indicates that changes to the model would not likely substantially change the results of the analysis discussed/presented in this Memorandum.

This Memorandum presents the results of an analysis that was performed to better align modeled AEDT/AERMOD one-hour concentrations of nitrogen dioxide (NO_2) to measured concentrations of the pollutant. The emission sources modeled in AEDT/AERMOD, which resulted in the modeled concentrations, were aircraft, ground support equipment (GSE), auxiliary power units (APUs), stationary sources, and motor vehicles (airport and non-airport-related on both on-and off-airport roadways).

The source of the emission rates coded in the AEDT for airport-related sources are:

- Aircraft – The majority (approximately 68 percent) of the aircraft emission rate data in AEDT is from the International Civil Aviation Organization's (ICAO's) Aircraft Engine Emissions Databank. Depending on the engine, other sources include engine manufacturers (e.g., Rolls Royce, Pratt Whitney), and the USEPA's Aircraft Environmental Support Office (AESO).
- GSE – The source of AEDT's emission rate data for GSE is USEPA's NONROAD2006.
- APUs – AEDT's emission rate data for APUs is from ICAO and the International Air Transport Association (IATA).
- Stationary sources – Emission rate data were obtained from O'Hare's Title 5 permit.
- Motor vehicles – Motor vehicle emissions data were obtained from USEPA's MOVES, Version 2014b.

[1] FAA, *Aviation Environmental Design Tool (AEDT) Users Guide*, September 2017, https://aedt.faa.gov/. AEDT 2d, Service Pack 2 was released on September 5, 2019

[2] USEPA Preferred/Recommended Models, *AERMOD Modeling System*, https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models

Of note, so that the concentrations of NO_2 presented in this Memorandum can be directly compared to the one-hour National Ambient Air Quality Standard (NAAQS), the measured and modeled concentrations represent the 98th percentile of the one-hour daily maximum concentrations of the pollutant.

Measured Concentration of NO_2

The Illinois Environmental Protection Agency (IEPA) operates an air monitoring station east of O'Hare in the City of Schiller Park. As shown on the aerial to the right, the station is in close proximity to O'Hare's Runways 28R, 28C, and 22L. The measured one-hour NO_2 concentration at the Schiller Park station in the year 2018, the year that is being evaluated as the Existing Condition for the TAP EA, was 115 $\mu g/m^3$. This concentration is lower (39 percent lower) than the applicable NAAQS of 188 $\mu g/m^3$.

Modeled Concentration of NO_2

The AEDT/AERMOD year 2018 one-hour NO_2 concentration at a receptor located at the Schiller Park monitoring station, without including a background concentration is 155 $\mu g/m^3$. Following standard modeling practice, a background concentration is added to computer model results to account for emissions from sources that are not included in the model (because they are either not included in the modeling effort or the sources are outside the study area but have an influence on pollutant concentrations within the study area). As previously stated, the emission sources modeled in AEDT/AERMOD for the TAP EA Existing Condition were aircraft, ground support equipment, auxiliary power units, stationary sources, and motor vehicles (airport and non-airport-related on both on-and off-airport roadways).

For the TAP EA analysis, background concentrations of carbon monoxide, sulfur dioxide, and particulate matter were derived from year 2016 through 2018 air monitoring data obtained from an IEPA-air monitoring station that is located approximately 12 miles north-northeast of O'Hare in the City of Northbrook. In a previous air quality assessment for O'Hare in which one-hour concentrations were modeled (i.e., the 2015 Re-Evaluation of July 2005 Environmental Impact Statement and September 2005 Record of Decision), the NO_2 background concentration was also derived using data from the Northbrook monitoring station. That is not possible for the TAP EA analysis because the IEPA discontinued measuring NO_2 at the Northbrook air monitoring station in 2015.

As described in the Air Quality Modeling Protocol, the monitoring objectives of other nearby air monitoring stations was reviewed and it was determined that measured NO_2 from a monitoring station located in the City of Nilwood would be most suitable from which to derive background NO_2 concentrations. The IEPA installed the NO_2 monitor in the City of Nilwood for the purpose of measuring background concentrations and pollutant transport from urban areas.

Seasonal/temporal NO_2 background concentrations were derived using year 2018 and 2019 data from the Nilwood station. Depending on the season and hour of the day[3], the concentrations range from 4 to 20 $\mu g/m^3$. Use of the seasonal/temporal background concentrations result in a total modeled year 2018 concentration at the Schiller Park monitoring station receptor of 168 $\mu g/m^3$. This modeled concentration is 53 $\mu g/m^3$ higher (46 percent higher) than the measured concentration of 115 $\mu g/m^3$.

Ninety-eight percent of the modeled concentration at the Schiller Park receptor results from aircraft activity (departure ground roll and taxi emissions contributing 90 percent of the total) and motor vehicles on

[3] USEPA, Additional Clarification Regarding Application of Appendix W Modeling Guidance for the one-hour NO_2 _National Ambient Air Quality Standard, dated March 1, 2011 and Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO_2 National Ambient Air Quality Standard, dated September 30, 2014.

roadways. And, the highest modeled concentrations occur when the wind is from the west, the wind speed is light (3 to 6 miles per hour). For the modeled scenarios, these conditions occur between the hours of 5 and 9 pm when the number of aircraft operations at O'Hare are often greatest.

It should be noted that the total modeled concentration at some of the other modeled receptors are higher than the concentration at Schiller Park (i.e., higher than 168 µg/m³) and the source apportionment results could be different than stated in the above paragraph. These receptors/concentrations are not discussed in this Memorandum because the purpose of the document and the evaluation is to compare modeled to measured concentrations of NO_2 at the Schiller Park monitoring station. It should also be noted that, the results presented in this Memorandum are only preliminary because the Draft EA has not yet been published. Further, results for the future alternatives (Build Out/Interim With Project and No Action) are not yet available and it is possible that the modeled concentrations for future years will be higher than the modeled concentrations for the Existing Condition and higher than the NAAQS.

Efforts That Were Taken to Better Align Modeled/Measured Concentrations

The modeled concentration of NO_2 reported above for the Schiller Park air monitoring station was derived after conducting numerous tests with AEDT/AERMOD to better align the modeled and measured NO_2 concentrations (i.e., without the testing, the modeled concentration without the background concentration was higher than 155 µg/m³). The testing resulted in the following:

- The elimination of runway overruns in AEDT;
- use of urban wind coefficients;
- use of actual aircraft departure stage (i.e., trip) lengths;
- use of site-specific emission ratios/ambient ratios for the conversion of nitrogen oxides (NO_x) to NO_2; and
- use of National Weather Service (NWS)/one-minute Automated Surface Observing System (ASOS) data.

Each of the above bulleted topics is briefly summarized below. With the exception of the elimination of the runway overruns in AEDT, additional details for each topic are provided in the TAP EA Air Quality Modeling Protocol (previously provided).

Elimination of the Runway Overruns

In July of 2019, information was exchanged with Volpe National Transportation Systems Center (Volpe) that identified that AEDT 2d was resulting in runway source overruns. Specifically, the model was including runway endpoints that were extended beyond the physical endpoint of the runways which resulted in excessively high modeled NO_2 concentrations. In September of 2019, Volpe released AEDT 2d Service Pack 2, which addressed the overruns. Use of this version of AEDT resulted in a decrease in the modeled one-hour NO_2 concentrations of approximately 25 percent.

Use of Rural/Urban Wind Coefficients

When executing AERMOD, the selection of appropriate dispersion wind coefficients is made based on the land use that is within three kilometers of the source being modeled. If 50 percent or more of the total area is comprised of the land use types, which are heavy industrial, light-to-moderate industrial, commercial, or compact residential, the USEPA's *Guideline on Air Quality Models*[4] recommends using urban dispersion coefficients. Otherwise, using rural coefficients is advised. To be consistent with historical assessments prepared for O'Hare and to provide conservative results, AEDT was initially executed using the rural coefficients. O'Hare is in an urban area; therefore, urban dispersion coefficients were also executed for the current TAP EA analysis.

[4] Appendix W to Part 51 – Guideline on Air Quality Models. http://www.ecfr.gov/cgi-bin/text-idx?SID=e6a5b817b94abf58460f48e032d9a39e&mode=40:2.0.1.1.2.23.11.5.37&rgn=div9

The use of the urban dispersion coefficients resulted in a decrease in the one-hour NO_2 concentrations of approximately 15 percent when compared to use of the rural coefficients.

Actual/Default Departure Stage Length

When executing AEDT, the selection of stage (i.e., trip) length is a function of aircraft departure weight. To provide a conservative analysis, the second highest departure weight/stage length is generally used. For the TAP EA, both the second highest weight and the actual stage length were evaluated with use of the actual stage length resulting in a decrease in the one-hour NO_2 concentrations of approximately two percent.

Site-specific Emission Ratios/Ambient Ratios for NOx to NO_2 Conversion

AEDT/AERMOD do not directly provide concentrations of NO_2. Instead, the emission rates and dispersion results from AEDT/AERMOD are for NO_x. For the purpose of making a comparison to the NAAQS, the NO_x concentrations are post-processed and converted to NO_2. An evaluation of approaches to converting NO_x to NO_2 was performed. A detailed description of the evaluation is provided in a separate memorandum entitled *Nitrogen Dioxide (NO2_ Conversion Methodologies Evaluation for the Terminal Area Plan (TAP) and Air Traffic Procedures Environmental Assessment (EA) for Chicago O'Hare International Airport (O'Hare), August* XX, 2020.

The evaluation of the USEPA NO_x to NO_2 conversion approaches involved comparing modeled NO_2 concentrations using each approach to measured NO_2 concentrations from the Schiller Park monitoring station. The comparison was performed using statistics that describe the general distribution of the data (i.e., descriptive statistics) and statistics that compare similarities between the modeled and measured values (i.e., validation statistics). Overall, the comparison indicated that the Ambient Ratio Method 2 (ARM2) method using site specific values is the best method for estimating NO_2 because this method resulted in modeled concentrations of NO_2 that are closest to the measured concentration (155 $\mu g/m^3$ and 115 $\mu g/m^3$, respectively). As previously stated, the modeled value does not include a background concentration.

Meteorological Data Sets

There is an ASOS at O'Hare. Due to construction at the airport, the location of the ASOS has changed in recent years. The previous location (prior to the summer of 2018) and the current location, west of Taxiway Z, are depicted on the aerial to the right.[6] The USEPA's *Guideline on Air Quality Models* provides three options for the selection of meteorological (met) data to conduct a dispersion modeling analysis. As stated, analysts should:

1. Use five years of adequately representative National Weather Service (NWS) or comparable met data, or
2. at least one year of site-specific data, or
3. at least three years of prognostic met data.

USEPA's guidance further states that if up to five years of site-specific data are available, use of the data is preferred for an air quality analysis. For the TAP EA, the most recent three years of met data (2016 through 2018) were evaluated and the year that resulted in the highest predicted concentration, year 2017, is being used for the analysis. Notably, the use of three years of site-specific met data is consistent with the air quality analysis methodology used for the *Written Re-Evaluation of the O'Hare Modernization Environmental Impact Statement for the Interim Fly Quiet Runway Rotation Plan* (July 2019).

[6] Previous location: N 41° 59' 15.1672", W 87° 55' 54.8027". Current location: N 41° 57'36.6092", W 87° 55'53.8006"

The FAA-recommended met processing methods are described in FAA's *Using Weather Data in AEDT* (April 2019). There are three recommendations:

- Use NWS data.
- Use NWS with one-minute Automated Surface Observing System (ASOS) data. Use of this data fills in data gaps that may exist in the wind speed and wind direction data.
- Use prognostic met data.

Because use of ASOS data produces more robust results, the NWS data method was not evaluated. Additionally, because the results of the evaluation using the prognostic data was not significantly different than the results with the ASOS data, only one year of prognostic meteorological data (year 2018) was evaluated.

Prior to executing AERMOD, the met data was processed using AERMET. AERMET creates two files: a surface data file and an upper air profile data file. AERMET was invoked using guidance from both the USEPA's *AERMET User's Guide* (dated August, 2019) and FAA's *Using Weather Data in AEDT*. A review of the recent AERMET update indicates that changes to the model would not likely substantially change the results of the analysis discussed/presented in this Memorandum.

According to FAA's guidance, there are eight USEPA-approved processing methodologies that have differing levels of effectiveness and applicability to specific dispersion modeling circumstances. The processing methodologies can be used singularly or in combination. The eight processing methodologies, and how they were applied to the analysis of the Existing Condition using ASOS data, are described below:

1. Randomization of Wind Direction - The NWS wind direction is reported to the nearest 10 degrees (°). The randomization procedure adds a single digit random number to each wind direction, and then subtracts 4° from the modified wind direction. This has the effect of randomizing the wind direction within a -4° to +5° window. For example, a wind direction of 270° would be randomized to a value anywhere between 266° and 275°. FAA guidance suggests including the randomization of wind direction so it was included in the development of the met data. Of note, the randomization procedure has no effect on wind direction when using one minute ASOS data.
2. Surface Friction Velocity Adjustment - Adjustment of the surface friction velocity (u*) for low wind speed stable conditions is an option in AERMET to address AERMOD's tendency to over predict concentrations from some emission sources under stable, low wind speed conditions. The air quality analysis performed for previous National Environmental Policy Act (NEPA)-related projects for O'Hare (e.g., a 2015 Environmental Impact Statement Re-Evaluation and the analysis for the Interim Fly Quiet program) suggests concentrations are over predicted when the u* adjustment is disabled. Further, a sensitivity analysis that was performed for the TAP EA Existing Condition found that disabling the u* adjustment resulted in one-hour NO_2 concentrations that were slightly higher (three percent higher) than when the u* adjustment was enabled. Therefore, for the TAP EA, the u* adjustment was enabled.
3. Wind Speed Truncation - When performed, the truncation adds 0.5 knots (0.26 meters/second (m/s)) to all ASOS-based wind speeds to compensate for the bias that is introduced because the wind speed is truncated, rather than rounded, to whole knots. The adjustment, or lack thereof, affects the met data output, because it increases the number of records that exceed three knots. This three-knot threshold is important because as a result of AERMOD's inability to simulate accurate concentrations at low wind speeds, AERMET eliminates all records for hours with wind speeds below three knots. A sensitivity analysis that was performed for the Existing Condition found that disabling the ASOS wind speed truncation resulted in slightly higher (two

percent higher) one-hour NO_2 concentrations than when enabling the truncation. Therefore, the truncation of ASOS wind speeds was enabled in the development of the TAP EA met data.

4. Treatment of Calm Wind Conditions - When wind speeds are below 0.5 m/s, conditions are considered "calm". For the TAP EA analysis, the AERMET processing option of truncating wind speeds was invoked and the threshold wind speed was set to 0.5 m/s. Current USEPA guidance sets the wind speed threshold for site-specific meteorological monitoring at 0.5 m/s (*Meteorological Monitoring Guidance for Regulatory Modeling Applications*). Notably, for the met data used in the analysis, less than one percent of the hours of data were considered calm (11 of the 8,760 hours of data).
5. Cloud Cover - AERMET provides options regarding substitution of missing cloud cover data based on linear interpolation/extrapolation across one- to two-hour gaps in the available data. AERMET guidance suggests enabling missing cloud cover substitution. Therefore, the application of missing cloud cover substitution was enabled in the development of the met data.
6. Temperature Data - Similar to cloud cover, AERMET provides options regarding substitution of missing temperature data based on linear interpolation/extrapolation across one- to two-hour gaps in the available data. AERMET guidance suggests enabling missing ambient temperature substitution. Therefore, the application of missing ambient temperature substitution was enabled in the development of the met data.
7. Surface Characteristics - AERSURFACE can be used to determine the surface characteristics of an area for input to AERMET.[7] AERSURFACE can also be used to assess the land use cover and determine the appropriate monthly surface roughness length, Bowen ratio, and albedo input based on land use cover, soil moisture, and seasonal conditions within twelve directional sectors per FAA guidance.
8. Bulk Richardson Number - The processing methodology provides an alternative scheme for estimating heat flux under stable conditions, based on the use of a low-level change in temperature measurement and a single wind speed measurement. Use of the Bulk Richardson Number does not apply to the analysis being performed for the TAP EA due to the type of met data available from the NWS site.

Based on experience and testing, adjusting the surface friction velocity (the second processing methodology above) and adjusting the ASOS wind speeds by truncation (the third methodology above) have the greatest effect on modeled concentrations.

Prognostic (i.e. model forecasted) data is a relatively new option for developing weather data for the purpose of dispersion modeling. Prognostic data is generated using three-dimensional mesoscale computer models. For the analysis presented in this Memorandum, the Weather Research and Forecasting (WRF) model, the primary prognostic-related meteorological model used by the USEPA, and the Mesoscale Model Interface (MMIF) program were used to prepare the AERMOD input files. Although there is site-specific data for O'Hare, the use of prognostic data was also evaluated for the purpose of determining its effect on predicted concentrations of one-hour NO_2. In the development of the prognostic data, default settings were used for physics and dynamics options, vertical layers, and output variables.

