

—TOWN OF—
MIDDLETON
Wisconsin

May 3, 2022

phbohsupport@cityofmadison.com

Dr. Jerry Halverson, Chair
Board of Health Madison and Dane County

Dear Chair Halverson,

Please consider this communication and Attachment a request on behalf of the children in the Town of Middleton to review, analyze, and take any necessary action to minimize or remove the breathable, airborne lead particles from the school environments of the Middleton Cross Plains Area School District.

As you are undoubtedly aware, the Wisconsin DNR has determined that the City of Middleton's Morey Airport Operations ("C29" or "Airport") produce 32% of all airborne lead pollution in Dane County on an annual basis. This breathable airborne lead is emitted as small particles in the exhaust from low flying aircraft burning leaded aviation gas. We are attaching the final report of Trinity Consulting with charts and modeling maps. This report was commissioned by the Town Board and demonstrates a distribution of airborne lead particles over residences, parks, and playgrounds as well as most of the schools in the Middleton Cross Plains District.

We also call your attention to two well-documented studies, both of which determined that children who lived near or had some continuing contact with general aviation airports acquired an elevated blood lead level (See Miranda Study at: <https://ncbi.nlm.nih.gov/pmc/articles/PMC3230438/>; Zahran Study at: <https://news.sccgov.org/sites/g/files/exjcpb956/files/documents/RHV-Airborne-Lead-Study-Report.pdf>).

The Miranda Study is especially instructive with respect to the Middleton Airport's operations. Miranda involved children living near 66 different general aviation airports in 6 different counties in North Carolina. The average lead produced annually by each of those airports was approximately 80 pounds. Morey Airport Operations currently produce two or more times as much lead annually as the average production of the 66 North Carolina airports. Some degree of lead toxicity in many, if not most, of the children in the Middleton Area Schools appears inevitable.

We are aware that Dane County Regional Airport also supports general aviation activities that produce a substantial amount of airborne lead particles on an annual basis. However, those particles are spread over the mostly vacant land of the airport's buffer zone, not over schools, parks, playgrounds, and residences. Morey Airport is primarily for recreation, does not support any essential community function and has no significant vacant land buffer zone around it.

Most parents of children in the Middleton Cross Plains Area School District are not aware of the breathable lead particles spread over the District schools on a daily basis. Neither are they probably aware of the potential health risks to their children if any of those particles are inhaled. Perhaps a health advisory concerning the potential health risks to children from inhaling even small amounts of airborne lead would be appropriate. A parent cannot protect their child from a health hazard if they are not aware it even exists, and in the case of airborne lead, primary prevention is the only defense.

The Madison & Dane County Public Health (“Dane County Public Health”) website under Environmental Health Services states: “We monitor our physical environments for environmental health issues and take action to minimize health hazards.” The DNR has recognized the airborne lead hazard in the Middleton area and Trinity Consulting has documented the areas of the potential impact of that hazard. Dane County Public Health should utilize this evidence along with its own analysis and help eliminate or at least minimize this public health risk.

It should also be noted that some of the heaviest areas of airborne lead particles are deposited immediately to the east of Morey Airport. There are hundreds of housing units being built or already constructed in that area. Many of these units will house young children and some are designated as “affordable” for underprivileged families.

As a representative governmental body, we are very concerned with the lead pollution and air quality in our community, and we will assist in any way reasonably possible to eliminate this dangerous public health condition. We look forward to your review and response.

Sincerely,

Town Board, Town of Middleton



By: Cynthia Richson
Town Board, Chair

Cc: Board of Health, Public Health Madison & Dane County:

Kimberly Whitmore, 1st Chair; Kimberly.whitmore@marquette.edu

Robin Lankton, 2nd Chair; rlankton@uwhealth.org

Holly Hatcher, Supervisor, Dane County Board, District 26;
hatcher.holly@countyofdane.com

* * * * *

Governor Tony Evers; EversInfor@wisconsin.gov

Maggie Gau, Governor Evers Chief of Staff; Maggie.gau@wisconsin.gov

Brian Weaver, WI DHS, Governor Evers Lead Policy Advisor;
brian.weaver@dhs.wisconsin.gov

Craig M. Thompson, WI Dept. of Transportation, Secretary; DOTExec@dot.wi.gov;
craigm.thompson@dot.wi.gov

SCREENING LEVEL ASSESSMENT OF AMBIENT LEAD CONCENTRATIONS AROUND THE MIDDLETON WISCONSIN MUNICIPAL AIRPORT

Prepared By:

Jeremias Szust
Jim Lyons

TRINITY CONSULTANTS

7919 Folsom Blvd
Suite 320
Sacramento, CA 95826

Jeremy Heiken
Oak Leaf Environmental, Inc.
8141 Mast Road
Dexter, MI 48130

March 18, 2022



TABLE OF CONTENTS

1. PROJECT INFORMATION	1-1
1.1 Project Description	1-1
1.2 Site Description.....	1-1
2. DEVELOPMENT OF AIRCRAFT LEAD EMISSIONS DATA	2-1
2.1 Annual Operations and Temporal Allocation	2-1
2.2 Operation Modes and Time in Mode	2-3
2.3 Aircraft Data and Fuel Flow Rates	2-4
2.4 Airport Inventory Results.....	2-5
2.5 Inventory Comparison and Other Sources of Lead Emissions.....	2-7
2.6 Spatial Allocation	2-8
3. AIR DISPERSION MODELING INPUTS	3-1
3.1 Model Selection.....	3-1
3.2 Meteorological Data	3-1
3.3 Urban versus Rural Determination	3-1
3.4 Receptor Grid.....	3-4
3.5 Terrain Data	3-4
3.6 Modeling Parameters	3-4
3.7 Emission Source Parameters	3-4
4. AIR DISPERSION MODELING RESULTS	4-1

LIST OF FIGURES

Figure 1-1. C29 Airport	1-1
Figure 2-1. 2021 Monthly Lead (Pb) Emissions and Piston Operations	2-6
Figure 2-2. Spatial Allocation of On-the-Ground Emissions	2-9
Figure 3-1. Airport Land-Use Imagery	3-3
Figure 3-2. July 30, 2017, Flight Track Data	3-5
Figure 3-3. Modeled Source Locations Reference	3-7
Figure 3-4. Modeled Source by Operations Type	3-8
Figure 4-1. Max Monthly Impacts	4-2
Figure 4-2. Annual Impacts	4-3
Figure 4-3. Maximum Monthly Impact Season	4-4

LIST OF TABLES

Table 2-1. Estimated 2021 Piston Aircraft Operations at C29	2-2
Table 2-2. Percent Operations by Month, MSN (2013-2019)	2-2
Table 2-3. Day-of-Week Factors, MSN (2013-2019)	2-3
Table 2-4. Apportionment of Daily Operations by Time Period, C29	2-3
Table 2-5. Operation Modes and Time in Mode	2-4
Table 2-6. Estimated Fuel Flow Rates (lb./hr.) by Operation Mode at C29	2-5
Table 2-7. Estimated 2021 Lead Inventory and Piston Operations for C29	2-6
Table 2-8. 2021 Lead Inventory Comparison to EPA's 2017 NEI	2-7
Table 2-9. Other Lead Sources within 10 miles of C29, EPA's 2017 NEI	2-8
Table 3-1. Airport Land-Use Analysis	3-1
Table 4-1. Points of Interest and Impacts from Nearest Receptors	4-1

1. PROJECT INFORMATION

1.1 Project Description

Trinity Consultants and Oak Leaf Environmental were asked by the Town of Middleton, Wisconsin to conduct a screening-level analysis to evaluate ambient concentrations of lead in the air around the Middleton Municipal Airport (C29). This effort involved two main components: 1) the development of spatially resolved estimates of lead emissions from the operation of piston-powered aircraft (which use lead aviation gasoline) at and around the airport and 2) dispersion modeling required to translate the lead emissions estimates into estimates of ambient lead concentrations. This report summarizes the results of the C29 airport analysis.

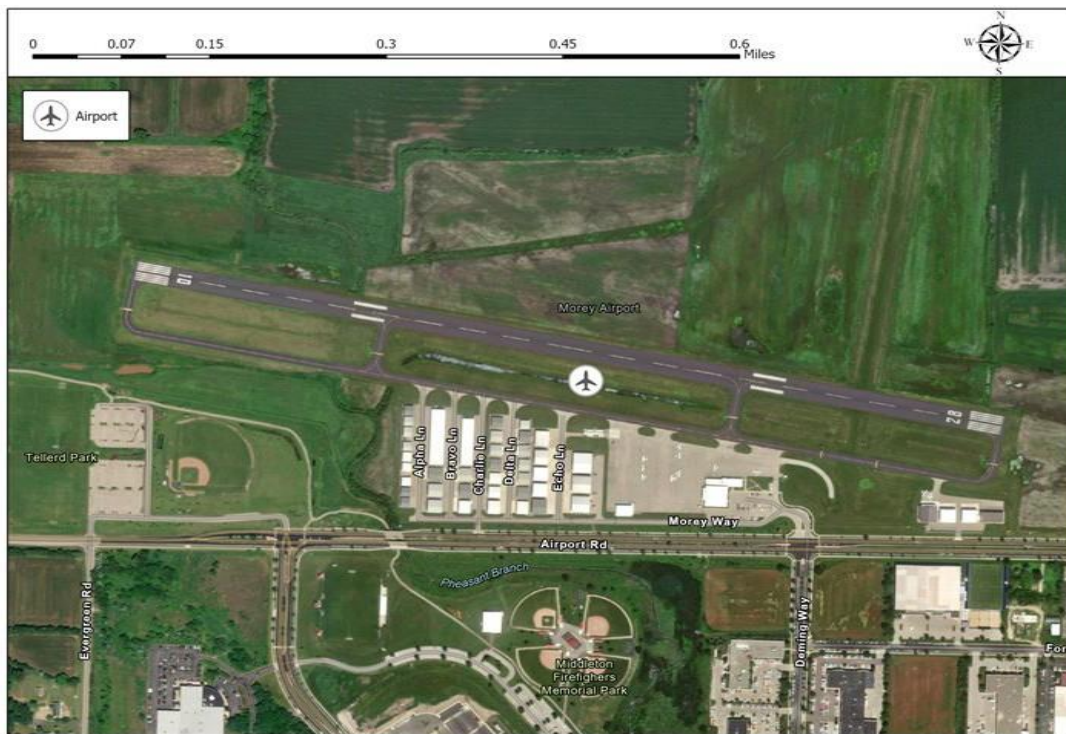
1.2 Site Description

C29 is located in the City of Middleton, WI. The Universal Transverse Mercator (UTM) coordinates for the center of the airport, in 1983 North American Datum (NAD83), are as follows:

- ▶ 293,918.5 meters (m) Easting;
- ▶ 4,776,533.4 m Northing;
- ▶ Zone: 16.

Figure 1-1 below shows the general layout and location of the airport

Figure 1-1. C29 Airport



2. DEVELOPMENT OF AIRCRAFT LEAD EMISSIONS DATA

In this section, the development of the spatially and temporally resolved lead emissions inventory used in the C29 screening analysis is described. The emission inventory estimating procedures followed published guidelines of the US Environmental Protection Agency (EPA)¹ and Transportation Research Board's Airport Cooperative Research Program (ACRP).² The procedures are considered screening-level in that four simplifying assumptions were employed.

1. All operations are modeled as standard takeoffs and landings.
2. The lead content of aviation gasoline is the maximum allowable (2.12 g/gal).
3. All operations are assigned to Runway 10(east)/28(west) with takeoffs occurring to the west on runway 28.
4. All operations are assigned to a single flight track assumption circling back to the airport characteristic of flight school operations

The discussion of the calendar year 2021 lead inventory is presented in the following topics.

- Annual Operations and Temporal Allocation
- Operation Modes and Time in Mode
- Aircraft Data and Fuel Flow Rates
- Airport Inventory Results
- Inventory Comparison and Other Sources of Lead Emissions
- Spatial Allocation

2.1 Annual Operations and Temporal Allocation

The 2021 annual operations for piston-aircraft operating at C29 were derived from the Master Plan.³ The base year of the Master Plan is 2019. Estimates for calendar year 2021 were developed by interpolation of estimates for calendar years 2019 and 2024 presented in Table 2-23 of the Master Plan. Operations for 2021 were approximately 1 percent higher than in 2019. The annual operations were assigned to aircraft by engine type (i.e., piston and jet), fleet type, and trip type (i.e., local and itinerant) using the data presented in Table 2-14 and Appendix A of the Master Plan. The C29-based aircraft are distinguished by flight- school, other airport-based fixed-wing (FW), and rotorcraft fleets. The resulting annual operations for piston aircraft are presented in Table 2.1. The 2021 inventory analysis is based on 40,253 piston aircraft operations. Temporal activity profiles were developed to allocate the estimated annual operations to individual months, days, and hours.

¹ <https://www.epa.gov/regulations-emissions-vehicles-and-engines/epas-data-and-analysis-piston-engine-aircraft-emissions>

² ACRP projects 02-34 and 02-57 include the development of "best practices" guidance for estimating Pb emission from aircraft intended to supplement EPA inventory modeling procedures:

<https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3035> and

<https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3703>.

³ [Airport Master Plan | Middleton, WI - Official Website \(cityofmiddleton.us\)](http://www.cityofmiddleton.us/AirportMasterPlan)

Table 2-1. Estimated 2021 Piston Aircraft Operations at C29

Fleet	Itinerant	Local	Total
Flight School, Piston	4,366	25,593	29,959
Other Airport-Based FW, Piston	9,252	0	9,252
Rotorcraft, Piston	0	271	271
Charter / Air Taxi, Piston*	26	0	26
Other Non-Based FW, Piston†	745	0	745
Total Piston Operations‡	14,389	25,864	40,253

* In the absence of local data, the piston share of charter and air taxi operations (22 percent) was taken from ACRP (see Footnote 2).

† In the absence of local data, the piston share of other non-based FW aircraft operations was assumed to equal that observed for the airport-based FW aircraft operations (91 percent).

‡ No piston-engine aircraft were assumed for military and freight operations.

Monthly and day-of-week profiles were based on daily general aviation operations data recorded at Dane County Regional Airport (MSN) given that suitable data are not available for C29. C29 and MSN both serve the Madison area and are equidistant to both the University of Wisconsin and downtown Madison making MSN the preferred surrogate of local general aviation activity patterns. Recorded FAA operations data at MSN, available through the Operations Network (OPSNET)⁴, over a 7-year period were utilized to estimate monthly and day-of-week profiles shown in Tables 2-2 and 2-3, respectively. The monthly factors of Table 2-2 represent the fraction of annual operations occurring within a given month. The day-of-week factors of Table 2-3 represent multiplicative factors that convert average day operations to estimated operations for each day of the week. For example, the local day-of-week factor of 1.129 on Tuesdays signifies that local operations are 12.9 percent higher on Tuesdays versus the week on average.

Table 2-2. Percent Operations by Month, MSN (2013-2019)

Month	General Aviation Itinerant	Local
January	5.7%	6.3%
February	5.8%	6.8%
March	7.9%	8.5%
April	8.0%	8.1%
May	9.1%	8.8%
June	8.9%	9.6%
July	11.4%	9.8%
August	9.8%	9.3%
September	9.4%	8.6%
October	9.5%	8.3%
November	8.1%	9.1%
December	6.3%	7.0%

⁴ <https://aspm.faa.gov/opsnet/sys/Main.asp>.

Table 2-3. Day-of-Week Factors, MSN (2013-2019)

Month	General Aviation Itinerant	Local
Sunday	1.014	1.022
Monday	0.865	0.967
Tuesday	0.972	1.129
Wednesday	1.075	1.103
Thursday	1.079	0.988
Friday	1.035	0.836
Saturday	0.960	0.954

The hourly operations profile was derived from Table 4-3 of the Master Plan, which apportioned operations between daytime (7 am to 10 pm) and nighttime (10 pm to 7 am). These data are summarized in Table 2-4. Without additional hourly information, it was assumed that operations were apportioned equally to each hour in the daytime and nighttime periods. It should be noted however that for purposes of dispersion modeling emissions were only modeled during daytime hours which were assumed to be between 8 am and 8 pm.

Table 2-4. Apportionment of Daily Operations by Time Period, C29

	Daytime Operation (7 am – 10 pm)	Nighttime Operation (10 pm – 7 am)
Itinerant	90.3%	9.7%
Local	95.5%	4.5%

2.2 Operation Modes and Time in Mode

Each aircraft operation is divided into individual operation modes and an estimated time spent in each mode. Fuel flow rates, and thereby lead emission rates, will vary by operation mode. As noted above, all operations were assumed to be standard, standalone takeoffs and landings. This assumption is consistent with standard EPA lead inventory procedures.⁵ Accordingly, C29 operations are equally apportioned to takeoffs (50 percent) and landings (50 percent). The operation modes associated with each are presented in Table 2-5 along with the estimated time spent in each mode.