The results of the evaluation revealed that the AEDT/AERMOD predicted one-hour NO_2 concentrations using the ASOS data are similar to the concentrations using the prognostic data (i.e., 155 versus 144 $\mu g/m^3$, respectively, at the receptor representing the Schiller Park monitoring station). Because the data are similar and development of the prognostic data is labor intensive, it was concluded that actual site-specific data is better than forecast data. Therefore, the ASOS data was used in the TAP EA evaluation of Existing Conditions.

[7] AERSURFACE is a tool that processes land cover data to determine the surface characteristics for use in AERMET.

Summary

This Memorandum presents the results of an analysis that was performed to compare modeled AEDT/AERMOD one-hour concentrations of NO_2 to measured concentrations of the pollutant. The testing and assumptions that were made to better align the modeled and measured NO_2 concentrations are presented, including methods of converting NO_x to NO_2, and methods for processing the met data used to prepare the dispersion analysis.

The analysis results reveal the following:

- Without considering a background concentration, the modeled one-hour NO_2 concentration at a Schiller Park air monitoring station receptor is 155 μg/m³ compared to a measured concentration of 115 μg/m³.
- With the addition of seasonal/temporal background concentrations derived from an air monitoring station that is specifically operated by the IEPA to measure background concentrations, the total modeled concentration at the Schiller Park receptor is 168 μg/m³. This concentration is 46 percent higher than the measured concentration at the same location.

It should be noted that while the total modeled concentration for the Schiller Park receptor is below the applicable NAAQS (188 μg/m³), there are modeled concentrations at other receptors for which the total modeled concentration is higher than the concentration for the Schiller Park receptor (i.e., higher than 168 μg/m³). Further, the analysis results presented in this Memorandum are for the TAP EA Existing Condition and are preliminary results since the Draft Environmental Assessment has not been released. Additionally, results for the future alternatives (Build Out/Interim With Project and No Action), which are not yet available, could be higher than the results for the Existing Condition and higher than the NAAQS.

Because, as demonstrated in this Memorandum, AEDT/AERMOD is over predicting one-hour NO_2 concentrations, there is a need to either 1) identify additional refinements to the modeling process or 2) implement a strategy/strategies such that the results presented in the TAP EA are not overly conservative. Without either, there is a potential for the analysis results to indicate an exceedance of the one-hour NO_2 NAAQS in the vicinity of O'Hare when, in fact, IEPA measured concentrations of the pollutant do not exceed the NAAQS.

Attachment B

Nitrogen Dioxide Conversion Methodologies Evaluation for the Terminal Area Plan and Air Traffic Procedures Environmental Assessment for Chicago O'Hare International Airport Memo

KB Environmental Sciences

MEMO

Date: August 27, 2020

To: Amy Hanson, Federal Aviation Administration (FAA)

From: Carrol Fowler and Justin Godin, KB Environmental Sciences, Inc. (KBE)
Mike Ratte, RCH Group

Cc: Diana Wasiuk, Harris Miller & Hanson, Inc.

Subject: **Nitrogen Dioxide (NO_2) Conversion Methodologies Evaluation for the Terminal Area Plan (TAP) and Air Traffic Procedures Environmental Assessment (EA) for Chicago O'Hare International Airport (O'Hare)**

Air dispersion modeling is being performed in support of the Terminal Area Plan and Air Traffic Procedures Environmental Assessment (TAP EA) for Chicago O'Hare Airport (O'Hare). For the air pollutant NO_2, an evaluation has been performed to identify the most suitable nitrogen oxide (NO_x) to NO_2 conversion method. This Memorandum presents the results of the evaluation.

Currently, the United States Environmental Protection Agency (USEPA) recommends a three-tiered approach to converting NO_x to NO_2 concentrations for dispersion modeling. The three tiers are described below:[1,2]

- Tier 1 – Assume full conversion (i.e., 100 percent) of NO_x to NO_2.
- Tier 2 – Use the Ambient Ratio Method 2 (ARM2). The ARM2 method applies an ambient ratio of NO_2/NO_x to the modeled NO_x concentration. The default upper and lower limits of the ambient ratios are 0.9 and 0.5, respectively. However, the ratios may be adjusted to represent site specific values.[3] For the TAP EA analysis, the dispersion modeling was also performed using site-specific NO_2 to NO_x maximum and minimum ambient ratios of 0.717 to 0.186, respectively. These ratios were developed using data from IEPA's Schiller Park air monitoring station (a sample size of 8,523 hours). The highest NO_2 concentrations are more reflective of the minimum NO_2 to NOx ambient ratio than the maximum NO_2 to NOx ambient ratio.[4] For example, if the modeled NOx concentration is estimated at 160 ppb, the estimated NO_2 concentration would be approximately 160 times 0.22 or 35 ppb. If the modeled NOx concentration is estimated at 20 ppb, the estimated NO_2 concentration would be approximately 20 times 0.65 or 13 ppb.
- Tier 3 – Use the Ozone Limiting Method (OLM) or Plume Volume Molar Ratio Method (PVMRM). As discussed in USEPA's *Guideline on Air Quality Models*, OLM is more appropriate for analyses with area sources, near-surface releases, or where plume overlap from multiple sources will occur and PVMRM is more appropriate for analyses with relatively isolated and elevated sources. For these methods, default and variable in-physics stack ratios (ISRs) were evaluated with measured hourly ozone data. For aircraft, the NO_2 fraction of NO_x decreases with

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[1] USEPA, *Appendix W of 40 CFR Part 51. July 1,* 2011 http://www.gpo.gov/fdsys/pkg/CFR-2011-title40-vol2/pdf/CFR-2011-title40-vol2-part51-appW.pdf

[2] FR 5182, *USEPA Revisions to the Guideline on Air Quality Models: Enhancements to the AERMOD Dispersion Modeling System and Incorporation of Approaches to Address Ozone and Fine Particulate Matter, January 2017,* https://www3.epa.gov/ttn/scram/appendix_w/2016/AppendixW_2017.pdf

[3] Of note, the ARM2 method was designated as the best performing method as part of the O'Hare 2015 Re-Evaluation Environmental Impact Statement when using 2002 and 2014 data.

[4] As noted in Table 1, the highest modeled NOx concentration (391 ppb) and the highest ARM2ss NO_2 concentration (89 ppb) yields a NO2/NOx ratio of 0.228, which means that the minimum ambient ratio of 0.186 is not impacting the model results. That is, use of a minimum ambient ratio of 0.228 or lower yields the same results.

engine power, from over 98 percent at the lowest power setting (i.e., four percent rated thrust or taxi/idle) to under 10 percent at higher power settings (65 to 100 percent rated thrust or climbout/takeoff).[5]

For the purpose of determining the most suitable conversion methodology, the following seven approaches were evaluated:

- Approach 1 (Tier 1): Full Conversion (referred to as "FULL" in this Memorandum).
- Approach 2 (Tier 2): ARM2 with default upper and lower ambient ratios of 0.9 and 0.5, respectively (ARM2def).
- Approach 3 (Tier 2): ARM2 with site specific upper and lower ambient ratios of 0.717 and 0.186, respectively (ARM2ss).
- Approach 4 (Tier 3): OLM with a default ISR of 0.5 (OLM).
- Approach 5 (Tier 3): OLM with variable ISRs (OLMv).
- Approach 6 (Tier 3): PVMRM with a default ISR of 0.5 (PVMRM).
- Approach 7 (Tier 3): PVMRM with variable ISRs (PVMRMv).

Modeled concentrations of NO_2 were derived using the Federal Aviation Administration's (FAA's) Aviation Environmental Design Tool (AEDT, Version 2d Service Park 2) and the American Meteorological Society (AWS)/USEPA Regulatory Model (AERMOD, Version 19191). Measured year 2017 NO_2 concentrations were obtained from an Illinois Environmental Protection Agency (IEPA) operated air monitoring station that is located on the southeast side of the airport in the City of Schiller Park. For the evaluation of the OLM and PVMRM which requires measured ozone concentrations, ozone data were obtained from a monitor located approximately 18 miles northwest of the airport within the City of Elgin. Ozone data was not obtained from the Schiller Park monitor because the data are not available.

Hourly year 2018 airport activity was modeled in the AEDT using temporal factors that describe the relationship of one period of time to another period of time. In AEDT, temporal factors are applied to represent varying levels of activity as a fraction of a peak hour. To represent aircraft activity at O'Hare though an entire calendar year (each hour of the day, each day of the week, and each month of the year), operational profiles were used. The operational profiles were developed using O'Hare-specific activity data from FAA's Operations and Performance Data (OPSNET). Notably, because the commercial activity at airports operates using schedules, a comparison of the activity at O'Hare hourly, daily, and monthly would show very little variance. The operational profiles are provided in the *Air Quality Modeling Protocol* for the Terminal Area Plan and Air Traffic Procedures EA. Use of the 2018 airport activity data is appropriate because the number of aircraft operations that occurred in the years 2017 and 2018 were similar (within four percent of each other) and, as stated above, hourly, daily, and monthly activity levels at O'Hare have very little variance.

Evaluation Methodology

The evaluation methodology involved comparing the modeled NO_2 concentrations using each of the approaches to measured (i.e., monitored) NO_2 concentrations. The comparison was performed using statistics that describe the general distribution of the modeled and measured data (i.e., descriptive statistics) and statistics that are used to compare similarities between the modeled and measured values (i.e., validation statistics). Notably, the conversion evaluation relied on both paired in time and unpaired in time statistics.

It should be noted that before making the comparison between modeled and measured NO_2 concentrations the measured data was screened to eliminate zero values. The zero values are likely due to equipment calibration, equipment maintenance, and other interruptions in the data collection. Zero values were also removed from the modeled concentrations because the values are likely due to atypical data in the meteorological dataset (a year 2017 dataset). A total of 8,760 hourly NO_2 concentrations were obtained for the year 2017 (24 hours for 365 days) from the Schiller Park monitoring station. Of the 8,760 hours of *measured* data, 160 hours (approximately two percent of the values) were zero and were therefore removed from the dataset. The zero values are of least importance to the purpose of the evaluation of the NOx to NO_2 conversion methodologies as the focus of the evaluation is on higher concentrations that could indicate a potential exceedance of the National Ambient Air Quality Standards (NAAQS). The one-hour NAAQS for ambient concentrations of NO_2 is 100 parts per billion (ppb).

Descriptive Statistics

Statistics such as means, standard deviations, medians, and minimum/maximum values were examined for both the measured and modeled NO_2 concentrations (**Table 1**). As shown, the standard deviation and, more importantly, the maximum value derived using the ARM2ss method are closest to the measured concentrations.

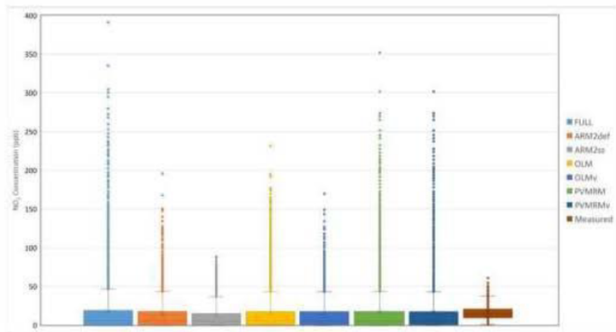
It is noteworthy that while closest to the measured concentration, the ARMss method produced a maximum value that is approximately 46 percent greater than the measured value. This is notable because the measured value is a result of emissions from all sources of pollutants (airport and non-airport) while use of the ARMss method only considers airport-related sources. Use of the ARMss method would therefore provide conservatively high estimates of NO_2. It is further noteworthy that all of the other evaluated approaches (i.e., FULL, ARM2def, OLM, etc.) produced maximum values of NO_2 ranging from 179 to 541 percent greater than the measured concentration.

Table 1 – Descriptive Statistics (ppb)

Statistic	Measured	FULL	ARM2def	ARM2ss	OLM	OLMv	PVMRM	PVMRMv
Mean	16	16	12	10	13	11	14	14
Standard Deviation	9	33	20	18	24	19	30	29
Median	14	3	3	2	3	3	3	3
Minimum	1	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Maximum	61	391	196	89	232	170	352	302

Box plots (also known as box-and-whisker plots) were also prepared. Box plots are visual depictions of a dataset's quartiles and are useful in visualizing a given dataset's range and outliers. Quartiles and interquartile ranges (IQRs) describe the statistical distribution of a given dataset and are used to create box plots. A box plot segregates a dataset in to four quartiles based on the spread of the data. The IQR ("the box") represents the middle 50 percent of the data with 25 percent of the data falling on either side of the IQR. The median concentration is designated by a bar within the IQR. The "whiskers" on either ends of the IQR box represent Quartiles 1 (Q1) and 3 (Q3) where 25 percent of the data lie (the data on each side of the IQR). The outer reaches of the "whiskers" represent the maximum (and minimum) non-outlier concentrations. Outliers are plotted outside of the "whiskers" on either end of the quartile range. Box plots are provided for the year 2017 data in **Figure 1**. As shown, with respect to higher concentrations, the modeled ARM2ss concentrations (gray plot) are most similar to the measured concentrations, which are previously stated are of greatest importance for regulatory purposes.

Figure 1 - Box Plot of One-Hour Modeled and Measured NO_2 Concentrations (ppb)



The number and distribution of hours during which measured concentrations were within certain ranges were also compared to the number/distribution of hours for each of the evaluated approaches. These data are provided in **Table 2**. The measured NO_2 concentrations all fall within the range of 0-100 ppb, with 12 occurrences in the 51-100 range. As shown, the ARM2ss NO_2 concentrations also fall within the range of 0-100 ppb with all of the other modeled datasets resulting in some concentrations above 100 ppb. A greater percentage of hours were estimated to be between 51 and 100 ppb with the ARM2ss method compared to the number of hours in this range for the measured values. Therefore, use of the ARM2ss method would also result in conservatively high estimates of the annual mean concentration of NO_2.

Table 2 – Concentration Frequency

NO2 Level (ppb)	Number of Hours							
	Measured	FULL	ARM2def	ARM2ss	OLM	OLMv	PVMRM	PVMRMv
>0-50	8,588	7,005	6,848	6,541	6,860	6,990	6,844	6,854
51-100	12	382	592	501	466	452	365	372
101-150	--	196	49	--	141	49	183	167
151-200	--	83	3	--	24	1	58	61
201-250	--	35	--	--	1	--	29	26
251-300	--	14	--	--	--	--	6	5
> 300	--	3	--	--	--	--	2	1

Validation Statistics

Model accuracy evaluation techniques were also applied to the modeled and measured datasets. The results from these techniques indicate how each approach method corresponds to measured concentrations and how well the techniques compare to each other. The following briefly describes each technique:

- **Maximum Concentrations Reported** – The maximum concentrations were examined for each method to determine if the models report realistic upper limits and concentrations.

- **Quantile-Quantile Plots (Q-Q Plots)** – Q-Q Plots provide a graphical method of comparing two probability distributions by plotting their quantiles against each other. For this analysis, the modeled NO_2 concentrations were compared to measured concentrations, unpaired in time.[7]
- **Scatterplots** – Scatterplots use Cartesian coordinates to illustrate the variables for a set of data. For this analysis, modeled versus measured NO_2 concentrations were paired in time before being compared.
- **Mean Squared Error (MSE)** – MSE is an important statistical test that is used to examine the performance of a model. This test is a measure of the squares of difference between modeled and measured concentrations.
- **Robust High Concentration (RHC)** – RHC is an aggregation statistic representing the highest concentrations from modeled or measured datasets. Similar to a geometric mean, the RHC helps to smooth out the effects of extreme values. RHC is calculated through a tail exponential fit to the high end of the frequency distribution of observed and predicted values.

The following provides the results of each of the above techniques when comparing the modeled to measured NO_2 concentrations.

Maximum Concentrations Reported

The top ten maximum modeled and measured daily one-hour NO_2 concentrations (unpaired in time) are presented in **Table 3**. As shown, the values with the ARM2ss method are closest to the measured values. Further, because the daily maximum ARM2ss values are all higher than the measured values, use of the ARM2ss method would result in conservatively high estimates of one hour concentrations of NO_2.

Table 3 - Top 10 Maximum Daily One Hour NO_2 Concentrations (ppb)

Rank	Measured	Full Conversion	ARM2def	ARM2ss	OLM	OLMv	PVMRM	PVMRMv
1	61	391	196	89	232	170	352	302
2	56	335	168	86	195	149	302	274
3	55	304	152	84	191	143	274	270
4	55	300	150	83	177	135	270	265
5	53	295	147	83	176	134	265	254
6	52	282	141	81	174	127	254	241
7	51	281	140	81	165	125	252	237
8	50	280	140	81	164	125	245	229
9	49	273	136	80	163	124	241	228
10	49	268	134	80	163	124	234	228

When determining if an ambient concentration has exceeded the one-hour NAAQS for NO_2, the 98th percentile (i.e., the eighth highest) one-hour daily maximum concentration is compared to the standard. As shown in Table 3, when considering the eighth highest NO_2 concentrations for each of the evaluation approaches, while still an overestimation, the ARM2ss method is the closest to the measured value (81 and 50 ppb, respectively).