⁵ A refinement of this assumption would be to evaluate additional operation types associated with flight school training such as touch-and-go and taxi-back-to-takeoff operations.

Table 2-5. Operation Modes and Time in Mode

Operation Type	Operation Mode	Time In Mode (Minutes)
Takeoff	Taxi & Idle #1 (hangar to runup area)	6.70*
	Taxi & Idle #2 (runup area to top of runway)	5.30*
	Runup (magneto test)	0.96†
	Takeoff	0.30‡
	Climb Out (0 – 1,000 ft. AGL)	1.67‡
Landing	Approach (1,000 – 0 ft. AGL)	2.00‡
	Taxi & Idle (wheels down to hangar)	4.08†

* Total taxi/idle time (#1 and #2 combined) of 12 minutes per takeoff taken from EPA (see Footnote 1); portion of taxi/idle time spent (#2) in runup area taken from ACRP (see Footnote 2).

† Time in mode estimates taken from ACRP (see Footnote 2).

‡ Time in mode estimates taken from EPA (see Footnote 1).

There were no airport-specific estimates of the time-in-mode for C29.⁶ Time estimates assigned in Table 2-5 were largely the recommended defaults that the EPA uses in modeling general aviation emissions. The EPA defaults for climb out and approach modes for fixed-wing piston aircraft, however, were truncated to 1,000 feet above ground level (AGL) traffic pattern altitude (TPA) of C29.⁷ ACRP was used for the time spent for the magneto test and the assignment of taxi & idle time spent to the runup area. ACRP was also used for the elapsed time between wheels down and parking as the EPA time estimate for this mode is a bit short relative to on-the-ground observations of the ACRP projects.

2.3 Aircraft Data and Fuel Flow Rates

Appendix A of the Master Plan provides annual operations data and statistics for 100 airport-based aircraft including N-number, make and model. Engine characteristics (manufacturer, model, and power rating) were identified and assigned based on the aircraft statistics. The engine data were combined with brake-specific fuel consumption rates (BSFCs) by engine and EPA assumed engine load points (by operation mode) to estimate operations-weighted aircraft fuel flow rates. Those rates are presented in Table 2-6. The C29-based aircraft are distinguished by flight-school, other airport-based fixed-wing (FW) and rotorcraft fleets. Non-based fleets (air taxi and other non-based) were assigned the same fuel flow rates as other airport-based FW aircraft in the absence of aircraft or engine specifications on these operations.

⁶ While time-in-mode estimates are not commonly collected, a refinement of this approach would be to measure the average time spent in each mode at C29.

⁷ EPA estimates of time in climb out and approach modes assumes an altitude of 3,000 ft. AGL for all aircraft – from large commercial jets to single-engine piston aircraft. 3,000 ft. AGL is a poor assumption for modeling general aviation as these aircraft operate at a TPA of 1,000 to 1,200 ft. AGL. Also, 1,000 feet AGL equals an elevation of 1,928 feet as the airport elevation is 928 feet.

Table 2-6. Estimated Fuel Flow Rates (lb./hr.) by Operation Mode at C29

Fleet	Takeoff	Climb Out	Approach	Taxi/Idle	Runup
Flight School, Piston	99.17	78.77	47.75	12.08	51.57
Other Airport-Based FW, Piston	142.35	114.69	63.40	21.35	66.88
Rotorcraft, Piston	n/a	99.38	53.21	14.39	60.42
Charter / Air Taxi, Piston	142.35	114.69	63.40	21.35	66.88
Other Non-Based FW, Piston	142.35	114.69	63.40	21.35	66.88

2.4 Airport Inventory Results

Lead (Pb) emissions were estimated for each fleet, flight type (e.g., local and itinerant) and operation mode combination. The emission inventory (in the units of grams) was calculated in accordance with the standard approach common to both EPA and ACRP methods.

$$\text{Emissions} = \text{Operations} \times \text{Time-in-Mode} \times \text{Fuel Rate} \times \frac{\text{Pb Content}}{\text{Density}} \times (1 - \text{Pb Retention Rate})$$

Within this equation, the daily C29 inventory was calculated using the following data:

- Operations counts of Table 2-1 along with temporal allocation of Tables 2-2 and 2-3;
- Time-in-mode estimates of Table 2-5;
- Fuel flow rates of Table 2-6;
- Lead (Pb) content of aviation gasoline (100LL) of 2.12 grams per gallon;⁸
- Aviation gasoline density of 6 lb./gal.; and
- Lead (Pb) retention rate with the aircraft fuel/engine system of 5 percent.⁹

The estimated lead inventory aggregated by month is reported in Table 2-7 and Figure 2-1 along with the monthly total operations. The 2021 total airport lead emissions are estimated to equal 77,055 grams (170 lbs.) based on 40,253 piston operations.

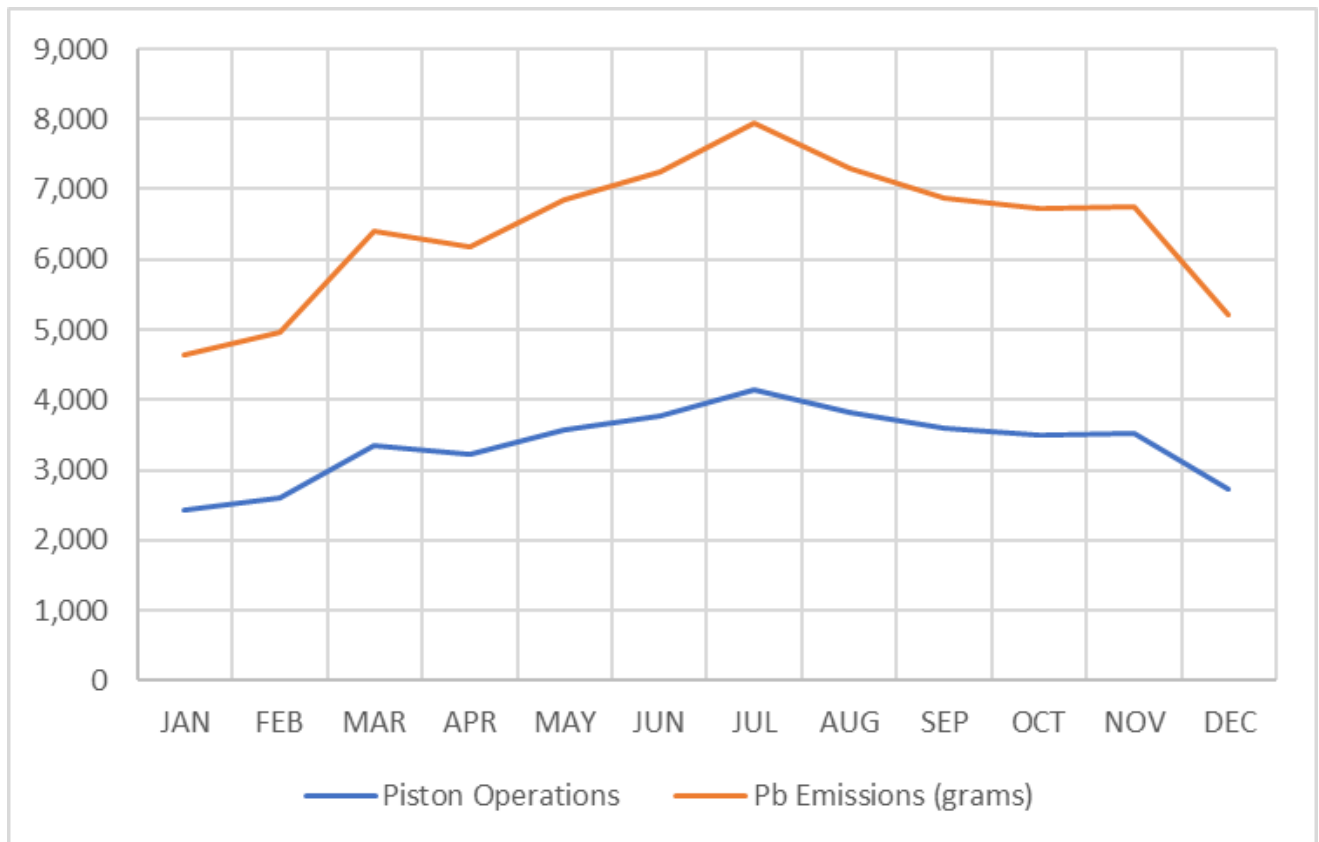
⁸ 2.12 g/gal represents the maximum lead allowable in 100LL aviation gasoline. This is the value commonly employed in emission inventory development including EPA estimates. While not commonly completed, a refinement of this approach would be to collect and analyze gasoline samples at C29 to assess the lead content of gasoline sold.

⁹ EPA defined assumption (see Footnote 1).

Table 2-7. Estimated 2021 Lead Inventory and Piston Operations for C29

Month	Piston Operations	Pb Emissions (Grams)
January	2,429	4,649
February	2,591	4,960
March	3,340	6,393
April	3,226	6,176
May	3,572	6,838
June	3,781	7,237
July	4,154	7,953
August	3,815	7,303
September	3,591	6,874
October	3,508	6,716
November	3,525	6,747
December	2,721	5,208
Total	40,253	77,055

Figure 2-1. 2021 Monthly Lead (Pb) Emissions and Piston Operations



2.5 Inventory Comparison and Other Sources of Lead Emissions

EPA inventory data were compared against this project’s estimates for C29 and to identify any other local sources of lead (Pb) emissions. EPA prepares national emission inventories, incorporating local and state input, of air emissions of key criteria and toxic pollutants – including lead (Pb). These triennially reported inventory efforts are the EPA’s National Emission Inventory (NEI). The current version of the NEI represents calendar year 2017.¹⁰

In the 2017 NEI for Dane County, the county-wide Pb emissions were estimated to equal 671 lbs. Of that total, 96 percent of the county’s Pb emissions are estimated to originate from aviation sources. Notably, 32 percent of the county’s Pb emissions were estimated to originate from C29 operation (217 lbs.) – representing the second-highest Pb source in the county. Dane County Regional Airport (MSN) was the top Pb source in the county in 2017, estimated at 260 lbs. The third highest is Pb source is estimated to be Waunakee Airport (95 lbs.). Nationally, the 2017 NEI estimated 450 tons of lead emissions in the United States in 2017 of which 63 percent came from general aviation operations. The NEI methods for estimating lead from aircraft are those of Footnote 1.

Table 2-8 compares this project’s 2021 lead inventory and operations statistics with those of the 2017 NEI. The 2021 inventory of 170 lbs. (77,055 grams) is below that of the EPA. Both the on-the-ground and aloft emissions of 98 and 72 lbs. are below the EPA estimates of 130 and 88 lbs., respectively. While the total airport operations are close in magnitude, the EPA’s estimate of the piston-engine share of those operations, based on national average statistics, does not match the C29 aircraft operations as documented in the Master Plan. Other key differences between the two inventory estimates are as follows.

- As described in Section 2.2, the maximum altitude of the climb out and approach operation modes equals the 1,000 ft. AGL traffic pattern altitude for the 2021 inventory; the EPA inventory assumes 3,000 ft. AGL.
- The 2021 inventory includes the runup mode (i.e., magneto test); EPA omits this operation.
- As described in Section 2.3, the 2021 inventory relies on an operations-weighted fuel flow rate analysis (based on 100 resident aircraft) and mapping of aircraft engines to 27 unique engines with fuel rates measurements compiled by ACRP (see Footnote 2). The EPA fuel flow rates are the simple average over 6 unique engines; EPA fuel flow rates are biased high.

Table 2-8. 2021 Lead Inventory Comparison to EPA’s 2017 NEI

Parameter	2021 Inventory, C29	EPA 2017 NEI, C29
Total Inventory (lbs.)	170	217
On-the-Ground Inventory (lbs.)	98	130
Aloft Inventory (lbs.)	72	88
Total Airport Operations	41,761	40,510
Piston-Engine Operations	40,253	29,187

For purposes of comparison, Table 2-9 summarizes all the sources of lead emissions within a 10-mile radius of C29, as reported in the 2017 NEI. Eleven sources of lead emissions were identified in this radius – six of which are airports. The 2017 NEI reports 44 sources of lead emissions in Dane County, WI.

¹⁰ <https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data>.

Table 2-9. Other Lead Sources within 10 miles of C29, EPA’s 2017 NEI

Distance from C29 (Miles)	Site Name	Sector	City/Town	Lead Emissions (Lbs.)
1.1	Springs Window Fashions	Manufacturing	Middleton	0.9
5.6	UW Hospital	Medical	Madison	0.3
6.0	Waunakee	Airport	Waunakee	94.5
7.0	UW Madison	Heating Plant	Madison	2.1
7.3	Meriter/Park	Airport	Madison	0.3
7.5	St. Mary's Hospital	Medical	Madison	0.3
8.1	Dane	Airport	Dane	1.6
9.1	Verona	Airport	Verona	5.5
9.6	Dane County Regional	Airport	Madison	259.5
9.6	Madison-Kipp Corp	Manufacturing	Madison	1.9
9.6	Army Guard	Airport	Madison	0.3

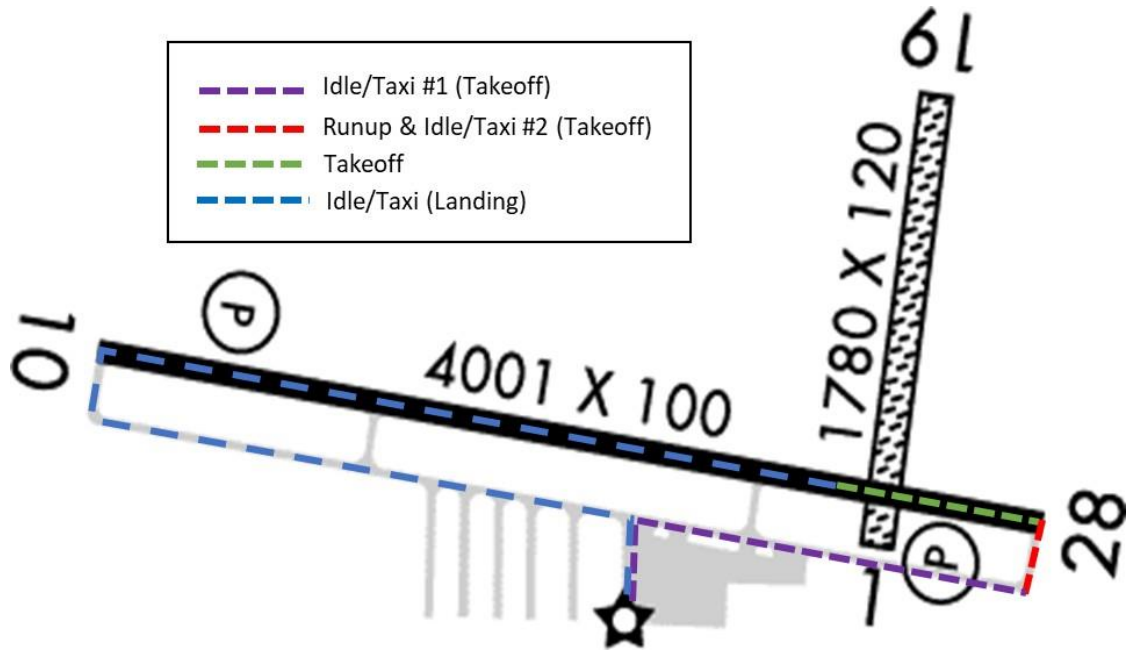
2.6 Spatial Allocation

The spatial allocation assigns the C29 emissions by operation mode within the air quality modeling domain for the purposes of pollutant concentration modeling. The spatial allocation of the on-the-ground emissions and emissions aloft applied different assumptions.

For the on-the-ground operation modes of taxi/idle, runup and takeoff, the emissions were spatially allocated under the simplifying assumption of 100 percent of operations occurring on Runway 10(east)/28(west) with takeoffs to the west. This is the predominate runway usage; the Master Plan assigns about 70 percent of operations to this runway. Moreover, a separate spatial allocation of rotorcraft operations was not completed as these operations were estimated to represent less than 1 percent of the airport emissions.¹¹ The spatial resolution of on-the-ground emissions is presented in Figure 2.2.

¹¹ A refinement to this approach would be to assign fixed-wing operations to a frequency distribution between the runways and develop separate spatial allocation rotorcraft operations.