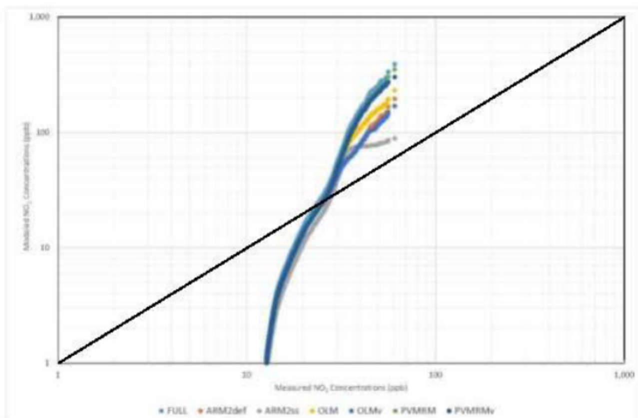
Quantile-Quantile Plots (Q-Q Plots)

The Q-Q plots comparing the distribution of the modeled and measured NO_2 concentrations, unpaired in time, are presented in **Figure 2**. Note that these plots are not an assessment of model accuracy, rather they are a comparison of distributions and ranges. Q-Q plots are ranked pairings of modeled and measured concentrations that are useful when comparing the frequency distributions of two datasets. A given quantile

[7] This approach is used by the USEPA and is widely accepted as a comparison of modeled to measured values (Blewitt and Wood, 2014).

of the modeled concentrations is plotted against the same quantile of the monitored concentrations. If the distributions are similar, they will fall on the 1:1 (x = y) line (plotted for reference). Over-predictions are plotted above the 1:1 (x = y) line, and underpredictions are plotted below the 1:1 (x = y) line. As shown on Figure 2, the models overpredict at higher concentrations and underpredict at lower concentrations. Again, although the Q-Q Plot indicates that all of the NOx to NO_2 evaluation methods greatly overpredict concentrations of NO_2, the ARM2ss method has the closest overall alignment to the measured conditions. Of note, the ARM2ss shows a leveling (or capping; as shown by the right portion of the grey plot line) of NO_2 concentration at the highest concentration which signifies less of an overestimation compared to the other methods.

Figure 2 – Q-Q Plot of One-Hour Modeled and Measured NO_2 Concentrations (ppb)



Scatterplots

For this analysis, modeled NO_2 concentrations were compiled and plotted against the corresponding, paired in time, measured ratios (**Figure 3a through 3g**). A one to one (x = y) reference line has also been added as an indication of whether a model conversion method over- or under-predicts the concentrations. Over-predictions occur above this line and under-predictions occur below. As shown, the ARM2ss is the only method that is not significantly over-predicting NO_2 concentrations (the overprediction is indicated by the number of data points above the reference line). Again, the ARM2ss shows a capping of NO_2 concentration at the highest concentration such that Figure 3c does not show a stovepipe (as shown by limited to no modeled NO_2 concentrations above 100 ppb and more data points clustered near the one to one reference line) which signifies less of an overestimation compared to the other methods.

Figure 3a - Scatterplot of One-Hour Modeled vs. Measured NO_2 Concentrations (ppb): FULL

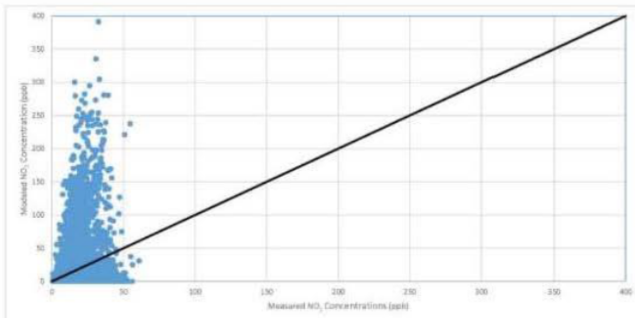


Figure 3b - Scatterplot of One-Hour Modeled vs. Measured NO_2 Concentrations (ppb): ARM2def

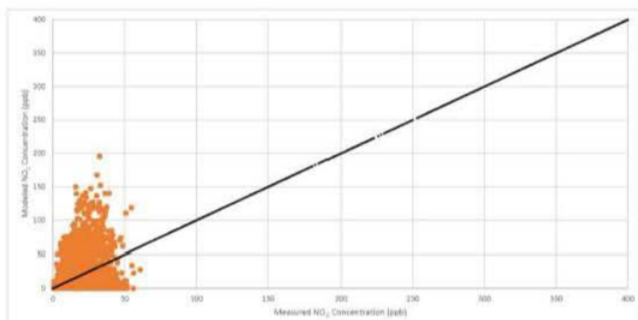


Figure 3c - Scatterplot of One-Hour Modeled vs. Measured NO_2 Concentrations (ppb): ARM2ss

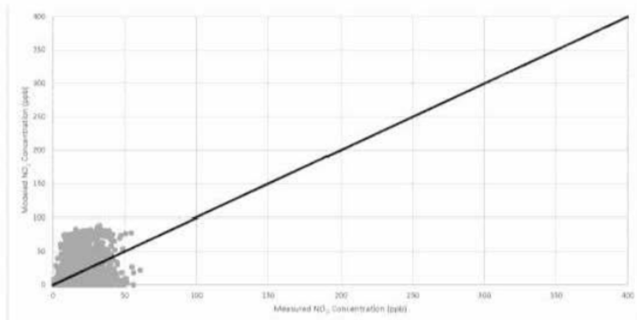


Figure 3d - Scatterplot of One-Hour Modeled vs. Measured NO_2 Concentrations (ppb): OLM

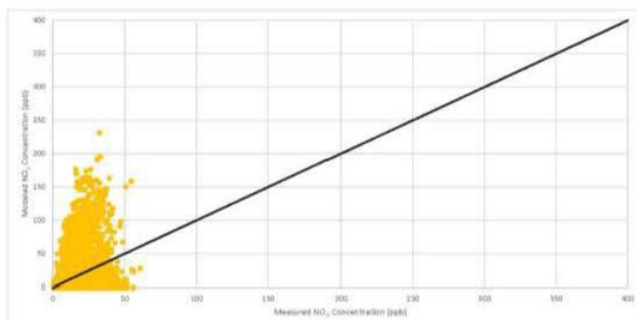


Figure 3e - Scatterplot of One-Hour Modeled vs. Measured NO_2 Concentrations (ppb): OLMv

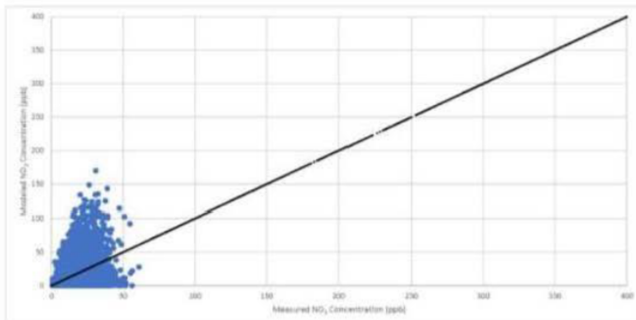


Figure 3f - Scatterplot of One-Hour Modeled vs. Measured NO2 Concentrations (ppb): PVMRM

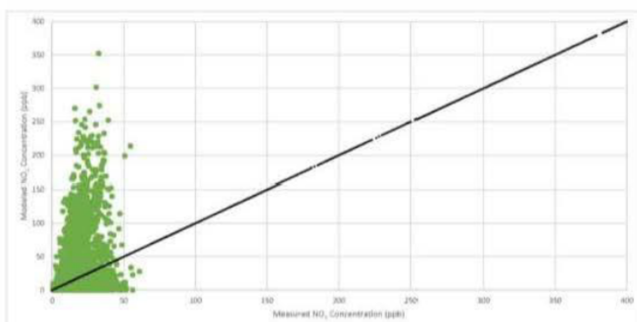
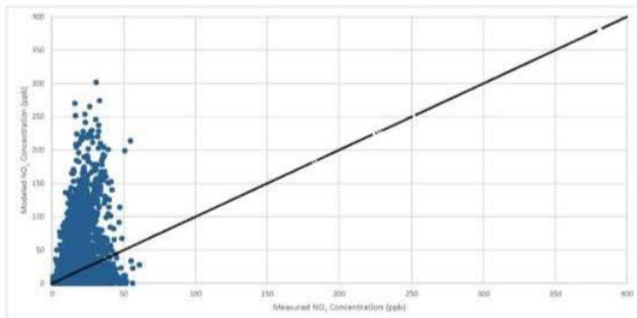


Figure 3g - Scatterplot of One-Hour Modeled vs. Measured NO_2 Concentrations (ppb): PVMRMv



Mean Squared Error (MSE)

The MSE is a measure of the squares of the difference between modeled and measured concentrations. The lower the MSE, the closer the modeled concentrations are to the measured concentrations. MSE concentrations are provided on **Table 4**. As shown, the ARM2ss conversion method has the lowest MSE.

Table 4 – Mean Squared Errors (ppb)

Statistic	FULL	ARM2def	ARM2ss	OLM	OLMv	PVMRM	PVMRMv
Mean Square Error	1,051	419	344	560	361	853	811

Robust Highest Concentration (RHC)

Because of the emphasis on the maximum measured versus modeled one-hour NO_2 concentrations, resulting from the need to compare modeled values to the NAAQS and the overprediction of one-hour NO_2 concentrations by AEDT/AERMOD, an evaluation of RHC values is of most interest in the evaluation of the conversion methodologies.

For the evaluation of the methodologies, RHC values were calculated using USEPA guidance which stipulates that a nominal number of 26 values be assumed to exceed the threshold value in the calculation of RHCs. The USEPA's formula for deriving the RHC is provided below.[8]

$$RHC = X(N) + [X - X(N)] \times \ln[(3N - 1)/2]$$

Where:

$X(N) = N^{th}$ largest concentration.

X = average of the N-1 largest concentrations.

N = number of concentrations exceeding the threshold value (i.e., 26).

The equation input and the resultant RHC values for each of the evaluated methodologies are provided in **Table 5**. As shown, the RHC value for the ARM2ss conversion method (87 ppb) is closest to the RHC value for the measured concentrations (64 ppb). Calculated NO_2 to NO_X ratios are also provided in **Table 5**. As shown, the ratio for the ARM2ss method (0.24) is closest to the ratio of the measured concentrations

[8] USEPA, Protocol for Determining the Best Performing Model, September 1992.

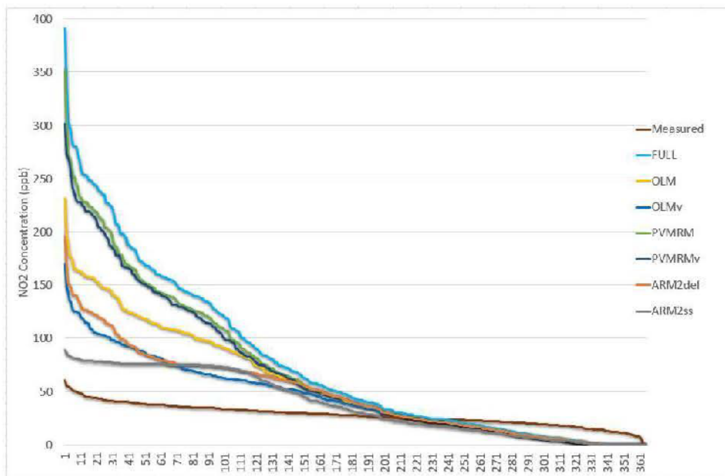
(0.18). Because the ratios of the RHC for the other methods are much higher, therefore the other methods do not perform as well as the ARM2ss.

Table 5 – RHC of Modeled and Measured NO_2 Concentrations

Factor	Measured	FULL	ARM2def	ARM2ss	OLM	OLMv	PVMRM	PVMRMv
8th Highest Daily Maximum Concentration (ppb)	50	280	140	81	165	125	246	229
X(N) - 26th Highest Concentration (ppb)	42	235	117	78	147	103	205	199
X – Average of the 25 Highest Concentrations (ppb)	48	268	134	80	165	120	241	230
RHC (ppb)	64	357	179	87	214	166	336	312
Ratio of RHC Values (NOx to NO2)	0.18	--	0.50	0.24	0.60	0.46	0.94	0.87

Figure 4 illustrates the ranked daily 1-hour maximum NO_2 concentrations. Note that the X axis represents the ranking of the daily concentrations not the day that the levels were measured/modeled. The ranking is shown for the seven conversion methodologies discussed in this Memorandum. As shown, the ARM2 with site specific ambient NO_2 ratios is better performing than the other methods. However, even this method provides an overprediction of approximately 50 $\mu g/m^3$ for the modeled concentrations when compared to the measured values.

Figure 4 – Maximum Daily One Hour Modeled and Measured NO_2 Concentrations (ppb)



According to USEPA, errors due to the limitation of the algorithms implemented in the air dispersion model in the highest estimated concentrations of +/- 10 percent to 40 percent are typical.[9] The source parameters used to model emission sources add uncertainty. Discrepancies also might exist in actual emissions characteristics of an emission source and its representation in the dispersion model. Therefore, model overprediction is an expectation and provides a margin of safety when evaluating air quality impacts.

Modeled/Measured NOx

In addition to use of the computer models to identify the most suitable NO_x to NO_2 conversion method, AEDT/AERMOD were also used to compare modeled concentrations of NO_x to measured NO_x obtained from the air monitoring station in the City of Schiller Park. The top ten maximum modeled and measured daily one-hour NOx concentrations (unpaired in time) are presented in **Table 6**. As shown, the modeled concentrations are greater than the measured concentrations and the pattern is similar to the comparison of NO_2 concentration (see Table 3).

Table 6 – Top 10 Maximum Daily One Hour NOx Concentrations (ppb)

Rank	Measured	Modeled
1	259	391
2	250	335
3	236	304
4	225	300
5	218	295
6	209	282
7	202	281
8	183	280
9	180	273
10	177	268

Figure 5 illustrates the ranked daily 1-hour maximum modeled and measured NO_x concentrations. As shown, the pattern of modeled and measured NO_x concentration is similar to the pattern (model overestimation of the highest concentrations and underestimation of the lowest concentrations) of modeled and measured NO_2 concentrations (see Figure 4). This comparison suggests that the model is providing an adequately similar tool for the estimation of both NO_x and NO_2 concentration.

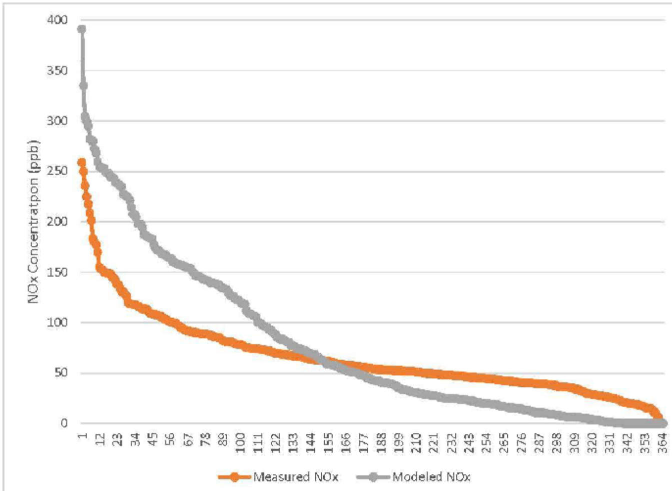
Summary and Conclusions

As stated previously, the evaluation for which results are presented in this Memorandum was performed to identify the most suitable NO_x to NO_2 conversion method of the methods in USEPA's three-tiered approach:

- Tier 1 – Full conversion of NO_x to NO_2.
- Tier 2 – ARM2 method using both default and site-specific values.
- Tier 3 – OLM and PVMRM methods with both default and variable ISRs.

[9] United States Environmental Protection Agency, *Guideline on Air Quality Models (Revised), 40 Code of Federal Regulations, Part 51, Appendix W*, November 2005, Accessed July 7, 2020 at: https://www3.epa.gov/scram001/guidance/guide/appw_05.pdf.

Figure 5 – Maximum Daily One-Hour Modeled and Measured NO_x Concentrations (ppb)



The evaluation methodology involved comparing the modeled NO_2 concentrations using each of the above approaches to measured NO_2 concentrations using statistics that describe the general distribution of the data (i.e., descriptive statistics) and statistics that compare similarities between the modeled and measured values (i.e., validation statistics). Overall, the comparisons indicate that the ARM2 method using site specific values (ARM2ss) is the best method for estimating NO_2 because the method resulted in modeled concentrations of NO_2 that were the closest match to measured concentrations. Of note, the ARM2 method was also designated as the best performing method as part of the O'Hare 2015 Re-Evaluation Environmental Impact Statement when using 2002 and 2014 data (with earlier versions of AEDT/AERMOD). This suggests that the ambient conditions and source release characteristics within O'Hare are better represented by the ARM2 method under a variety of evaluations and that changes to the data used and methodologies are unlikely to change this conclusion.

The results of the evaluation also demonstrate that regardless of the method used to convert modeled NO_x concentrations to NO_2, both the short-term results (i.e., one-hour averages) and long-term results (i.e., annual means) are overpredicted. This is especially true as the measured values are a representation of all sources of NO_x within the vicinity of the airport/region, including the airport-related sources, while the modeled values are only a result of the airport-related sources for which data were input to the AEDT.