Figure 2-2. Spatial Allocation of On-the-Ground Emissions



For the two aloft operation modes of climb out and approach, we reviewed available flight track data and other resources. We were provided with a data capture of representative aircraft tracking data (i.e., latitude, longitude, and altitude) on a 4 or 5-second frequency with separate databases by aircraft operating under visual flight rules (VFR) and instrumented flight rules (IFR). We were provided with five years' IFR data and 17 months' VFR data. The data were not specific to C29. The use of IFR for operations at C29 is sporadic and infrequent, which was expected. Therefore, the VFR data are preferable for identifying flight patterns aloft at C29. The climb out and approach for July 30, 2017, was selected as the representative date for modeling the spatial allocation of aloft modes at C29. This date included 83 operations identified and nearly 100 percent use of Runway 10(east)/28(west). These data are presented in Section 3.7 of this report.¹²

¹² There were no automated procedures identified for isolating individual C29 operations within the larger VFR data files, which were organized by date. A handful of dates were examined. Criteria were applied to isolate the operation in the airport environs, eliminating flyovers, and to approximate when a landing or takeoff had occurred at C29 (as the tracking did not include on-the-ground movements). Within the original VFR data capture supplied for July 30, 2017, only 0.4% of the flight track records were specific to climb out and approach operations occurring at C29.

3. AIR DISPERSION MODELING INPUTS

The following sections describe the procedures and methods for conducting the air quality modeling analysis. Dispersion modeling techniques applied in this analysis are in accordance with 40 CFR Part 51 Appendix W, also known as the Environmental Protection Agency’s (EPA’s) Guideline on Air Quality Models.

3.1 Model Selection

Air dispersion modeling was performed using version 21112 of the AERMOD modeling system which is the latest version of AERMOD.

AERMOD is composed of three modular components: AERMAP, the terrain preprocessor that characterizes the terrain and generates source and receptor elevations; AERMET, the meteorological preprocessor that processes raw surface and upper air meteorological observations for use by AERMOD; and AERMOD, the control module and modeling processor.

3.2 Meteorological Data

Meteorological data used in the dispersion modeling analysis was obtained from the Wisconsin Department of Natural Resources (WDNR) Site-Specific Meteorological Data table¹³. Data were processed by WDNR using the meteorological preprocessors AERMET (21112) and AERMINUTE (15272). Data consists of five years (2016 through 2020) of National Weather Service (NWS) surface data collected at the Madison, WI airport. Concurrent upper-air observations used in AERMET were obtained from the Green Bay, WI airport. The data underwent quality assurance and was selected as the most representative data due to its proximity to the site and consistent terrain characteristics with the site location. Additionally, while the Airport does have a meteorological station onsite, it does not meet EPA quality assurance requirements and would not represent high-quality meteorological data for an air dispersion modeling analysis.

3.3 Urban versus Rural Determination

40 CFR Part 51 Appendix W Section 7.2.1.1 provides guidelines on selecting rural or urban dispersion coefficients. This is used in determining the planetary boundary layer characteristics that affect the model’s prediction of downwind concentrations.

Table X below shows the percentage of land that can be categorized as urban vs non-urban, indicating that <50% of the land-use surrounding the Airport can be classified as urban.

Table 3-1. Airport Land-Use Analysis

Value	Description	Count	Urban?	%
11	Open Water	205	N	0.58%
21	Developed, Open Space	2917	N	8.19%
22	Developed, Low Intensity	4911	Y	13.78%
23	Developed, Medium Intensity	4885	Y	13.71%
24	Developed, High Intensity	2759	Y	7.74%

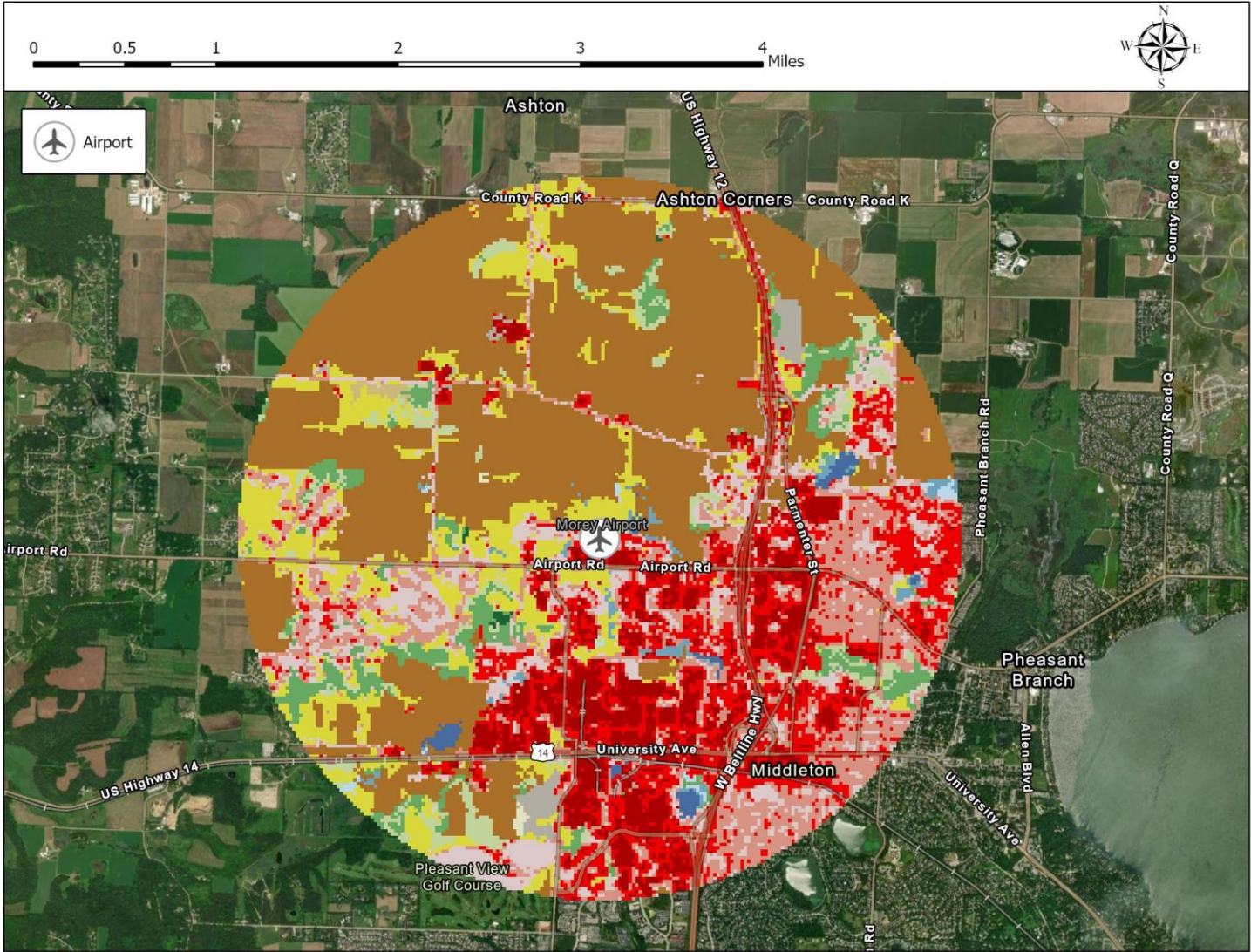
¹³ <https://dnr.wisconsin.gov/sites/default/files/topic/AirPermits/model/MetData2021.pdf> - accessed January 31, 2022

Value	Description	Count	Urban?	%
31	Barren Land	338	N	0.95%
41	Deciduous Forest	1321	N	3.71%
42	Evergreen Forest	28	N	0.08%
43	Mixed Forest	1013	N	2.84%
52	Shrub/Scrub	66	N	0.19%
71	Herbaceous	34	N	0.10%
81	Hay/Pasture	3646	N	10.23%
82	Cultivated Crops	13179	N	36.99%
90	Woody Wetlands	85	N	0.24%
95	Emergent Herbaceous Wetlands	242	N	0.68%

Figure 3-1 depicts the land-use types surrounding the Airport. Only the areas shaded deep-red can be considered urban areas for the purposes of determining whether the use of urban dispersion coefficients is appropriate.

Given that less than 50% of the surrounding land-use type in a three-kilometer radius can be described as urban, urban dispersion coefficients were not utilized in this modeling analysis.

Figure 3-1. Airport Land-Use Imagery



3.4 Receptor Grid

A modeling domain was developed for the air dispersion analyses to encompass the location of nearby areas with points of interest. Discrete receptor locations in AERMOD were based on UTM coordinates in the WGS84 datum.

The receptor grid was developed to ensure that the maximum pollutant concentrations and points of interest were captured by the model. The grid consisted of 1,343 receptors with the following spacing:

- ▶ 100-meter spacing for receptors extending from the center of the Airport to 2,000 meters;
- ▶ 250-meter spacing for receptors extending from the course receptor grid to 8,000 meters.