Based on the evaluation results presented in this Memorandum, the ARM2ss method will be used for the dispersion analysis of the existing and future year conditions being evaluated for the TAP EA.

Attachment C

Terminal Area Plan and Air Traffic Procedures Environmental Assessment
Air Quality Analysis Proposed Increment Methodology Memo

MEMO

Date: August 14, 2019

To: Amy Hanson, Federal Aviation Administration (FAA)

From: Mike Ratte, RCH Group and Carrol Fowler, KB Environmental Sciences, Inc.

Cc: Diana Wasiuk, HMMH

Subject: Terminal Area Plan and Air Traffic Procedures Environmental Assessment Air Quality Analysis Proposed Increment Methodology

RCH Group and KB Environmental Sciences have been involved in discussions with staff of the U.S. Department of Transportation John A. Volpe National Transportation Systems Center (Volpe). These discussions have been about the ability of the Aviation Environmental Design Tool (AEDT) Version 2d and American Meteorological Society/USEPA Regulatory Model (AERMOD) to provide estimated modeled concentrations of one-hour nitrogen dioxide (NO_2) that are comparable to measured levels of this pollutant in the vicinity of Chicago O'Hare International Airport (O'Hare). The discussions are being held because of AEDT/AERMOD results from an evaluation for San Diego International Airport's Airport Development Plan Environmental Impact Report (EIR), the Written Re-Evaluation of the O'Hare Modernization Environmental Impact Statement (EIS) for the Interim Fly Quiet Runway Rotation Plan, and preliminary testing for the Terminal Area Plan and Air Traffic Procedures Environmental Assessment (EA) show significant differences between modeled and measured levels.

Specifically, these analyses have shown that the current version of AEDT/AERMOD is over predicting one-hour nitrogen dioxide (NO_2) concentrations by approximately two to three times the measured values taken at air monitoring stations surrounding the subject airports. Therefore, RCH Group and KB Environmental Sciences are proposing an increment methodology to estimate the NO_2 concentrations for the Terminal Area Plan and Air Traffic Procedures EA.

The EA would also include an emissions inventory and dispersion modeling for the existing conditions and future No Action and With Project alternatives (Interim and Build Out) for carbon monoxide (CO), particulate matter with a diameter of 10 micrometers or less (PM_{10}), particulate matter with a diameter of 2.5 micrometers or less ($PM_{2.5}$), and sulfur dioxide (SO_2), and nitrogen oxides (NO_x). The estimated concentrations for CO, PM_{10}, $PM_{2.5}$, and SO_2 would use the typical methodology.[1]

Estimated NO_2 Concentrations

To comply with the Clean Air Act (CAA) and the National Environmental Policy Act (NEPA), the air quality analysis for the EA must 1) disclose the environmental impacts of the With Project alternative, and 2) demonstrate that the proposed projects would not cause, or worsen, violations of the National Ambient Air Quality Standards (NAAQS). The increment methodology would allow for one-hour NO_2 comparisons to the NAAQS and a comparison of No Action and With Project concentrations.

[1] USEPA, 40 CFR Part 51 Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule, November 9, 2005, https://www3.epa.gov/scram001/guidance/guide/appw_05.pdf

August 14, 2019
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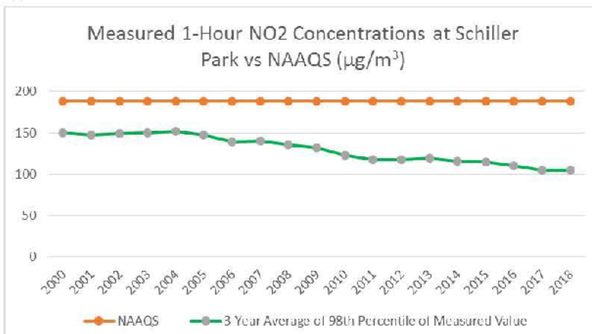
As previously stated, the increment methodology is being proposed because AEDT/AERMOD over predicts one-hour NO_2 concentrations and reporting the modeled concentrations in the EA would be a misrepresentation of levels that are currently being measured near O'Hare.

The Illinois Environmental Protection Agency (IEPA) owns/operates an air monitoring station that is located approximately 0.8 miles east of O'Hare's Runway 28C, in the City of Schiller Park. Air monitoring data from the Schiller Park monitoring station shows that measured levels of NO_2 in the vicinity of O'Hare have not exceeded the one-hour NO_2 NAAQS since the IEPA began monitoring at this location in 1998.

For example, in 2018 the measured 98th percentile one-hour NO_2 concentration at Schiller Park was 115 micrograms per cubic meter (μg/m³) and the recent three-year average was 105 μg/m³ - both well below the 188 μg/m³ NAAQS. Additionally, the monitoring data has shown a decrease and then leveling off of NO_2 concentrations over time with a measured level of 166 μg/m³ in 2002, 141 μg/m³ in 2007, 118 μg/m³ in 2013, and 115 μg/m³ in 2018. The following figure illustrates the measured three year average one-hour NO_2 concentrations at the Schiller Park monitoring station.



Importantly, NO_2 dispersion modeling for O'Hare has previously demonstrated that the greatest predicted concentrations of this pollutant occur at a modeling receptor placed at the Schiller Park monitoring station. This is expected to occur again with the Terminal Area Plan and Air Traffic Procedures EA because the monitoring station and receptor would be located due east of the ends of two of O'Hare's frequently used departure runways (Runway 28R and Runway 22L), and dispersion modeling typically indicates that airport-related NO_2 concentrations are highest near the departure end (*i.e.*, where aircraft start their takeoff roll) of runways.

Therefore, given that the Schiller Park monitoring location likely represents the highest ambient concentrations in the vicinity of the airport and the modeled values are likely to also greatly over predict the measured values at the Schiller Park monitoring station (by approximately two to three times the measured values), the use of an increment method to assess project impacts is proposed to demonstrate compliance with the NAAQS. The proposed method is described as follows:

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Firstly, the average measured 98th percentile one-hour NO_2 concentration over the last three years (105 µg/m³) will be used to represent the existing condition:

Existing Concentration = Measured Existing Concentration at Schiller Park

Secondly, the following formulas will be used to derive estimated NO_2 concentrations for future conditions (for the No Action Interim/Build Out and With Project Interim/Build Out alternatives):

Estimated Interim With Project Concentration = (Modeled AEDT/AERMOD Interim With Project Concentration − Modeled AEDT/AERMOD Existing Concentration) + Measured Existing Concentration at Schiller Park

Estimated Build Out With Project Concentration = (Modeled AEDT/AERMOD Build Out With Project Concentration − Modeled AEDT/AERMOD Existing Concentration) + Measured Existing Concentration at Schiller Park

Estimated Interim No Action Concentration = (Modeled AEDT/AERMOD Interim No Action Concentration − Modeled AEDT/AERMOD Existing Concentration) + Measured Existing Concentration at Schiller Park

Estimated Build Out No Action Concentration = (Modeled AEDT/AERMOD Build Out No Action Concentration − Modeled AEDT/AERMOD Existing Concentration) + Measured Existing Concentration at Schiller Park

The modeled future With Project concentration minus the modeled existing concentration represents the estimated future contribution of the airport-related sources relative to the existing condition or Project Increment. For the calculation of No Action and With Project-related one-hour NO_2 concentrations, the measured existing concentration will be obtained from the air monitoring station located at Schiller Park (as NO_2 monitoring was discontinued at Northbrook in 2016) and be added to the increment value. Notably, the Project Increment plus the measured concentration from Schiller Park would likely represent a conservative estimate of the future one-hour NO_2 concentration.

Lastly, these calculations 1) account for the "change" in airport-related emissions that would occur over time, 2) allow a comparison of the No Action and With Project NO_2 concentrations to the NAAQS, and 3) provide the predicted change in concentrations of the pollutant as a result of the Project (i.e., discloses the environmental impact of the Project).

The following is provided to illustrate an example of results (although not based on actual results) that could be obtained using the previous formulas:

Alternative	Condition	Concentration (µg/m³)
Existing	Measured (Schiller Park)	105
	Modeled	295
No Action	Modeled	310
With Project	Modeled	305

Existing Concentration = 105 µg/m³

Estimated Build Out No Action Concentration = (310 - 295) + 105 = 120 µg/m³

Estimated Build Out With Project Concentration = (305 - 295) + 105 = 115 µg/m³

These example results show that the No Action and With Project one-hour NO_2 concentrations would be less than the NAAQS, would be slightly greater than the existing measurement at Schiller Park (hypothetically due to an increase in airport operations in the future), and that the With Project concentration would be slightly lower than the No Action (hypothetically, due to greater efficiency in airfield operations).

Estimated CO, PM_{10}, $PM_{2.5}$, and SO_2 Concentrations

Airport-related dispersion analyses provide computer-model predictions of air pollutant concentrations for existing and future conditions, both with and without proposed projects.

Because the analysis is typically performed only for airport-related sources and for the purpose of estimating a total pollutant concentration, a measured concentration from a monitoring station representing the contribution of non-airport sources and referred to as a background concentration, will be added to the predicted airport-related concentration. For the evaluation of CO, PM_{10}, $PM_{2.5}$, and SO_2, background concentrations will be obtained from an air monitoring station located in Northbrook, approximately 12 miles north-northeast of O'Hare. The Northbrook monitoring station is owned/operated by the IEPA.

Therefore, the following formulas will be used to derive estimated CO, PM_{10}, $PM_{2.5}$, and SO_2 concentrations for both existing and future conditions (for the No Action Interim/Build Out and With Project Interim/Build Out alternatives):

Estimated Existing Conditions Concentration = Modeled AEDT/AERMOD Existing Conditions Concentration + Measured Background Concentration at Northbrook

Estimated Interim With Project Concentration = Modeled AEDT/AERMOD Interim With Project Concentration + Measured Background Concentration at Northbrook

Estimated Build Out With Project Concentration = Modeled AEDT/AERMOD Build Out With Project Concentration + Measured Background Concentration at Northbrook

Estimated Interim No Action Concentration = Modeled AEDT/AERMOD Interim No Action Concentration + Measured Background Concentration at Northbrook

Estimated Build Out No Action Concentration = Modeled AEDT/AERMOD Build Out No Action Concentration + Measured Background Concentration at Northbrook

The results will allow a comparison of the No Action and With Project CO, PM_{10}, $PM_{2.5}$, and SO_2 concentrations to the NAAQS and a comparison of No Action and With Project concentrations.

Evaluations for Which the Increment Method Has Been Used

The increment method has been used to prepare air quality evaluations that are included in other airport-related environmental planning documents including the Written Re-Evaluation for the Proposed Interim Fly Quiet at O'Hare and an EA prepared to evaluate landside improvements at Los Angeles International Airport. The following provides a listing of, and webpages for, these and other documents in which the increment method was used for an air quality evaluation.

- Re-Evaluation of the O'Hare Modernization EIS for the Interim Fly Quiet Runway Rotation Plan, July 2019. https://www.faa.gov/airports/airport_development/omp/ifq_re_eval/
- Final Environmental Impact Report (EIR) – Los Angeles International Airport (LAX) Proposed Master Plan Improvements. City of Los Angeles. April 2004; and Final EIS – LAX Proposed Master Plan Improvements. Federal Aviation Administration, January 2005. https://www.lawa.org/en/lawa-our-lax/environmental-documents/documents-certified/2004-lax-master-plan-program/final-environmental-impact-statement-feis

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- Final EIR LAX Specific Plan Amendment Study. City of Los Angeles. January 2013, https://www.lawa.org/en/lawa-our-lax/environmental-documents/documents-certified/specific-plan-amendment-study/documents
- Final EIR LAX Midfield Satellite Concourse. City of Los Angeles, June 2014, https://www.lawa.org/en/lawa-msc-north/project-documents
- Final EIR Runway 6L-24R and Runway 6R-24L Runway Safety Area and Associated Improvements. City of Los Angeles, July 2014; and Final EA Runway 6L-24R and Runway 6R-24L Runway Safety Area and Associated Improvements. Federal Aviation Administration, July 2014. https://www.lawa.org/en/lawa-our-lax/environmental-documents/documents-certified/runway-6l24r-and-runway-6r24l-runway-safety-area-and-associated-improvements
- Final EIR Replacement Airline Passenger Terminal at Burbank Bob Hope Airport, June 2016, https://burreplacementterminal.com/documents/
- Final EIR – LAX Landside Access Modernization Program. City of Los Angeles, February 2017; and Draft EA – LAX Landside Access Modernization Program. Federal Aviation Administration, August 2017 (FONSI/ROD issued January 2018), https://www.lawa.org/en/lawa-our-lax/environmental-documents/documents-certified
- Draft EIR – San Diego International Airport Development Plan, July 2018, https://www.san.org/Airport-Projects/Environmental-Affairs#1245170-ceqa--nepa

Attachment D

Minimum Ambient Ratio for the Terminal Area Plan and Air Traffic Procedures Environmental Assessment for Chicago O'Hare International Airport (O'Hare)

CMT

MEMO

Date: February 11, 2021

To: Amy Hanson, Federal Aviation Administration (FAA)

From: Carrol Fowler and Justin Godin, Crawford, Murphy & Tilly, Inc. (CMT)
Mike Ratte, RCH Group (RCH)

Cc: Diana Wasiuk, Harris Miller & Hanson, Inc.

Subject: Minimum Ambient Ratio for the Terminal Area Plan (TAP) and Air Traffic Procedures Environmental Assessment (EA) for Chicago O'Hare International Airport (O'Hare)

Air dispersion modeling is being performed in support of the Terminal Area Plan and Air Traffic Procedures Environmental Assessment (TAP EA) for Chicago O'Hare Airport (O'Hare). Because the emission rates for the airport-related sources are for nitrogen oxides (NO_x), the results of the dispersion (concentration) analysis will be converted to nitrogen dioxide (NO_2) for comparison to the National Ambient Air Quality Standards (NAAQS). The results of an evaluation that was performed to determine the best method of converting NO_x to NO_2 are described in a memorandum prepared by KB Environmental Sciences, Inc. (KBE)[1]/RCH entitled *TAP EA NO_2 Conversion Methodologies Evaluation* (August 27, 2020). Based on the results of the evaluation, the Ambient Ratio Method 2 (ARM2) was determined to be the best performing method (i.e., the method that would best align modeled with measured concentrations of NO_2).

The ARM2 method applies ambient ratios of NO_2/NO_x to modeled NO_x concentrations to derive NO_2 concentrations. For the TAP EA, a site-specific NO_2/NO_x minimum ratio of 0.186 was derived by RCH and proposed within the *Air Quality Modeling Protocol* (August 27, 2020). The ratio of 0.186 was derived using ambient measurements of NO_x and NO_2 from the Schiller Park air pollutant monitoring station for the years 2014 through 2018.

While the United States Environmental Protection Agency (USEPA) did not comment on the general use of the ARM2 method, the agency did comment (July 2, 2020) that "it is difficult to argue that a value lower than 0.2 [the minimum ratio], that the method [ARM2] itself is based on, should be used". The USEPA also stated (October 1, 2020) that they "…strongly recommend use of a higher minimum ambient ratio (i.e., 0.3) for the ARM2 approach." The agency further stated that "[The] higher ratio would be more defensible and consistent with the data and the conservative nature of the ARM2 method".

In addition to deriving a minimum ratio using measured concentrations of NO_x and NO_2, RCH also derived a ratio using modeled concentrations for a receptor that represents the Schiller Park monitoring station. As noted within the *TAP EA NO_2 Conversion Methodologies Evaluation*, when applying full NO_x conversion to modeled results for the Existing Condition and using the ARM2 method with site specific ambient ratios (ARM2ss), the highest modeled NO_x concentration is 391 parts per billion (ppb) and the highest NO_2 concentration is 89 ppb. These modeled concentrations result in a NO_2/NO_x ambient ratio of 0.228 - a ratio that is greater than the ratio derived using measured concentrations. As such, and to be conservative, the air quality analysis for the TAP EA is being performed with the minimum ambient ratio of 0.228.

The reasons why we believe use of a minimum ambient ratio of 0.228 and not an overly conversative ratio of 0.3 should be used (as was recommended by the USEPA) are discussed in the following sections of this Memorandum.

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[1] KBE was acquired by CMT on November 1, 2020.

Ambient Ratio Documentation

The following summarizes four documents that discuss how the ARM2 method was developed by USEPA and the suggested use of the method for the purpose of performing air pollutant dispersion modeling:

- **Ambient Ratio Method Version 2 (ARM2) for use with AERMOD for 1-hr NO2 Modeling *(RTP Environmental Associates, Inc., September 20, 2013)*[2]** – This report discusses the development and evaluation of ARM2 including performance evaluations and sensitivity analyses using data from a 10-year period from more than 580 monitoring stations throughout the United States. The following ARM2 equation (based on Figure 4 within the cited document) is used within AERMOD to estimate NO_2 concentration as a function of predicted (modeled) NO_x concentrations:

  USEPA ARM2 Equation

  $$y\ (NO_2 \text{ concentration in ppb}) = -5.176E\text{-}16*x^6+1.005E\text{-}12*x^5-7.288E\text{-}10*x^4+2.296E\text{-}07*x^3-1.981E\text{-}05*x^2-5.148E\text{-}03*x+1.244, \text{ where } x \text{ is the } NO_x \text{ concentration in ppb}$$

  As previously stated, for the Existing Condition, the maximum modeled NO_x concentration is 391 ppb (735 μg/m³). Using this equation, the derived NO_2 concentration is 89 ppb (167 μg/m³) and the NO_2/NO_x ratio is 0.228. As previously stated, this is the minimum ambient ratio that is being used to convert modeled NO_x to NO_2 for the TAP EA.