3.5 Terrain Data

Receptor terrain and source elevations were derived from 1/3 arc-second National Elevation Dataset (NED) data obtained from the U.S. Geological Survey. AERMAP version 18081 was used to determine elevations for all receptors and emission sources, with the exception of elevated sources which are discussed in Section 3.7.

3.6 Modeling Parameters

All sources modeled were represented as volume sources which are unaffected by building downwash (wake effects from buildings) in the AERMOD model, therefore buildings were not included in the modeling analysis.

3.7 Emission Source Parameters

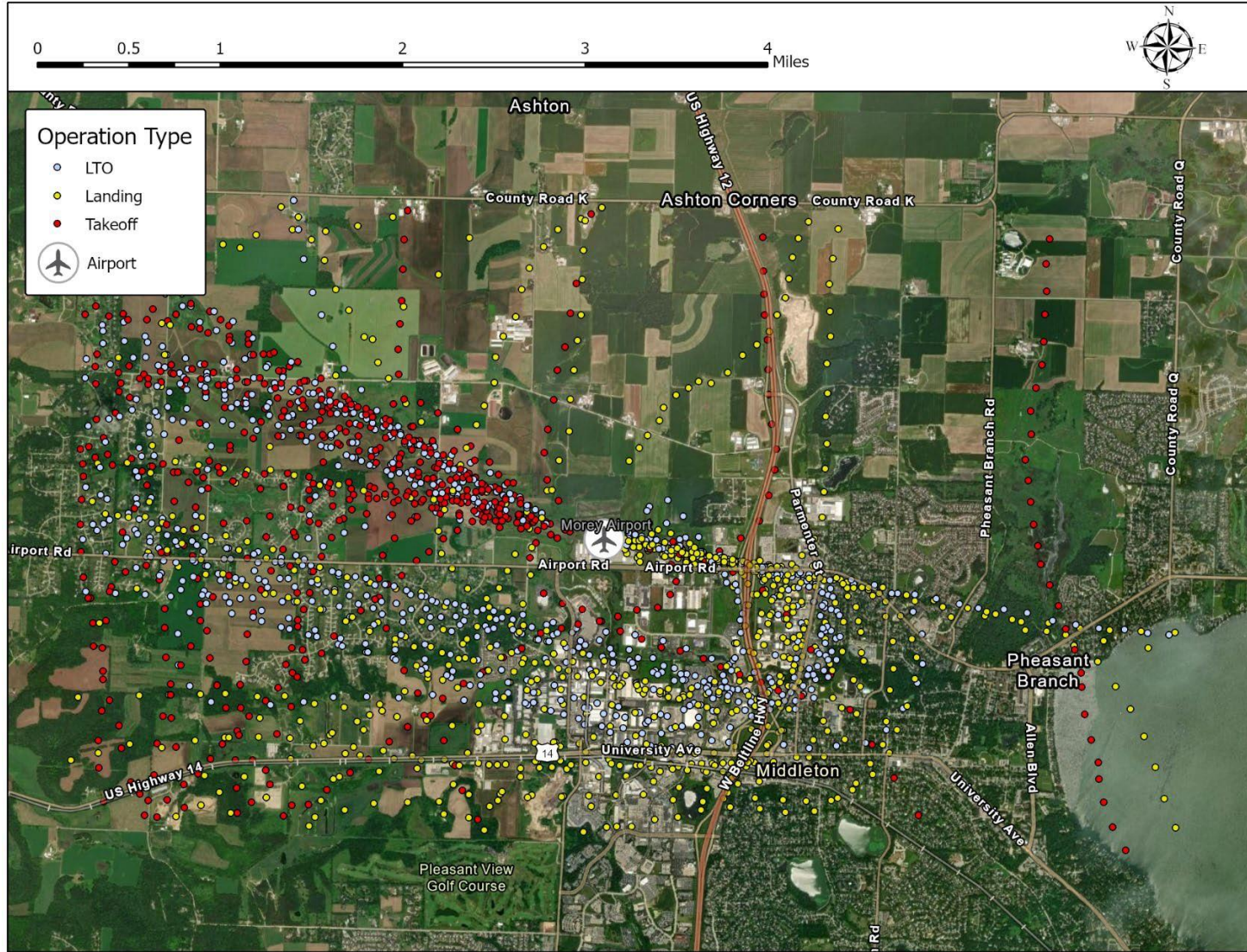
The modeling analysis included six types of airport operations, which can be described as follows:

- Idle/Taxi #1 (Idle/Taxi to Run-Up)
- Run-Up prior to takeoff and Idle/Taxi #2
- Takeoff
- Climb-Out
- Approach
- Idle/Taxi to Hangar

The location of these sources is based on information obtained from the Airport Master Plan, for movement within the airport, as well as a single day of VFR Flight Tracks data from July 30, 2017, for movement of aircraft once they are airborne.

Figure 3-2 below shows a geospatial representation of the flight tracks for July 30, 2017, along with the purpose of each operation.

Figure 3-2. July 30, 2017, Flight Track Data



In an effort to reduce model processing time and represent a “worst-case” scenario, climb-out and approach sources were represented as the average location of Landing and Take-off (LTO) operations, therefore combining all itinerant flight emissions with LTO emissions.

Figure 3-3 shows the locations of modeled sources with respect to the July 30, 2017, flight track information. Figure 3-4 shows the locations of modeled sources along with the type of operation for each source.

Figure 3-3. Modeled Source Locations Reference

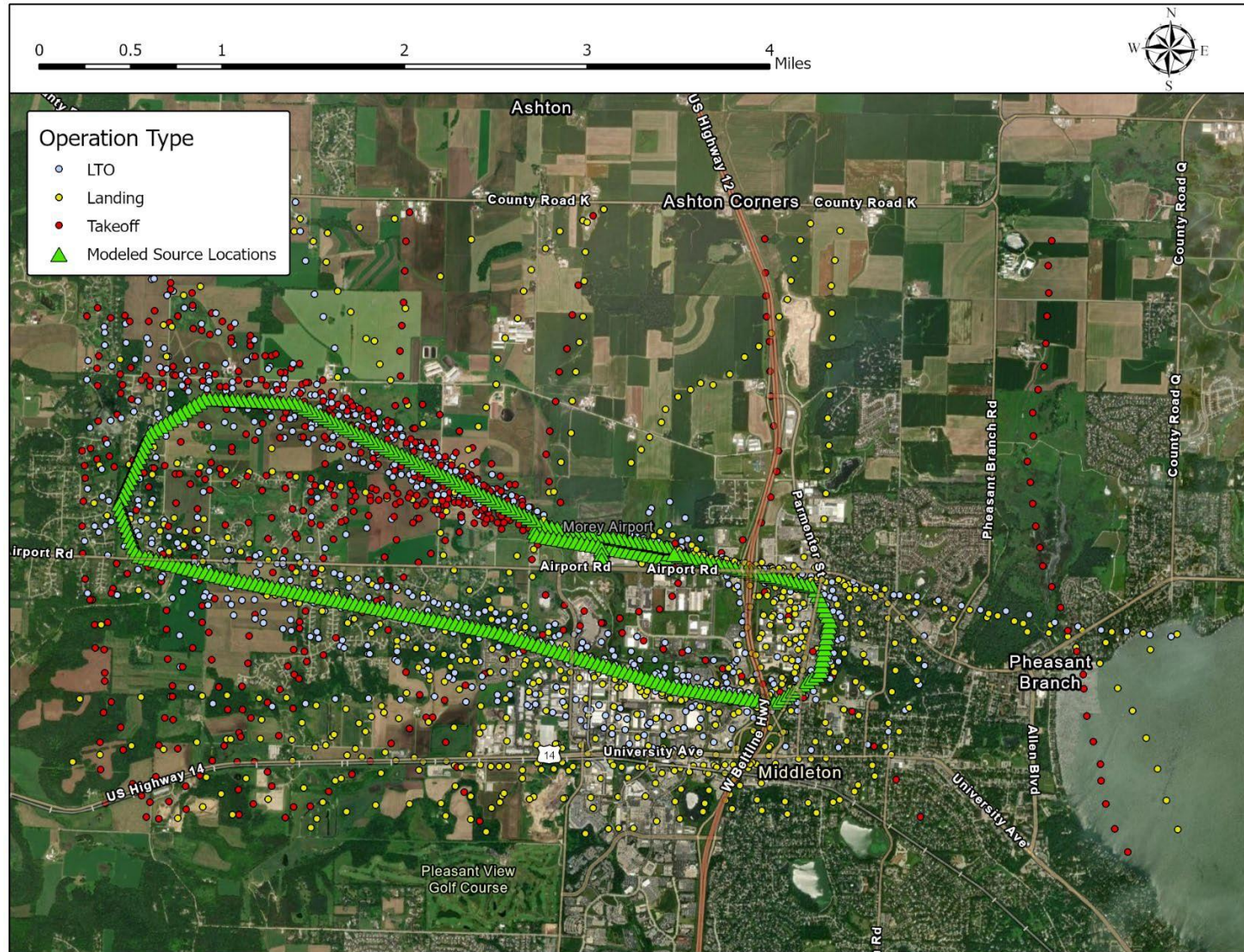
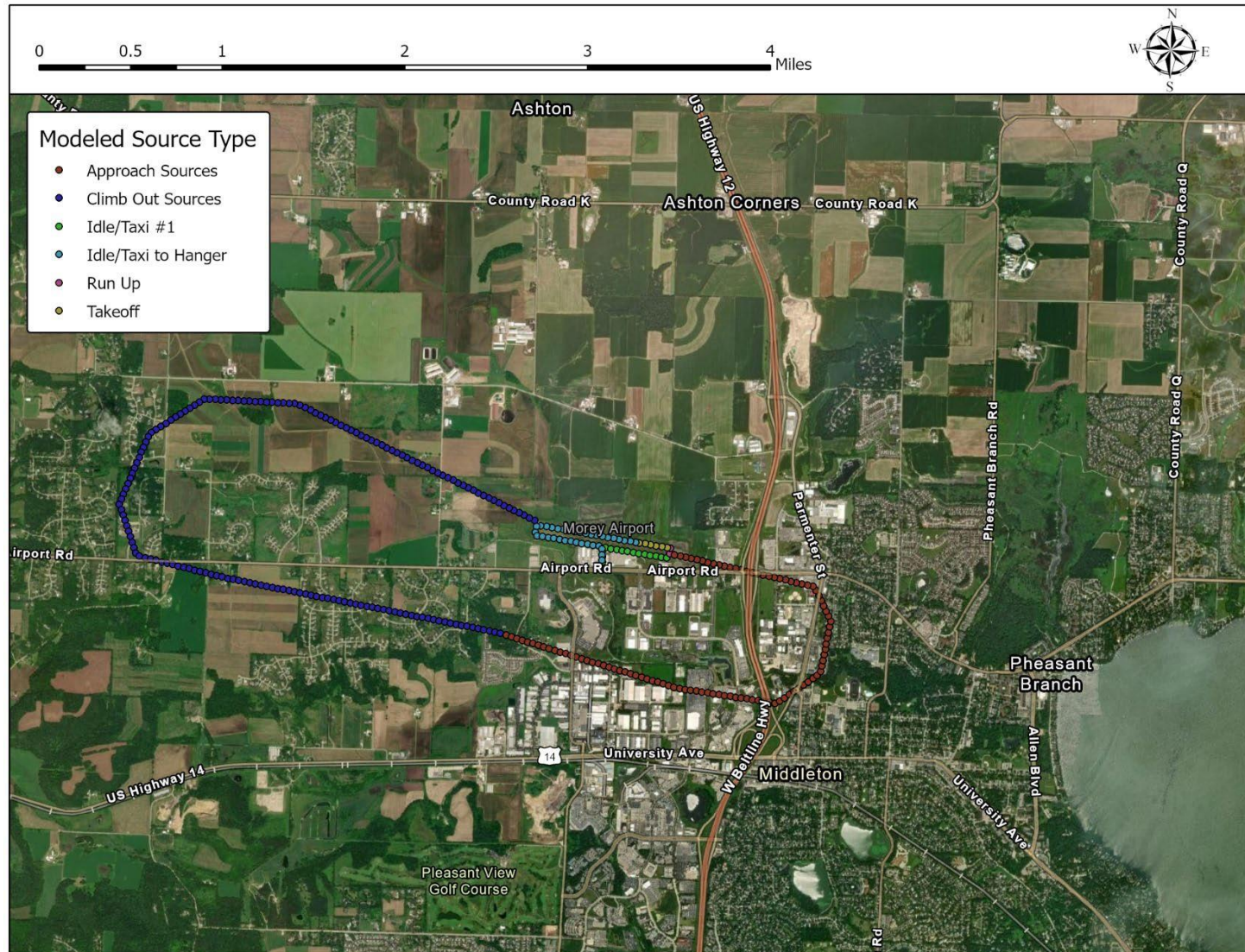


Figure 3-4. Modeled Source by Operations Type



Operations of each source type were then broken down further by Season and Hour-of-Day by utilizing the AERMOD "SEASHR" keyword, which allowed AERMOD to apply variable emission rates to each source. This was applied to account for operations only occurring between 8 AM and 8 PM and the seasonality of emissions. Figure 2- shows how lead emissions vary by month.

The seasons were defined as follows:

- Winter – December, January, and February
- Spring – March, April, and May
- Summer – June, July, and August
- Autumn – September, October, and November

These seasons align closely to the magnitude of monthly lead emissions profiles shown in Figure 3-5.

The modeling analysis was conducted assuming all emissions were from fixed-wing aircraft. Initial horizontal dispersion (σ_y) was calculated as suggested in AERMOD documentation (U.S. EPA 2004, Table 3-1) as the source separation distance divided by 2.15. Initial vertical dispersion (σ_z) was calculated using the mixing zone residence time as defined in the CALINE3 model:

Equation 3-1. Initial Vertical Dispersion Calculation

$$\sigma_z = (1.8 + 0.11) * \frac{WW2}{UU} * \frac{60}{30}^{0.2}$$

where

SZI = initial vertical dispersion (m);

W2 = half-width of the runway or taxiway (m); and

U = average wind speed over the modeling period (m/s).

The values for the initial vertical dimension parameters are as follows:

W2 = 16 meters

U = 4.044 m/s average between 8 AM and 8 PM

SZI = 8.68 meters

Additionally, the source separation distance (the center-to-center distance of adjacent volume sources) was taken as 50 meters, following the ICF report (ICF International and T&B Systems 2010). This means the initial lateral dimension utilized was 23.3 m (50/2.15).

The initial release point for all sources is calculated as the center-line of the initial vertical dispersion coefficient, i.e. the height of the plume divided by two (8.68*2.15/2 = 9.33 meters).

These source characterizations were utilized for all sources and did not account for wake turbulence effects from climb-out and approach sources, which would require additional surveying to determine the takeoff and landing angles. Additionally, wingspan wake, horizontal momentum, and propeller turbulence wake were not utilized in the preparation of run-up source characterization.

Lastly, the elevations for climb-out and approach sources were assumed to be 500 feet (152.4 meters) above ground level elevations (GLE). In order to determine these values, AERMAP was utilized to calculate the GLE for each climb-out and approach source, and 152.4 meters were added to the calculated value.

4. AIR DISPERSION MODELING RESULTS

Modeling results are included in this section in Figure 3-1 and Figure 3-2. Figure 3-3 indicates during which season maximum monthly impacts occur. Points of interest are included in each figure and labeled with unique IDs. Table 3-1 includes a description for each point of interest along with maximum monthly and annual impacts as estimated by the AERMOD model for the receptor closest to each location. Even though the spring and summer months have higher emission rates, most receptors have highest impacts in the autumn and winter months due to calmer winds and weaker convective forces during those months.