- ***Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO_2 National Ambient Air Quality Standard (USEPA, September 30, 2014)***[3] – This document states that the ARM2 method initially included "a default minimum ratio of 0.2 at very high levels of NO_x" (i.e., assuming the default ratio, when ambient NO_x levels are high, the NO_2 concentration is equal to 20 percent of the NO_x concentration). The document also states that "…implementation of ARM2 in AERMOD allows the user to set the maximum and minimum ratios, when such a change is determined appropriate".

  In their analysis of ARM2, the USEPA recognized that the monitoring data used to derive the default ARM2 ratios may not be representative of locations where there is a direct impact from a specific source (like O'Hare) because the data used to develop the ARM2 was from stations across the United States at which the agency measured background concentrations of NO_x (i.e., not designed for specific emission source contribution).

  As previously stated, the minimum ambient ratio of 0.186 was derived using measurement data from the Schiller Park monitoring station, a station near O'Hare's Runways 28R, 28C, and 22L and a location at which it could reasonably be expected O'Hare-related emission sources would contribute to measured levels of NO_x. Because the measurement data is representative of a location where there is a direct impact from a specific source, and based on the guidance in this USEPA document, the use of the minimum ambient ratio of 0.186 should be appropriate. However, as also stated previously, a more conservative ambient ratio of 0.228 (based on the Existing Condition model evaluation) is being used for the TAP EA.

- ***An Update to the Ambient Ratio Method for 1-Hour NO2 Air Quality Standard Dispersion Modeling (RTP Environmental Associates, Inc., February 2015)***[4] - of an evaluation of the performance of ARM2 as a NO_x to NO_2 conversion method using the data that was obtained from the more than 580 monitors over the 10-year period. The results demonstrated that when NO_x concentrations are high and ozone concentrations are typical[5], the ratio to convert NO_x to NO_2 is in

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[2] https://www3.epa.gov/ttn/scram/models/aermod/ARM2_Development_and_Evaluation_Report-September_20_2013.pdf
[3] https://www3.epa.gov/scram001/guidance/clarification/NO2_Clarification_Memo-20140930.pdf
[4] https://www.sciencedirect.com/science/article/pii/S1352231014009698

[5] The RTP document defines high O_3 concentrations as concentrations that exceed 80 to 90 ppb more than seven days a year. As this is not the case for measured O3 concentrations from the Schiller Park air monitoring station, it is assumed that Schiller Park concentrations can be considered "typical".

the range of 0.1 to 0.2. Further, the modeling results that are associated with emission sources that had a NO_2 to NO_x ratio of 0.2 agree well with the ambient measurements to which they are compared. Although there was good agreement with ratios in the range of 0.1 to 0.2, the USEPA felt that for sources with greater NO_x to NO_2 ratios, modeled concentrations would be underpredicted. As such, to be conservative and to capture all situations, the USEPA increased the minimum ambient ratio to 0.5. It is noteworthy, that as demonstrated in this Memorandum (see the section entitled *Aircraft-Specific NO_2 to NO_x Testing* below), that the ratio for the source contributing the most to the maximum modeled NO_2 concentration (i.e., aircraft) has a low NO_2 to NO_x ambient ratio.

- ***Guideline on Air Quality Models (USEPA, January 17, 2017)***[6] – This most recent guidance states that a "reviewing agency may establish alternative minimum ambient NO_2/NO_x values based on the source's in-stack emissions ratios…".[7] Based on emission testing conducted on aircraft engines, airports represent an emission source with a low in-stack emission ratio. This information along with the finding that a site-specific ambient ratio developed using data from the Schiller Park monitoring station is also low, gives further credence to use of an alternative minimum ambient NO_2/NO_x value (i.e., a ratio of 0.186 or 0.228).

Unlike most efforts to perform airport-related dispersion modeling, for the TAP EA, not only is there source-specific emissions data available but there is also an air monitoring station in close proximity. This situation allows for a direct comparison of modeled and measured data for the Existing Condition. Notably, we recognize that for the assessment of air quality impacts associated with airport improvement projects, it is very unusual to have site-specific data. As such, the use of the site-specific ambient ratios derived using the Schiller Park data can be considered unique and, only relevant to the TAP EA.

Using source-specific data (the airport) and Schiller Park monitoring data, we conclude that the proposed more conversative minimum ambient ratio of 0.228 (more conservative than 0.186) is appropriate. This conclusion is based on the information presented above and in the following sections of this Memorandum.

Aircraft-Specific NO_2 to NO_x Testing

Extensive emission testing has been conducted on a wide range of aircraft engines in the last decade.[8] This research has shown that the aircraft-related NO_2/NO_x emission ratio differs markedly from most other NO_x emission sources.[9] For aircraft, the NO_2 fraction of NO_x decreases with power, from over 98 percent at the lowest power setting (taxi/idle) to under 10 percent at higher power settings (climbout/takeoff).[10] Based on the research findings, the amount of NO_x emissions emitted by aircraft was assumed to be 3.3 kilogram (kg) per engine per landing-takeoff cycle (LTO), of which 0.8 kg (a ratio of 0.242) was emitted in the form of NO_2.[11] The NO_2 to NO_x ratios for each aircraft operating mode based on the testing over the last decade are provided in **Table 1**. Based on the results of the modeling for the TAP EA, the maximum modeled NO_2 concentration is primarily due to aircraft takeoffs - a mode for which research indicates the NO_2/NO_x ratio is 0.081 (i.e., less than the more conservative ratio of 0.228 that is being used for the TAP EA analysis).

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[6] Federal Register / Vol. 82, No. 10 / Tuesday, January 17, 2017 / Rules and Regulations, Revisions to the Guideline on Air Quality Models: Enhancements to the AERMOD Dispersion Modeling System and Incorporation of Approaches To Address Ozone and Fine Particulate Matter, https://www.govinfo.gov/content/pkg/FR-2017-01-17/pdf/2016-31747.pdf#page=22

[7] An in-stack ratio is the ratio of NO_2 to NO_x that is emitted directly from a source.

[8] Wood, Ezra, Scott Herndon, Michael Timko, Paul Yelvington, and Richard Miake-Lye. Speciation and Chemical Evolution of Nitrogen Oxides in Aircraft Exhaust Near Airports. Environmental Science & Technology, Inc., 2008.

[9] Aircraft Particulate Emissions eXperiment – APEX (2004), JETS-APEX2 (2005), and APEX3 (2005).

[10] Wormhoudt, Joda, Scott Herndon, Paul Yelvington, Richard Miake-Lye, and Changlie Wey. *Nitrogen Oxide (NO/NO2/HONO) Emissions Measurements in Aircraft Exhausts*. Journal of Propulsion and Power 23, no. 5 (2007): 906-11.

[11] Wood, Ezra, Scott Herndon, Michael Timko, Paul Yelvington, and Richard Miake-Lye. *Speciation and Chemical Evolution of Nitrogen Oxides in Aircraft Exhaust Near Airports*. Environmental Science & Technology, 2008, 42, 1884-1891.

Table 1: Aircraft NO_2 to NO_x Emission Ratios

Operating Mode	NO_2/NOx Ratio (kg/kg)	NO_2 Emissions (kg)	NOx Emissions (kg)
Idle/Taxi	0.914	0.53	0.58
Approach	0.155	0.08	0.49
Takeoff	0.081	0.06	0.70
Climbout	0.088	0.13	1.53
Source: Wood, Ezra, Scott Herndon, Michael Timko, Paul Yelvington, and Richard Miake-Lye. *Speciation and Chemical Evolution of Nitrogen Oxides in Aircraft Exhaust Near Airports*. Environmental Science & Technology, 2008, 42, 1884-1891. See Table 7 of the TAP EA Air Quality Modeling Protocol.			

Development of NO_2/NOx Ratio Using Measured Data from Schiller Park

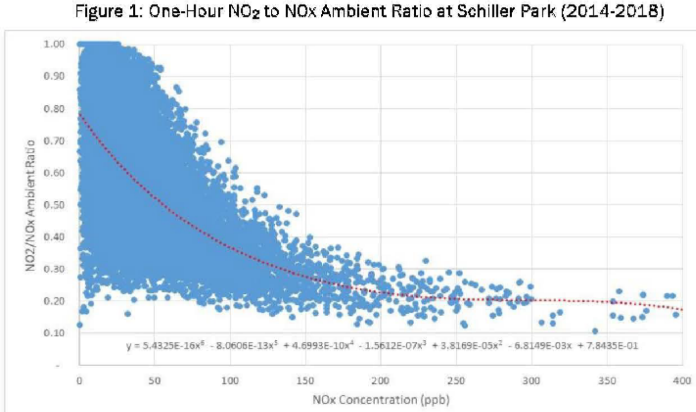
As shown previously, the minimum ambient NO_2/NO_x ratio of 0.228 was derived using the ARM2 method presented in the 2013 RTP Environmental Associates (RTP) document based on monitoring stations throughout the United States. For comparative purposes, a minimum NO_2/NO_x ratio of 0.186 was also derived using the same methodology but utilizing site specific monitoring data. To calculate the ratio, hourly measured levels of NO_2 and NO_x for the years 2014 through 2018 from the Schiller Park monitoring station were used.

Figure 1 plots the NO_2/NO_x ambient ratio versus the NO_x concentration along with the trend line (as a six order polynomial equation per USEPA and RTP guidance. The following equation was derived based on the corresponding trend line:

ARM2 Equation Using Data from Schiller Park Monitoring Station

*y (NO_2 concentration in ppb) = 5.4325-16*x^6-8.0606E-13*x^5+4.6993-10*x^4-1.5612E-07*x^3+3.8169E-05*x^2-638149E-03*x+7.8435, where x is the NO_x concentration in ppb*

Figure 1: One-Hour NO_2 to NOx Ambient Ratio at Schiller Park (2014-2018)

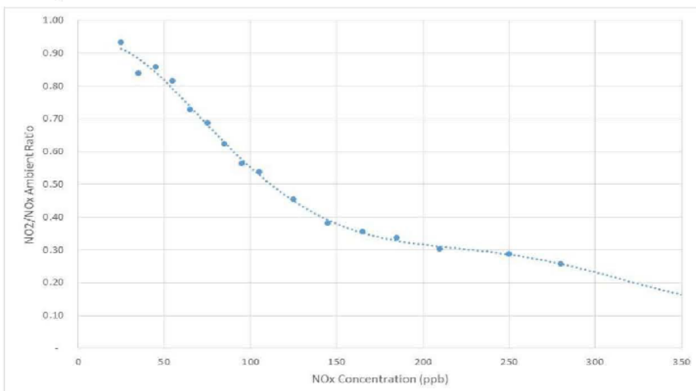


Source: KB Environmental Science/RCH Group analysis of USEPA ambient monitoring data (*AIRData – Monitor Values Reports*, http://www.epa.gov/air/data/index.html), 2020.

As previously stated, for the Existing Condition, the maximum modeled NO_X concentration at the Schiller Park receptor is 391 ppb (735 µg/m³). Based on the equation above, the derived NO_2 concentration is 71 ppb (133 µg/m³) and the NO_2/NO_X ratio is 0.186 (71 ppb/391 ppb = 0.186) - a ratio less than the 0.228 ratio being used for the TAP EA.

Again, like the process performed by USEPA/RTP, **Figure 2** displays the binned NO_2/NO_X ambient ratio versus the NO_X concentration. The measured NO_X values were grouped into bins with intervals of 10 ppb up to 200 ppb (starting with 20 ppb) and 20 ppb up to 600 ppb. The 98th percentile within each bin were then determined. Figure 2 plots the results for each bin. Notably, the patterns in Figures 1 and 2 are very similar to the patterns found in the USEPA/RTP documents and based on the patterns, the minimum ambient ratio should be less than 0.2.

Figure 2: Binned One-Hour NO_2 to NOx Ambient Ratio at Schiller Park (2014-2018)



Source: KB Environmental Science/RCH Group analysis of USEPA ambient monitoring data (*AIRData – Monitor Values Reports*, http://www.epa.gov/air/data/index.html), 2020.

Notably, the difference in the minimum ambient ratio using measured concentrations of NO_X and NO_2 (0.186) and the ambient ratio using modeled concentrations (0.228) may partly be due to differences in environmental conditions near O'Hare including ozone levels, the type of emission sources, and meteorological conditions when compared to the environmental conditions associated with the larger dataset that was used by USEPA to determine the ARM2 equation.

<u>Modeled Concentrations vs. Measured NO_2 Concentrations from Schiller Park</u>

To further demonstrating the appropriateness of the more conservative minimum ambient ratio derived by RCH (i.e., 0.228), this section compares the maximum measured concentration of NO_2 from the Schiller Park monitoring station in the year 2018 (115 micrograms per cubic meter[12] (µg/m³)) to modeled year 2018 concentrations derived using:

[12] One-hour NO_2 concentrations represent the maximum 98th percentile.

1. the USEPA-default minimum ratio (0.5),
2. the USEPA-recommended minimum ratio (0.3),
3. the ambient minimum ratio that was derived by RCH using USEPA ARM2 (0.228), and
4. the ambient minimum ratio derived by RCH using measured concentrations from the Schiller Park monitoring station and the ARM2 method (0.186).

As shown in **Table 2**, use of the above ambient ratios result in NO_2 concentrations, without a background concentration, that range from 155 to 274 μg/m³. As also shown, the RCH-derived ratios of 0.186 and 0.228 result in a modeled concentration that is closest to, but 35 percent greater than, the measured concentration pf 115 μg/m³. Notably, the modeled concentrations using the RCH-derived ratios are the same (i.e., 155 μg/m³) because AERMOD ignores minimum ambient ratios less than 0.2. With a background concentration, the modeled NO_2 ranges from 178 to 342 μg/m³ with levels exceeding the NAAQS for NO_2 (188 μg/m³) using either the USEPA recommended or default ratios. It is also notable that the concentration using the USEPA-recommended minimum ambient ratio of 0.3 results in a modeled NO2 concentration that is nearly twice the measured concentration and use of the USEPA-default ratio of 0.5 results in a modeled NO_2 concentration that is almost three times the measured concentration.

Table 2: Comparison of Modeled NO2 Concentrations with Minimum Ambient Ratios

Measured NO_2 (μg/m³)	Minimum Ambient Ratio	Source	Modeled NO_2 (μg/m³) Without Background Concentration	Modeled NO_2 (μg/m³) With Background Concentration
115	0.5	USEPA default	274	342
	0.3	USEPA recommended	164	211
	0.228	Derived using ARM2 site-specific modeled data	155	178
	0.186	Derived using ARM2 site-specific (Schiller Park) monitoring data	155	178

Summary

In our approach to the air quality analysis for the TAP EA, a minimum ambient ratio of 0.228 is being used to convert modeled NO_x concentrations to NO_2 concentrations. The USEPA commented that "it is difficult to argue that a value lower than 0.2 [the minimum ratio], that the method [ARM2] itself is based on, should be used" and that they "…strongly recommend use of a higher minimum ambient ratio (i.e., 0.3)."

The following are reasons why use of the minimum ambient ratio of 0.228 (i.e., which is more conservative than the 0.186 ratio derived from measured concentrations) instead of the USEPA recommend value of 0.3, is appropriate for predicting NO_2 concentrations for the TAP EA:

- USEPA documentation states that the ARM2 method includes a default ratio of 0.5 at very high levels of NO_X and the documentation states that users can "…set the maximum and minimum ratios, when such a change is determined appropriate". Based on the reasons documented in this Memorandum, such a change is appropriate.
- The USEPA has recognized that the monitoring data used to derive the default ARM2 ratios may not be representative of locations where there is a direct impact from a specific source. The sources operating at O'Hare have a direct impact on the measured concentrations at the Schiller Park monitoring station.
- Analysis performed using data over an extended period (10 years) and from more than 580 ambient monitors indicates that when NO_X concentrations are high along with typical ozone levels, the ambient minimum ratios to convert NO_X to NO_2 are in the range of 0.1 to 0.2. Because high O_3 concentrations are defined as concentrations that exceed 80 to 90 ppb more than seven days a year

and this is not the case for measured O3 concentrations from the Schiller Park air monitoring station, it is assumed that Schiller Park concentrations are "typical".

- Recent guidance from USEPA states that "…minimum ambient NO_2/NO_x values [may be developed] based on the source's emissions ratios…". Aircraft takeoff operations account for most of the aircraft NO_x emissions and emissions testing indicates that the NO_2/NO_x ratios for the aircraft modes of takeoff and climbout, the modes during which most of the aircraft-related NO_x is emitted, are less than 0.1.