Table 4-1. Points of Interest and Impacts from Nearest Receptors

ID	Description	Type	Max Season	µg/m ³	
				Monthly	Annual
1	Highwood Circle Estates	Homes	Autumn	0.0047	0.0017
2	Madison Montessori	School	Autumn	0.0011	0.0006
3	Sunset Ridge Elementary	School	Autumn	0.0014	0.0009
4	Primrose School of Middleton	School	Winter	0.0035	0.0015
5	Middleton Gymnastics Academy	Recreation	Winter	0.0121	0.0067
6	Ed Tallard Park	Park	Autumn	0.0019	0.0012
7	Northside Elementary School	School	Winter	0.0016	0.0006
8	Kromrey Middle School	School	Winter	0.0021	0.0010
9	Clark Street Community School	School	Winter	0.0028	0.0016
10	Clubhouse For Kids II	School	Autumn	0.0044	0.0018
11	Miramont Behavioral Health	Hospital	Autumn	0.0054	0.0024
12	Penni Klein Park	Park	Autumn	0.0024	0.0012
13	Middleton Firefighters Memorial Park	Park	Autumn	0.0077	0.0040
14	Firemen's Park	Park	Winter	0.0019	0.0009
15	Keva Sports Center	Recreation	Autumn	0.0144	0.0082
16	Hinrichs Family Farm Park	Park	Winter	0.0017	0.0008
17	Murphy Park	Park	Autumn	0.0047	0.0013
18	Hickory Woods Park	Park	Autumn	0.0021	0.0012
19	Summit Ridge Park	Park	Winter	0.0006	0.0003
20	Vosen Memorial Park	Park	Autumn	0.0009	0.0005
21	Settler's Prairie Park	Park	Autumn	0.0009	0.0005
22	Enchanted Valley Park	Park	Autumn	0.0004	0.0003

Figure 4-1. Max Monthly Impacts

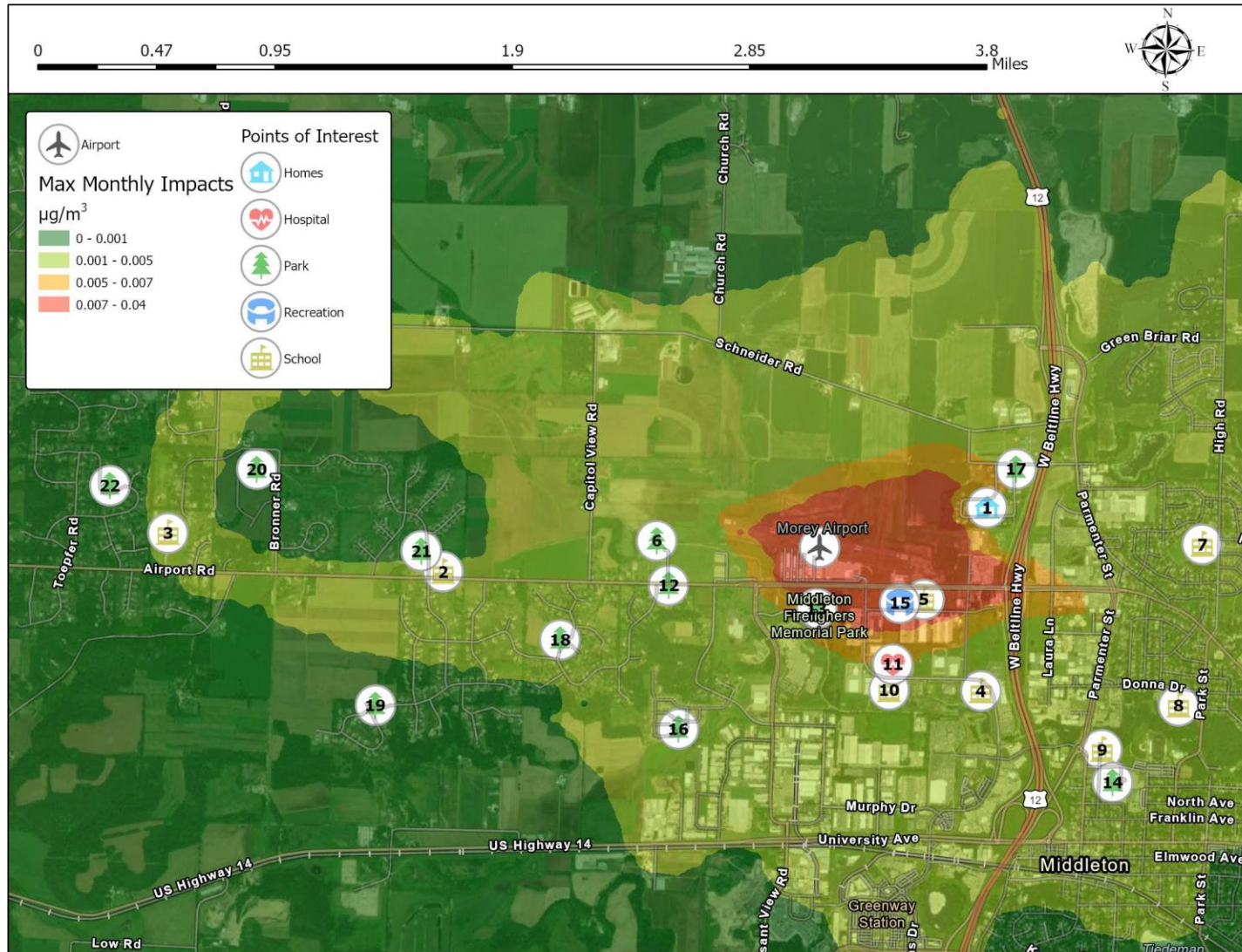


Figure 4-2. Annual Impacts

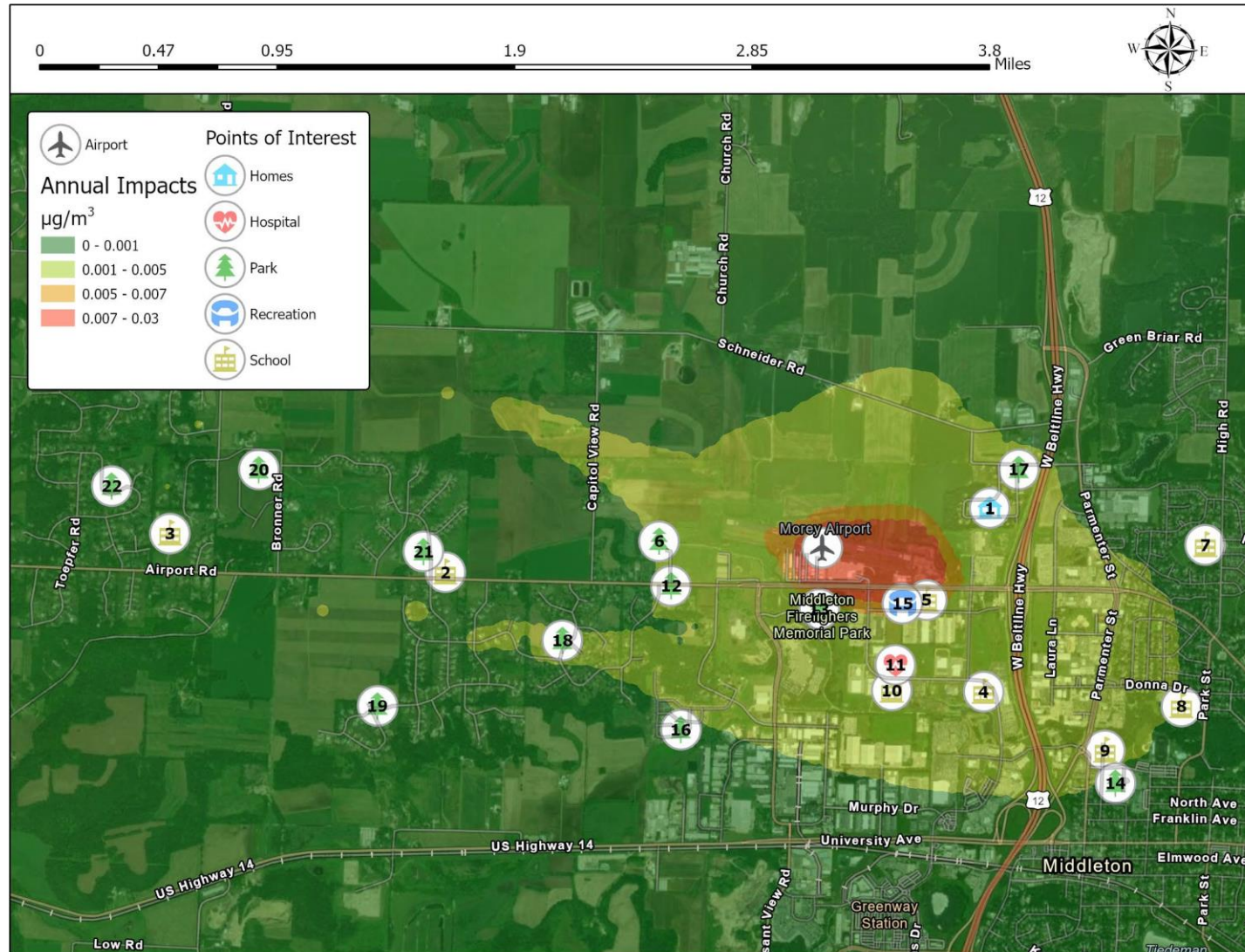


Figure 4-3. Maximum Monthly Impact Season