Attachment E

Response to Comments

Chicago O'Hare International Airport
Terminal Area Plan and Air Traffic Procedures Environmental Assessment
Air Quality Modeling Protocol
Response to USEPA Comments
November 15, 2019

1. Table 1 on Page 3: The description of the 1-hour SO2 Design Value should read "99th Percentile of 1-hour <u>Daily</u> Maximum averaged...."
   Agreed

2. Page 5 - The EPA is replacing CAL3QHCR with AERMOD as the Appendix A preferred model for refined modeling for PM2.5 mobile source applications. CAL3QHCR can be used for PM hot-spot analyses until January 17, 2020. All new PM hot-spot analyses begun after January 20, 2020 must use AERMOD.
   Because the air quality analysis for the Chicago O'Hare International Airport Terminal Area Plan and Air Traffic Procedures Environmental Assessment began in May of 2019, which is prior to January 20, 2020, CAL3QHCR will be used to prepare the hot-spot analyses.

3. Last sentence on Page 12: In this meteorological data section, the last sentence discusses a value of 2,510 feet to be used for the mixing height. Since AERMET generates hourly stable and convective mixing heights for use in AERMOD, it's unclear what the 2,510 ft value is to be used for.
   The mixing height is used by AEDT in the calculation of air pollutant/pollutant precursor emissions inventories. The mixing height value is not specifically used within the AERMOD dispersion model. In AEDT, a landing and take-off cycle is comprised of the following operational mode categories:
   Descend Below Mixing Height: The modes in this category are associated with an aircraft's arrival, beginning at the atmospheric mixing height and including descend emissions below 1,000 feet, the landing ground roll, and arrival taxi (i.e., taxi-in) emissions.
   Climb Below Mixing Height: The modes in this category are associated with an aircraft's departure, beginning with startup and including climb taxi (i.e., taxi-out), takeoff ground roll, climb below 1,000 feet and climb to the atmospheric mixing height.

4. Top of Page 14: This paragraph is discussing AERSURFACE parameters for use in running AERMET. The AERSURFACE estimated values of 1.0, 1.625 and 0.2075, for surface roughness length, Bowen ratio, and albedo, respectively. The value for surface roughness, in particular, seems very high based on work we've previously done using various O'Hare meteorological tower locations as the center point in AERSURFACE.
   The Air Quality Protocol will be revised to state that the monthly surface roughness length, Bowen ratio, and albedo for the analysis were estimated with AERSURFACE within twelve directional sectors, with calculated values of 0.012 to 0.023 meters, 0.79 to 1.03, and 0.17 to 0.18, respectively, indicative of land use designations containing urban/recreational grasses/commercial/industrial/transportation within and surrounding the airport.

5. Page 14: The second paragraph discusses a screening approach using NOx to determine the worst-case meteorological year to model for all the pollutants. Are the emission distributions for the other pollutants the same/similar as for NOx? If not, it's possible another year may be worst-case for a different pollutant.

The Existing Condition (2018) air quality analysis is ongoing. However, it is anticipated that the emission distribution for NOx will be similar to the emission distribution for CO, SO_2, PM_{10}, and $PM_{2.5}$ because the majority of the emissions result from aircraft and the temporal operational profiles for aircraft are the same regardless of pollutant. It is also anticipated that both the 1-hour and annual NO_2 concentration will be worst-case for the same meteorological year. As such, the worst-case concentrations of CO, SO_2, PM_{10}, and $PM_{2.5}$ for both short- and long-term averaging periods would occur in the same year. Of note, based on experience, the percentage of the airport/project contribution to the total concentration (airport/project plus background) will be highest for NO_2 and the closest to the NAAQS compared to the other pollutants. Therefore, it is unlikely that use of a different year of meteorological data would substantially change the resulting conclusions for CO, SO_2, PM_{10}, or $PM_{2.5}$.

6. Page 14: Boundary receptors are placed at a spacing of approximately 10 degrees. How does that translate, roughly, into meters between boundary receptors?
The boundary receptor spacing is approximately 600 meters (2,000 feet). This distribution of receptors is standard when conducting an airport air quality assessment.

7. Page 14, Last paragraph: The last complete sentence states that a receptor height of 1.8 meters above the ground is consistent with USEPA modeling guidance. A receptor height of 1.8 m appears to be consistent with FAA modeling guidance. However, USEPA policy recommends ground-level receptor heights (0 m) when conducting regulatory modeling.
A sensitivity analysis shows very little difference in the air quality results between a receptor height of 1.8 meters and 0 meters. All previous air quality analyses for NEPA projects at ORD have used a receptor height of 1.8 meter (a typical breathing height). Therefore, the analysis will be performed with a receptor height of 1.8 meters per FAA's *Aviation Emissions and Air Quality Handbook*.

8. Page 19 Last section: This is similar to our comment made earlier. The sentence states that AEDT/AERMOD over-predicts, without providing any more detail other than citing a 2-3 factor difference between modeled and measured concentrations.
The cited statement was based on test cases for ORD. The Existing Condition (2018) air quality analysis is ongoing. The Build Out with Project (2030) and other future year alternatives' air quality analyses will be initiated in early 2020 through mid-year. Although the statement is based on test cases, the relationship between the modeled and measured concentrations (i.e. the 2 to 3 times factor) is not expected to change. Notably, a project-specific factor will be derived as the air quality analyses is finalized.

9. Page 20: Also similar to previous comments, this section describes the increment approach to be used for NO2 concentration comparisons to the 1-hr NO2 NAAQS. However, the section does not explain how the actual modeled delta between "modeled project concentrations" and "modeled existing concentrations" will be determined.
The actual delta (or increment) between the modeled future year and modeled existing conditions concentrations will be derived/reported when the air quality analysis is finalized. It is intended that the increment be defined as the modeled future year concentration minus the modeled existing conditions concentration or, more simply, the change (increase/decrease) in concentration from the existing year to the future year as estimated by the model. The Increments for each receptor will then be added to the measured existing condition (2018) concentration from the Schiller Park monitoring station to derive the total future year

concentration. In this manner, the increments will be derived for the Project and No Project as well as the Build Out (2030) and Interim (2023).

Chicago O'Hare International Airport
Terminal Area Plan and Air Traffic Procedures Environmental Assessment
Air Quality Modeling Protocol
Response to USEPA Comments
February 10, 2020

- Thank you for the explanation of the use of the 2,510 ft mixing height. The FAA Air Quality Handbook notes the importance of the height of the mixing zone, primarily when calculating NOx emissions. Given this, the documentation should provide some additional justification of the 2,510 ft value and why it is considered an appropriate site-specific height for O'Hare.

  The mixing height of 2,510 feet was obtained from the USEPA's *Mixing Heights, Wind Speed, and Potential for Urban Air Pollution throughout the Contiguous United States*. This document provides National Weather Service upper atmosphere data for a station in Peoria, Illinois, the closest station to O'Hare. Use of this mixing height is consistent with previous NEPA air quality analyses for the airport. Notably, because a majority of the NO_2 concentrations are due to ground-based sources such as runway departure operations. Therefore, the use of a mixing height of 2,510 feet only affects the results of an emissions inventory and would have very little effect, if any, on the results of a dispersion analysis.

- Thanks also for the response on the receptor grid question. The protocol approach to placing receptors looks to be consistent with the FAA guidance of placing receptors at 10 degree spacing along the airport boundary, adding receptors at sensitive locations, and adding receptors to ensure peak impacts are captured. This is, of course, an iterative process and it would be useful to include modeling results at all receptors to illustrate where the peaks were identified in the modeling and where receptors were added.

  As dictated in the FAA's Aviation Emissions and Air Quality Handbook, pollutant concentrations will be predicted for boundary, sensitive, and worst-case receptors (e.g., receptors located around the airport boundary including receptors at the ends of O'Hare's runways, in the terminal areas, and at off-site roadway intersections). Notably, because the analysis is being conducted as data for the scenarios are completed (i.e., currently only data for the existing condition is available and each scenario that will be evaluated will be provided at different times in the future), adding additional receptors for any of the future year scenarios through an iterative process would require reanalysis of the scenarios for which analysis has already been completed. This would not allow for timely completion of the air quality analysis given the extensive runtime for the model and the need for post-processing of the data. As suggested, to better illustrate where the maximum concentrations are predicted to occur, the documentation prepared for the analysis will provide modeling results for all evaluated receptors.

- Your response on the use of the NOx emissions to determine the worst-case year to use for the examination of alternatives was useful. It appears the selection of the worst-case meteorological year is based on a 3-year period, 2016-2018. EPA modeling guidance, and I believe, FAA guidance both state that 5 years of meteorological data should be examined. We recommend 5-years of meteorology be used to select the worst-case year for evaluation. Additionally, we recommend the 5-year period also be used in the final submittal.

  The FAA's Air Quality Handbook states that "Typically...five years of meteorological data are first analyzed in AERMET...", it is not a FAA requirement to do so. The USEPA's Guideline on Air Quality Models (2017) provides three options for the selection of meteorological data (see page 5223 of Volume 82, No. 10 of the Federal Register). As stated in the Recommendations and Requirements discussion of the document (see Section 8.4.2.e), analysts should:

1. Use five years of adequately representative National Weather Service or comparable meteorological data, or

2. At least one year of site-specific data, or

3. At least three years of prognostic meteorological data.

For the air quality analysis that will be performed for the TAP EA, the USEPA option to use one year of site-specific data was selected. However, to better ensure results that are worst-case, the most recent three years (2016-2018) of meteorological data are being evaluated and the year that results in the highest predicted concentration will be used. This same worst-case meteorological data will be used for the analysis of the existing condition and for future conditions both with and without the proposed improvements.

- NO_2 Screening Modeling: The document discusses the use of all three NO to NO_2 screening techniques. Given the importance of NO_x in this assessment, it may be wise to simply use the most refined screening approaches; either PVMRM or OLM. Default in-stack ratios could be used or the in-stack ratios identified in the document would also be available. For clarification, units should be added to help clarify the values in the NO_2 and NO_x emission columns in Table 6. If ARM2 is also used, the nearby NO_x data from the Schiller Park monitor is available to determine alternative ratios, as you note. However, it's unclear why the chart (Figure 5) used to illustrate the new ratios has so few data points. Additionally, it would be more appropriate to select the higher of the two ratios associated with the higher end NO_x concentrations. Lastly, the minimum ratio used in ARM2 would need to be reconciled with the high in-stack ratio associated with idling operations, particularly if idling emissions are a significant percentage of total NO_x emissions.

Table 6 will be revised to indicate that the emission units are kilograms.

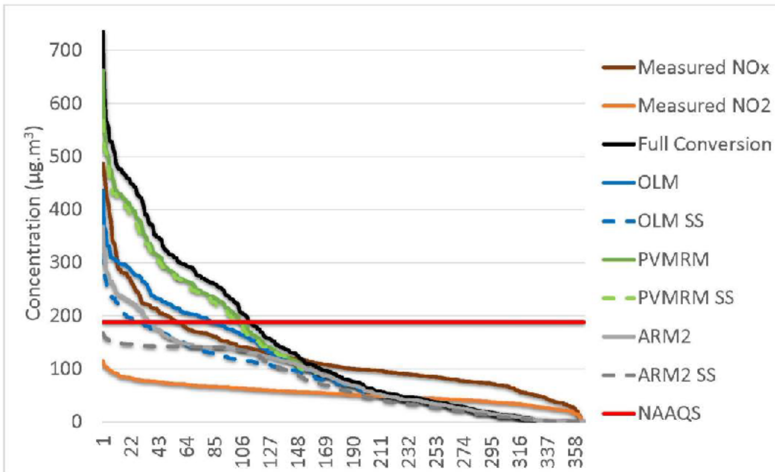
The data in Figure 5 illustrates 8,523 data points (i.e., the sample size) which is the number of hours in the year 2018 for which NO_2 and NOx measurements were available. While not all of the data points are plotted, all of the points are accounted for in the regression line.

Idle emissions are not a significant percentage of NOx aircraft emissions (approximately 10 percent of the total emissions that result from an aircraft landing, taxiing in, taxiing out, taking off and climbing out). The vast majority of aircraft NOx emissions occur in the aircraft takeoff mode, which has a low in-stack ratio. This fact gives credence to the use of lower NO_2 ratios for the ARM2 screening method.

To clarify, in addition to full conversion and OLM and PVMRM (default and site -specific emission NO_2 ratios), the evaluation of the modeled results will be conducted with both ARM2 with default ambient NO_2 ratios (of 0.5 and 0.9) and ARM2 with site specific ambient NO_2 ratios (of 0.186 and 0.717). Notably, the preliminary model evaluation results demonstrate that ARM2 is better performing than OLM or PVMRM and that ARM2 with site specific ambient NO_2 ratios is better performing than ARM2 with default ambient NO_2 ratios.

The figure below illustrates the ranked daily 1-hour maximum NO_2 concentrations (i.e., the X axis represents the ranking of the daily concentrations not the day that the levels were measured/modeled) for the seven methodologies for NOx conversion (i.e., full conversion, ARM2, OLM, OLM w/variable, PVMRM, PVMRM w/variable, and ARM2 with site-specific NO_2 ratios). The figure shows that ARM2 with site specific ambient NO_2 ratios is better performing than the other methods but even this method provides an overprediction of approximately 50 $\mu g/m^3$ for the modeled concentrations when compared to the measured values.

Ranked Maximum Daily 1-Hour NO_2 Concentrations for Several NOx Conversion Methodologies and Measured



- NOx Increment: The use of an increment for a NO_2 NAAQS attainment demonstration, due to a stated AEDT/AERMOD overprediction issue, is still an issue in our mind. Apparently, there is much work to do yet to determine the extent of any overprediction and the cause. We recommend that collaboration be a priority between FAA and EPA headquarters' technical staff. In the meantime, we would prefer an approach that does not compare directly to the NO_2 NAAQS but rather begins with a claim that the area is in attainment, based on data from the nearby Schiller Park monitor, and that the modeled information shows future NO_2 air quality is no worse or better with the project versus without.

  It is our understanding that FAA's and EPA's headquarters' will be working together to address the issue of overestimation of the modeled 1-hour NO_2 concentrations within an airport environment. However, it is not expected that a solution will be developed within the scheduled time to prepare the air quality analysis for the TAP EA.

  While we appreciate the suggestion to use an approach that would not directly compare the predicted concentrations of NO_2 to the NAAQS, because there will be an increase in the number of aircraft operations for the future condition when compared to existing levels as well as changes in the positioning of aircraft at gates and runway assignments for aircraft arrivals and departures, we expect that the air quality analysis results will predict increases in NO_2 concentrations at the receptors most influenced by aircraft activity. Also, the shift in motor vehicle traffic from the east side of the airport to the west side will likely result in predicted increases in NO_2 at the receptors on the west side of the airport that would be most influenced by motor vehicle traffic.

  Our preliminary results of the existing condition indicate that if ARM2 with site specific ambient NO_2 ratios is used, the modeled maximum 98th percentile 1-hour concentration, without adding a background concentration, is 151 $\mu g/m^3$, which is less than the NAAQS of 188 $\mu g/m^3$. However, when adding the seasonal temporal background concentration for NO_2 that is presented in the Air Quality Protocol, a measured concentration at the Schiller Park monitoring station, the total maximum 98th percentile 1-hour concentration is 240 $\mu g/m^3$, a concentration greater than the NAAQS. Of course, adding a background concentration from Schiller Park which is located in close proximity to O'Hare, to the modeled concentration provides a concentration that double counts the emission sources at the airport.

  It is very notable that the year 2018 measured levels of NO_2 at the Schiller Park monitoring station are substantially less than the modeled values for the same year (the 98th percentile of 1-hour daily maximum concentrations is 115 $\mu g/m^3$ and the three-year average of the 98th percentile of 1-hour daily maximums is 105 $\mu g/m^3$).

  Because the measured values are substantially less than the modeled values and the model input will include the sources that are expected to provide a significant contribution to the measured values at the Schiller Park monitoring station (i.e., on airport sources and motor vehicle emissions from off airport roadways), it would therefore seem appropriate to:

  1) Use the incremental method of deriving future year concentrations.

  2) Adjust the background concentration to eliminate or reduce the source contribution double counting (this may entail using the modeled concentration only when the wind direction [$\pm$ 75 degrees] is from the Airport to the receptor and using the modeled concentration plus background concentration when the wind direction is from the receptor to the Airport), and/or

  3) Calibrate the modeled results from AEDT/AERMOD to eliminate or reduce the overprediction (this may entail developing an adjustment factor based on statistical correlations such as robust

highest concentration and mean squared error and applying the adjustment factor to the modeled concentration [for example, decrease by 42 µg/m³] only when the wind direction [± 75 degrees] is from the Airport to the receptor and using the unadjusted modeled concentration plus background concentration when the wind direction is from the receptor to the Airport).

Notably, the background concentration and calibration methods would require a protocol revision to detail how either would be accomplished if USEPA indicates that either one or the other is acceptable.

Any of the three methods (adjusted background concentration, calibration, or increment) are suited to evaluate the project effect because the methods:

1) Account for the "change" in airport-related emissions over time (existing to future),

2) Allow a comparison of the no action and project-related NO_2 concentrations to the NAAQS, and

3) Disclose the impact of the proposed improvements as required by NEPA.

KB Environmental Sciences

MEMO

Date: August 28, 2020

To: Amy Hanson, Federal Aviation Administration (FAA)

From: Carrol Fowler, KB Environmental Sciences, Inc. (KBE) and Mike Ratte, RCH Group

Subject: Nitrogen Oxide (NO_2) Conversion Methodologies Evaluation and Meteorological Data Processing and NO_2 Background Concentrations for the Terminal Area Plan (TAP) and Air Traffic Procedures Environmental Assessment (EA) for Chicago O'Hare International Airport (O'Hare)

On June 16, 2020, the FAA transmitted two memorandums to the United States Environmental Protection Agency (USEPA). The memorandums had been revised in response to comments received from the USEPA. Following the submittal of the revised memorandums, the USEPA transmitted their remaining comments to the FAA (email from Jennifer Tyler to Amy Hanson dated July 2, 2020) and a video conference was held July 7, 2020 to review and discuss the comments. This Memorandum lists each comment and either provides a response or states at what location in the final Air Quality Modeling Protocol (the Protocol) that a comment is addressed (the revised memorandums are incorporated in to the final Protocol as attachments).

No.	Comment	Response/Document Location
1	Overall comment – For the EA, EPA previously recommended use of a build vs no build scenario to demonstrate that the proposed project would not worsen air quality. Will that strategy be pursued? If so, please describe the methodology. If a build vs no build scenario is being pursued, we'd also like to better understand the intent of the technical memos provided. This will frame the dialogue for us and help EPA to better assist your team.	With the exception of one-hour NO_2, a comparison of build versus no build will likely result in some receptors showing a build increase in concentrations due to changes in the locations at which the sources will operate (e.g., motor vehicles will increase on the west side of the Airport). Even with the change, concentrations should be below the National Ambient Air Quality Standards (NAAQS). Because the Aviation Environmental Design Tool (AEDT)/AERMOD are overpredicting, both the build (and no build) concentrations of one-hour NO_2 may be above the NAAQS.
2	This analysis shows that all the AERMOD NO_x to NO_2 screening techniques produce concentrations at the location of the Schiller Park monitor higher than the monitored values at that site. However, the analysis does not speak to the possibility that emissions of NO_x may not be well-represented. While the ARM2 approach with site-specific ratios provides the best match with measured concentrations at the Schiller Park location, there is no guarantee that the ARM2 approach would perform best in all applications, given the potential emissions estimation uncertainties.	See Page 1 of Attachment A of the final Protocol which provides the source of the emission rates in AEDT. The results of the NO_2 evaluation are only applicable to the air quality assessment being prepared in support of the O'Hare EA.

No.	Comment	Response/Document Location
3	The new background monitor is located in a significantly different environment than the O'Hare airport. Northbrook was discontinued, however, there are other monitors in the area which may better represent an urban area contribution of NO_2.	See Pages 9 through 11 of the Protocol and the section entitled *Modeled Concentration of* NO_2 on Page 2 of the Protocol's Attachment A.
4	The meteorology processing report notes that met data for the year 2017 was used. The NO_2 evaluation document states that NO_2 values for the year 2018 were selected for the study. It's not clear whether this is a typo. However, for comparing modeled to monitored values, the same year(s) should be used for both meteorology and concentration measurements.	See the last sentence before the *Evaluation Methodology* section on Page 2 of Attachment B of the Protocol.
5	Just for clarification, page 5 of the Met Data Processing document states that "the USEPA option to use one year of site-specific data was selected." Site-specific met data is preferred, however, if more than 1-year of data (up to 5 years) is available, those years should be used.	See Page 4 of Attachment A of the Protocol.
6	On page 5 of the Met Data document, it discusses randomization of the wind direction. When using 1-minute NWS data, and the AERMINUTE preprocessor, there is no need to randomize the wind direction since AERMINUTE averages the rolling 2-minute directions over the hour.	See Page 5 of Attachment A of the Protocol.
7	On page 6 of the Met Data document, item 4, it discusses treatment of calm winds. This paragraph discusses the use of a 0.5 m/s wind speed threshold. At the end of the paragraph it states that wind speeds less than 0.5 m/s are adjusted to 0.5 m/s. The use of the 0.5 m/s threshold is to limit the use of very low wind speeds. It is not expected that winds less than 0.5 m/s be set to that level. Rather, those lower wind speeds will be considered calm and AERMOD will process using the calms routine. The approach described in the document would likely be conservative for 1-hr averaging times.	See Page 5 of Attachment A of the Protocol.
8	AERSURFACE is an appropriate tool to use for generating surface roughness, Bowen ratio, and albedo for use in AERMET. EPA is curious about the current location of the O'Hare meteorological tower. It has moved over the years and getting the right location for the tower is very important when running AERSURFACE.	See the section entitled *Meteorological Data Sets* on Page 4 of Attachment A of the Protocol.

No.	Comment	Response/Document Location
9	The scatterplots included in the Model Evaluation document show very little correlation between modeled predictions and measured values. This is often the case when comparing model to monitor concentrations, paired in both time and space, especially for short-term averaging periods. EPA recommendations for model evaluation put an emphasis on values unpaired in time (e.g., the provided Q-Q plots).	See the first paragraph in the *Evaluation Methodology* section of Attachment B of the Protocol (Page 2 of the memo).
10	Figure 2 shows a Q-Q plot for the NO_2 concentrations. The ARM2ss values show an unusual flattening relative to the other NO_2 methods. It would be useful to describe why this is happening, particularly since all the methods seem to converge so closely at around 30 ppb of measured NO_2.	See the section entitled *Scatterplots* on page 6 of Attachment B of the Protocol.
11	The report focused much detail on the NO2 performance without much detail on the total NOx performance. Pages 9 & 10 have a very brief discussion of the NO_2/NO_x ratio of the RHC, which seems to suggest that the NO_x performance is OK, such that the ARM2ss method is the most appropriate, as it gives the closest NO_2/NO_x ratios. This provides a fairly narrow view of the NO_x performance and how choosing the ARM2ss method will be consistently representative of concentrations at other locations or how good the base NO_x performance is overall to apply the proposed ARM2ss. At a minimum, we recommend adding the total measured NO_x to all tables showing the measured NO_2 as well as showing the statistics in table 5 with total NO_x.	See the section entitled *Modeled/Measured NO_x* on Page 12 of Attachment B of the Protocol.
12	We note that at the highest NO_x concentration (391 ppb) the ARM2ss method gives 89 ppb, which is a ratio of 0.228, which is notably higher than the site-specific value of 0.186, which means that this lower value is not actually impacting the model results. The ARM2 method is developed based on a minimum ambient ratio of 0.2, the 0.5 default in AERMOD is given absent any other information. However, it is difficult to argue that a value lower than the 0.2, that the method itself is based on, should be used.	See Page 23 of the Protocol and the second bullet on Page 1 of Attachment B of the Protocol.

No.	Comment	Response/Document Location
13	The January 8, 2020 "Chicago O'Hare International Airport Terminal Area Plan and Air Traffic Procedures Environmental Assessment Air Quality Modeling Protocol" (January Modeling Protocol) described the operational profile used to adjust annualized activity to month, day, and hour specific adjustments, indicating that the activity data is not actually correlated to the meteorology and monitoring data. The emissions scenario is not described in the NO2 technical memo, but we assume that the same modeling from the January Modeling Protocol is the basis for the June NO_2 memo. If this is the case, then there's little reason for there to be any correlation between the paired hourly measurements and modeled concentrations shown in Figures 3a-g. It is generally reasonable to compare distributions of concentrations in these cases, so we recommend removing figures 3a-g and focusing instead on concentrations unpaired in time, such as the QQ plots and RHC values already provided.	See Page 22 of the Protocol and the paragraph before the section entitled *Evaluation Methodology* on Page 2 of Attachment B of the Protocol.

Chicago O'Hare International Airport
Terminal Area Plan and Air Traffic Procedures Environmental Assessment
Air Quality Modeling Protocol
Response to USEPA Comments
June 29, 2021

On August 27, 2020, the Federal Aviation Administration (FAA) transmitted the Draft Final Air Quality Modeling Protocol for the Chicago O'Hare International Airport Terminal Area Plan and Air Traffic Procedures Environmental Assessment (EA) to the United States Environmental Protection Agency (USEPA). USEPA provided comments on October 1, 2020. The following lists each USEPA comment (in italics) and either provides a response or indicates the section/page in the Final Air Quality Modeling Protocol that a comment is addressed.

1. *We continue to strongly recommend use of a higher minimum ambient ratio (i.e., 0.3) for the ARM2ss approach. This higher ratio would be more defensible and consistent with the data and the conservative nature of the ARM2 method. The ratio can be applied without conducting new modeling. We would be glad to discuss further.*

   A memo on this subject, entitled *Minimum Ambient Ratio for the Terminal Area Plan and Air Traffic Procedures Environmental Assessment for Chicago O'Hare International Airport*, was prepared (see Attachment D of the Final Air Quality Modeling Protocol). The memo documents that a minimum ambient ratio of 0.186 was derived using ambient measurements of NO_x and NO_2 from the Schiller Park monitoring station and states reasons why the air quality analysis for the TAP EA is being performed with the minimum ambient ratio of 0.228. Because modeled 1-hour NO_2 concentrations are overestimated when compared to measured concentrations, the FAA determined that a minimum ambient ratio of 0.228 is appropriate for use in the EA analysis.

2. *Add language clarifying why 3 years of meteorological data were examined rather than the USEPA and FAA recommended 5-year period.*

   The dispersion modeling analysis is being performed using hourly meteorological data from O'Hare that was obtained from the National Weather Service. The data are for the three-year period from 2016 through 2018.

   The USEPA's Guideline on Air Quality Models (2017) provides three options for the selection of meteorological data (Section 8.4.2.2 of Volume 82, No. 10 of the Federal Register[1]). The three options are:

   1. Use five years of adequately representative National Weather Service or comparable meteorological data, or
   2. At least one year of site-specific data, or
   3. At least three years of prognostic meteorological data.

   As stated, the analysis is being performed with using site-specific data so there is only a USEPA requirement to perform the analysis using one year of data. Typically, the one year would be the most recent available. To be conservative, for the EA analysis, three years of data were evaluated and the year resulting in the highest concentrations was used.

[1] https://www.epa.gov/sites/production/files/2020-09/documents/appw_17.pdf

With respect to FAA's recommendations regarding use of meteorological data, the Air Quality Handbook states that "Typically…five years of meteorological data are first analyzed in AERMET…", it is not a FAA recommendation to do so.

3. *Edit the language on page 15 of the protocol to say a receptor height of 1.8 m is consistent with USEPA hot-spot modeling guidance. It isn't the recommended receptor height for permitting or site-specific State Implementation Plan attainment demonstrations.*

   The language on page 15 of the Final Air Quality Modeling Protocol was revised to state that use of 1.8 meters is consistent with USEPA modeling guidance.

4. *While we find that the Nilwood, IL NO_2 monitoring site is likely not representative of background conditions around O'Hare, the application of the background value in the increment modeling approach may minimize its importance. Additionally, the "existing conditions" NO_2 concentration added to the modeled increment will also contain background source impacts. Consequently, we are not asking for further changes.*

   Comment noted. NO_2 concentration from the Nilwood monitoring station will be used for background concentrations.

5. *For clarity, it would be useful to more fully explain in the document what modeled values will be used to generate the NO_2 modeled increment impacts. For example, will the concentrations selected from each model run be the peak values at each receptor paired in time, peak values at each receptor unpaired in time, 98th percentile values, etc.?*

   It is intended that the increment be defined as the modeled future year concentration minus the modeled existing conditions concentration or, computer more simply, the change (increase/decrease) in concentration from the existing year to the future year as estimated by the model. The increments for each receptor will then be added to the measured existing condition (2018) concentration from the Schiller Park monitoring station to derive the total future year concentration. In this manner, the increments will be derived for the Project and No Action as well as the Build Out (2030) and Interim (2023). The values at each receptor paired in time would be used to determine the increment and the 98th percentile value would be added to the measured existing condition (2018) concentration from the Schiller Park.

   Notably, although the increment method has been retained in the Final Air Quality Modeling Protocol, use of the method may not be required to predict concentrations of NO_2. Draft modeling results suggest that the modeled NO_2 concentration plus background concentrations may be slightly less than the National Ambient Air Quality Standard (NAAQS) with the proposed project. If the final modeling results are also below the NAAQS, the increment method will not be used.

ATTACHMENT E-2

CLEAN AIR ACT STATE IMPLEMENTATION PLAN GENERAL CONFORMITY DETERMINATION

Chicago O'Hare International Airport
Terminal Area Plan and Air Traffic Procedures
General Conformity Determination

The Clean Air Act (CAA) requires federal agencies to ensure that actions proposed to occur in a designated nonattainment or maintenance area conform to the appropriate State Implementation Plan (SIP), also known as General Conformity. The General Conformity Rule requires that a proposed action comply with the SIP's purpose of eliminating or reducing the severity and number of violations of the National Ambient Air Quality Standards (NAAQS) and achieving expeditious attainment of such standards. Compliance is achieved if a proposed action would not cause emissions that exceed de minimis levels defined for the criteria pollutants. If the proposed action's emissions exceed the de minimis levels, a conformity determination would be required. The General Conformity Rule applies to all federal actions except for certain highway and transit programs that must comply with the Transportation Conformity Rule contained in 40 CFR Part 93, Subpart A.

The General Conformity Rule of the CAA establishes the procedures and criteria for determining whether certain federal actions conform to state or federal air quality implementation plans. Within areas designated nonattainment, and for the pollutant(s) for which the designation is relevant (e.g., the air pollutant O_3 in both Cook and DuPage County), the General Conformity Rule of the CAA prohibits federal agencies (including the FAA) from permitting or funding projects or actions that do not conform to an applicable SIP (e.g., Chicago-Naperville 8-hour Ozone SIP). A SIP is developed/used by state agencies to bring an area into compliance with the NAAQS. Common features of a SIP include attainment timeframes and milestones, area-wide emissions inventories and budgets, as well as emission control and mitigation strategies.

Under the General Conformity Rule, all reasonably foreseeable direct and indirect emissions occurring due to federally supported actions should be quantified and compared against de minimis thresholds in what is known as an applicability test. The applicability test is only conducted on pollutants for which the area is classified as either maintenance or nonattainment. Because O'Hare is located within an area that United States Environmental Protection Agency (USEPA) has designated as nonattainment/serious with respect to the 2008 ozone NAAQS, the *de-minimis* levels for volatile organic compounds (VOC) and nitrogen oxides (NOx) are 50 tons per year and are used in the applicability analysis for this EA.[1] General Conformity for airports focuses on construction, aircraft, auxiliary power units (APUs), and ground support equipment (GSE) emissions, while motor vehicle emissions are part of Transportation Conformity and stationary sources are part of the air quality permitting process.

In an area with a SIP, conformity can be demonstrated in one of the following ways:

- By showing that the emission increases caused by an action are included in the SIP
- By demonstrating that the State agrees to include the emission increases in the SIP
- Through implementation of emissions reductions to offset the action's emissions in the same or nearby area
- Through mitigation to reduce the emission increase

Construction Activities

For the purpose of evaluating the construction emissions associated with the TAP EA and their potential to impact regional levels of the air pollutant ozone, the Illinois Environmental Protection Agency (IEPA)

[1] United States Environmental Protection Agency, General Conformity De Minimis Tables, https://www.epa.gov/general-conformity/de-minimis-tables

provided their year 2025 (construction year 3) and 2030 (construction year 8) emission inventories of VOC and NO_x for Cook and DuPage counties. The emissions, for sources identified in IEPA's data (dated January 28, 2020) as "Construction Equipment" and "Construction and Mining Equipment" are provided in the following table.

IEPA CONSTRUCTION EMISSIONS INVENTORY FOR COOK AND DUPAGE COUNTIES

	Tons	
Year	VOC	NO_x
2025 (3)	1,117	4,187
2030 (8)	1,089	3,653

The Baseline/TAP/ALP construction emission estimate of VOC represent less than one percent of the IEPA's inventory and the Baseline/TAP/ALP NO_x emissions represent approximately two percent of the inventory. While the IEPA's regional emission estimates do not identify specific projects, because the O'Hare-related emissions represent a small percentage of the regional estimates for Cook and DuPage, it is reasonable to assume that the Baseline/TAP/ALP emissions are included in IEPA's regional emission estimates. Therefore, the TAP/ALP construction emissions for VOC and NO_x are accounted for within IEPA budgets and General Conformity compliance is achieved.

CONSTRUCTION EMISSIONS INVENTORY FOR TAP COMPARED TO REGIONAL EMISSIONS

Year	VOC		NO_x	
	Tons	Percent of Regional	Tons	Percent of Regional
2025	7	0.6	88	2.1
2030	2	0.2	22	0.6

Source: Crawford Murphy & Tilly, Inc./RCH Group, 2021.

Operational Activities

The results of the operational emission inventories indicate that emissions of NO_x and VOC temporarily increase 63 and 26 tons, respectively, when comparing the Interim With Project to the Interim No Action. For VOC, these increases are less than the de minimis threshold but for NO_x, these increases are greater than the de minimis threshold. Therefore, compliance with General Conformity must be demonstrated. In contrast, the results of the emission inventories indicate that emissions of NO_x and VOC decrease by 16 and 5 tons, respectively, when comparing the Build Out With Project to the Build Out No Action.

The source of the operational emissions are aircraft activities consisting of both ground-based emission sources (i.e., ground taxi/idle), emissions above ground level (i.e., approach, climbout, and takeoff), as well as APU and GSE within the terminal/apron areas. The operational emissions inventory is conducted using the FAA's Aviation Environmental Design Tool (AEDT, Version 2d Service Pack 2).[2] The aircraft fleet mix, annual operations, and aircraft ground taxi time used to prepare the operational inventories are consistent with data generated from the Total Airspace and Airport Modeler that is prepared in support of the TAP EA. APU emissions are based on the availability of electrical power and pre-conditioned air specific to O'Hare. GSE emissions are based the type of equipment, fuel type, and operating times that are specific to O'Hare.

[2] Federal Aviation Administration, Aviation Environmental Design Tool (AEDT) Users Guide, September 2017, https://aedt.faa.gov/. AEDT 2d, Service Park 2 was released on September 5, 2019

AIRCRAFT, APU, AND GSE EMISSIONS INVENTORY – INTERIM CONDITION

	Tons					
Source Category	CO	VOC	NO_x	SO_x	PM_{10}	$PM_{2.5}$
	Interim With Project					
Aircraft	5,410	593	4,712	459	31	31
APU	29	2	29	4	4	4
GSE	470	18	43	5	3	3
With Project Total	**5,909**	**613**	**4,784**	**469**	**38**	**38**
	Interim No Action					
Aircraft	5,098	568	4,649	444	30	30
APU	29	2	29	4	4	4
GSE	465	17	43	5	3	3
No Action Total	**5,592**	**587**	**4,721**	**453**	**37**	**37**
	Incremental Difference (With Project minus No Action)					
Aircraft	312	25	63	15	1	1
APU	0	0	0	0	0	0
GSE	4	<1	<1	<1	<1	<1
Total	**316**	**26**	**63**	**15**	**1**	**1**
Conformity Threshold		**50**	**50**			

Values reflect rounding.
Source: Crawford Murphy & Tilly, Inc./RCH Group, 2021.

AIRCRAFT, APU, AND GSE EMISSIONS INVENTORY – BUILD OUT CONDITION

	Tons					
Source Category	CO	VOC	NO_x	SO_x	PM_{10}	$PM_{2.5}$
	Build Out With Project					
Aircraft	5,281	551	5,573	502	31	31
APU	29	2	23	3	3	3
GSE	451	17	37	6	3	3
With Project Total	**5,761**	**570**	**5,633**	**511**	**37**	**37**
	Build Out No Action					
Aircraft	5,356	556	5,589	506	31	31
APU	29	2	23	3	3	3
GSE	455	17	37	6	3	3
No Action Total	**5,840**	**575**	**5,649**	**515**	**37**	**37**
	Incremental Difference (With Project minus No Action)					
Aircraft	-75	-5	-16	-4	<-0	<-0
APU	0	0	0	0	0	0
GSE	-4	<-0	<-0	<-0	<-0	<-0
Total	**-79**	**-5**	**-16**	**-4**	**0**	**0**
Conformity Threshold		**50**	**50**			

Values reflect rounding.
Source: Crawford Murphy & Tilly, Inc./RCH Group, 2021.

The operational emissions inventories are prepared for two periods for the TAP EA: Interim with Project (representing year 2025) and Buildout with Project (representing year 2032). As shown, in the years 2025 and 2032, the total estimated emissions of VOC from aircraft, APU, and GSE is 613 and 570 tons, respectively and the total estimated emissions of NO_x is 4,784 and 5,633 tons, respectively.

Estimates for operational emissions associated with the TAP EA can be assumed to be included in the ozone-related SIP inventory, the IEPA provided the agency's year 2025 and year 2030 inventories of VOC and NO_x emissions form aircraft, APU, and GSE within Cook and DuPage counties (dated January 28, 2020). Based on correspondence with the IEPA, O'Hare-related emissions from these sources comprise approximately 90 percent of the emissions in the two counties. The following table provides the derived SIP emissions for O'Hare. The TAP EA values for 2030 are linearly interpolated between the Interim with Project (2025) and the Buildout with Project (2032). Secondly, the IEPA emissions inventory for 2032 are linearly grown based on the rate of change from 2025 to 2030.

As shown, the TAP operational emissions for VOC and NO_x are less than the IEPA's regional inventory for 2025, 2030, and 2032. Therefore, the TAP operational emissions for VOC and NO_x are accounted for within IEPA budgets and General Conformity compliance is achieved.

As shown, the TAP/ALP operational emissions for VOC and NO_x are less than the IEPA's regional inventory (inclusion of the emissions within the Ozone State Implementation Plan) for the Interim With Project and Build Out With Project and compliance with General Conformity is demonstrated.

AIRCRAFT, APU, AND GSE EMISSIONS INVENTORY COMPARED TO SIP BUDGET

Year	Pollutant	SIP: Aircraft, APU, GSE Emissions in Cook/DuPage	SIP: Derived O'Hare-Related Emissions	TAP EA	TAP EA Emissions Less Than SIP Emissions
2025	VOC	1,027	924	613	Yes
	NO_x	5,696	5,126	4,784	Yes
2030	VOC	1,096	986	582	Yes
	NO_x	6,107	5,496	5,390	Yes
2032	VOC	1,124	1,012	570	Yes
	NO_x	6,271	5,644	5,633	Yes

Values reflect rounding.
Source: Crawford Murphy & Tilly, Inc./RCH Group, 2021.

Summary

The TAP construction emissions would exceed the de minimis thresholds for VOC and NOx. However, the construction emissions are accounted for in the applicable SIP. The TAP operational emissions would exceed the de minimis thresholds for NOx. However, the operational emissions are also accounted for in the applicable SIP.

This attachment includes a letter to IEPA entitled Construction Emissions Inventory and Operational Emissions Inventory for the Terminal Area Plan and Air Traffic Procedures Environmental Assessment for Chicago O'Hare International Airport, dated June 3, 2021 which documents the estimated construction and operational emissions and associated SIP emission budgets. This attachment also includes a letter from IEPA, entitled General Conformity Determination for the O'Hare Terminal Area Plan Project, stating concurrence that the TAP construction and operational emissions are included in the applicable SIP.

DRAFT MEMO

Date: June 3, 2021

To: Amy Hanson, Federal Aviation Administration (FAA)
Diana Wasiuk, Harris Miller & Hanson, Inc. (HMMH)

From: Carrol Fowler, Crawford, Murphy & Tilly, Inc. (CMT)[1]
Mike Ratte, RCH Group (RCH)

Subject: Construction Emissions Inventory and Operational Emissions Inventory for the Terminal Area Plan (TAP) and Air Traffic Procedures Environmental Assessment (EA) for Chicago O'Hare International Airport (O'Hare)

The Federal Aviation Administration (FAA) is preparing an Environmental Assessment (EA) for the Terminal Area Plan (TAP or Projects) and Air Traffic Procedures at Chicago O'Hare International Airport (O'Hare). The TAP and Air Traffic Procedures would result in new passenger terminal space and changes to airfield and air traffic operating procedures.

Based on previous discussions with, and requests by, the Illinois Environmental Protection Agency (IEPA), this Memorandum presents the construction emissions inventories and operational (aircraft, auxiliary power units [APU], and ground support equipment [GSE]) emissions inventories that were prepared in support of the TAP EA. The inventories were prepared for carbon monoxide (CO), volatile organic compounds (VOC), nitrogen oxides (NO_x), sulfur dioxide (SO_2), particulate matter less than 10 micrometers (coarse particulate or PM_{10}), and particulate matter less than 2.5 micrometers (fine particulate or $PM_{2.5}$).

Construction Emissions

The sources of construction emissions are combustion exhaust from the on- and off-site construction equipment/vehicles and delivery/haul trucks, as well as employee vehicles travelling to and from O'Hare. Emissions from sources such as the placement of asphalt, concrete batch plants, surface disturbance, excavation, and demolition are also included in the inventories.

The construction inventories were derived based on a Construction Equipment Schedule (dated September 11, 2020) that was prepared in support of the TAP EA. US Environmental Protection Agency's (USEPA) Motor Vehicle Emissions Simulator (MOVES, Version 2014b) and the NONROAD emission models were used to determine emission factors for the construction emissions inventories.

Two construction-related inventories were prepared. The first inventory provides the estimated emissions resulting from Baseline projects (**Table 1**). Baseline projects are projects that would be constructed in the future but are not associated with the TAP. The Baseline inventory was prepared for the years 2023 through 2028. The second inventory (**Table 2**), prepared for the years 2023 through 2032, and provides the estimated emissions for the TAP plus future projects that are identified on the Airport Layout Plan (ALP) for O'Hare.

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[1] KB Environmental Sciences, Inc. recently merged with Crawford, Murphy & Tilly, Inc.

Table 1: Construction Emissions Inventory – Baseline (Tons/Year)

Year	CO	VOC	NO_x	SO_2	PM_{10}	$PM_{2.5}$
2023	20	3	35	<1	4	2
2024	10	2	16	<1	2	1
2025	10	2	17	<1	2	1
2026	3	1	5	<1	1	<1
2027	2	<1	3	<1	<1	<1
2028	<1	<1	<1	<1	<1	<1

Table 2: Construction Emissions Inventory - TAP and ALP (Tons/Year)

Year	CO	VOC	NO_x	SO_2	PM_{10}	$PM_{2.5}$
2023	34	6	67	<1	15	5
2024	61	9	115	<1	28	9
2025	42	6	71	<1	24	6
2026	27	4	53	<1	24	5
2027	17	2	24	<1	14	3
2028	16	2	27	<1	11	3
2029	17	2	26	<1	19	4
2030	15	2	22	<1	20	4
2031	1	<1	2	<1	4	1
2032	<1	<1	1	<1	1	<1

For the purpose of evaluating the construction emissions associated with the TAP EA and their potential to impact regional levels of the air pollutant ozone, the IEPA provided their year 2025 and 2030 emission inventories of VOC and NO_x for Cook and DuPage counties. The emissions, for sources identified in IEPA's data (dated January 28, 2020) as "Construction Equipment" and "Construction and Mining Equipment" are provided in **Table 3**.

Table 3: IEPA Construction Emission Inventory – Cook and DuPage Counties (Tons/Year)

Year	VOC	NO_x
2025	1,117	4,187
2030	1,089	3,653

For comparative purposes, the VOC and NO_x emissions for the Baseline, TAP, and ALP projects (Tables 1 and 2 above) were summed. These data are provided in **Table 4**. As shown, the Baseline/TAP/ALP construction emission estimate of VOC represent less than one percent of the IEPA's inventory and the Baseline/TAP/ALP NO_x emissions represent approximately two percent of the inventory. While the IEPA's regional emission estimates do not identify specific projects, because the O'Hare-related emissions represent a small percentage of the regional estimates for Cook and DuPage, we believe that it is reasonable to assume that the Baseline/TAP/ALP emissions are included in IEPA's regional emission estimates and we respectfully request IEPA's concurrence with this assumption.

Table 4: Construction Annual Emissions Inventory – Baseline, TAP, and ALP

Year	VOC		NO_x	
	Tons/Year	Percent of Regional	Tons/Year	Percent of Regional
2025	7	0.6	88	2.1
2030	2	0.2	22	0.6

Operational Emissions

The source of the operational emissions are aircraft activities consisting of both ground-based emission sources (i.e., ground taxi/idle), emissions above ground level (i.e., approach, climbout, and takeoff), as well as APU and GSE within the terminal/apron areas. The operational emissions inventory was conducted using the FAA's Aviation Environmental Design Tool (AEDT, Version 2d Service Pack 2). The aircraft fleet mix, annual operations, and aircraft ground taxi time used to prepare the operational inventories were consistent with data generated from the Total Airspace and Airport Modeler that was prepared in support of the TAP EA. APU emissions were based on the availability of electrical power and pre-conditioned air specific to O'Hare. GSE emissions were based the type of equipment, fuel type, and operating times that are specific to O'Hare.

The operational emissions inventories were prepared for two periods for the TAP EA: Interim with Project (representing year 2025) and Buildout with Project (representing year 2032). The TAP EA inventories are provided in **Table 5**. As shown, in the years 2025 and 2032, the total estimated emissions of VOC from aircraft, APU, and GSE is 613 and 570 tons, respectively and the total estimated emissions of NO_x is 4,784 and 5,633 tons, respectively.

Table 5: TAP Operational Emissions Inventory (Tons/Year)

Period	Source Category	CO	VOC	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Interim with Project (2025)	Aircraft	5,410	593	4,712	459	31	31
	APU	29	2	29	4	4	4
	GSE	470	18	43	5	3	3
	Total	**5,909**	**613**	**4,784**	**469**	**38**	**38**
Buildout with Project (2032)	Aircraft	5,281	551	5,573	502	31	31
	APU	29	2	24	3	3	3
	GSE	451	17	37	6	3	3
	Total	**5,761**	**570**	**5,633**	**511**	**37**	**37**

For the purpose of determining if the CMT/RCH estimates for operational emissions associated with the TAP EA can be assumed to be included in the ozone-related SIP inventory, the IEPA provided the agency's year 2025 and year 2030 inventories of VOC and NO_x emissions form aircraft, APU, and GSE within Cook and DuPage counties (dated January 28, 2020). These data are provided in **Table 6**. Based on correspondence with the IEPA, O'Hare-related emissions from these sources comprise approximately 90 percent of the emissions in the two counties. The derived SIP emissions for O'Hare are also provided in **Table 6**. Within **Table 6**, the TAP EA values for 2030 were linearly interpolated between the Interim with Project (2025) and the Buildout with Project (2032). Secondly, the IEPA emissions inventory for 2032 were linearly grown based on the rate of change from 2025 to 2030.

As shown, the TAP operational emissions for VOC and NO_x are less than the IEPA's regional inventory for 2025, 2030, and 2032. Per previous discussions with IEPA, we understand that IEPA will incorporate the TAP operational emissions into the IEPA's regional inventory for VOC and NO_x.

Table 6: TAP Operational Emissions Compared to SIP Emissions

Year	Pollutant	SIP		TAP EA	TAP EA Emissions Less Than SIP Emissions
		Aircraft, APU, GSE Emissions in Cook/DuPage	Derived O'Hare-Related Emissions		
2025	VOC	1,027	924	613	Yes
	NO_x	5,696	5,126	4,784	Yes
2030	VOC	1,096	986	582	Yes
	NO_x	6,107	5,496	5,390	Yes
2032	VOC	1,124	1,012	570	Yes
	NO_x	6,271	5,644	5,633	Yes

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
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JB PRITZKER, GOVERNOR JOHN J. KIM, DIRECTOR

November 30, 2021

Amy Hanson
Environmental Protection Specialist
Federal Aviation Administration
2300 East Devon Avenue
Des Plaines, IL 60018

Re: General Conformity Determination for the O'Hare Terminal Area Plan Project

Dear Ms. Hanson:

The Illinois Environmental Protection Agency ("Illinois EPA") has reviewed the draft Terminal Area Plan and Air Traffic Procedures ("TAP/ATP") Environmental Assessment memorandum dated June 3, 2021. The memorandum indicates that construction and operational changes related to this modernization project will generate emissions of volatile organic compounds (VOC) and oxides of nitrogen (NOx) that exceed the General Conformity *de minimis* levels. Therefore, Illinois EPA has made a determination that the project's emissions are accounted for within the State Implementation Plan ("SIP") for the area.

The applicable SIP for the Chicago area is the Attainment Demonstration for the 2008 Ozone National Ambient Air Quality Standard for the Chicago Nonattainment Area. This SIP was approved by the U.S. Environmental Protection Agency on August 19, 2020 [85 FR 50955]. Although this SIP did not explicitly include additional VOC and NOx emissions to account for the construction and operational changes described by the draft memorandum, sufficient emissions were incorporated into the Attainment Demonstration and the projected emissions therein to accommodate the emissions projected to result from the O'Hare TAP/ATP project.

The Illinois EPA worked with the FAA in the preparation of the General Conformity Determination, providing information on the level of VOC and NOx emissions incorporated into the SIP for O'Hare aircraft, aircraft refueling, and ground service equipment operations, as well as regional construction equipment and motor vehicle emissions. Comparing the level of emissions projected for the construction and operation of the O'Hare TAP/ATP project in the General Conformity Determination for the necessary analysis requirements, the Illinois EPA concurs that such emissions are accounted for within the SIP for the Chicago Nonattainment Area. Notwithstanding this determination, as O'Hare Airport is located in the Nonattainment Area and an Environmental Justice area, emissions resulting from all projects undertaken at the airport should be minimized to the extent possible.

Please feel free to contact Rory Davis, Manager of the Regulatory Development Unit, at (217) 782-7397 with any additional questions you may have,

Sincerely,

Julie K. Armitage
Chief, Bureau of Air

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