Appendix E — Air Quality

Appendix E is intended to supplement and provide background information for the materials contained in Chapter 8 Air Quality.

E.1 Emissions Modeling Tools

Analysis of current conditions and modeling of future year scenarios for aircraft-related emissions in the *2017 ESPR* was completed using the FAA's Aviation Environmental Design Tool (AEDT). This updated tool replaced the older Emissions and Dispersion Modeling System (EDMS) which was used in prior ESPRs.

E.1.1 Differences between AEDT and EDMS

AEDT is the most recent tool developed by the FAA for modeling noise and emissions at airports. It is based on the best current available science for calculating aircraft-related emissions (from main aircraft engines, auxiliary power units, and ground support equipment). As described in Chapter 7 – Noise, AEDT is also used to assess and model airport noise. AEDT capability provides a user the ability to simultaneously model aircraft noise and emissions, replacing the legacy tools of EDMS and the Integrated Noise Model (INM). Due to methodological updates and the inclusion of more recent data, results between the various models may vary.

Many updates have been incorporated into AEDT from EDMS. An overview of the main differences is provided below:

- **Input Data** – Aircraft take-off weight values are somewhat different in each model, and take-off weight affects emissions. This in turn results in potential differences in aircraft emissions during the take-off mode of operations. Unlike EDMS, AEDT does not allow adjustments in take-off weights.
- **Aircraft Operational Modes** – AEDT provides a more detailed output on aircraft operational modes than EDMS, which results in more specific operational characteristics and thus a difference in emissions estimates.
  - In EDMS, the four primary operational modes are: (1) Take-Off, (2) Climb Out. (3) Cruise, and (4) Taxi-Idle.
  - In AEDT, there are thirteen operational modes, including: (1) Take-Off, (2) Climb Taxi, (3) Climb Ground, (4) Climb Below 1,000 Feet, (5) Climb Below Mixing Height, (6) Climb Below 10,000 Feet, (7) Cruise Above 10,000 Feet, (8) Descend Below 10,000 Feet, (9) Descend Below Atmospheric Mixing Height, (10) Descend Below 1,000 Feet, (11) Descend to Ground, (12) Descend Taxi, and (13) Full Flight.

- **Time-In-Modes (TIM)** – Due to the changes described in the Operational Modes section above and changes in how aircraft "climb out" and cruise times are calculated in AEDT, there are also differences in TIM between the two models. This difference affects the total emissions calculated for Landing and Takeoff (LTO) cycles. The AEDT TIM updates provide more accurate emissions estimates than EDMS.
- **Emission Factors** – Both models contain many aircraft engine emission factors that are based on engine model, fuel type and operational mode. Most factors are identical across the models but there are some differences. If a particular fleet mix at an airport contains a higher percentage of aircraft with updated emissions factors, the difference in emissions estimates between AEDT and EDMS will be greater.
- **Missing Aircraft / Engine Combinations** – There are some aircraft and engine combinations that were included in EDMS but are not in AEDT - particularly for newer aircraft. Again, the combinations included in AEDT are based on the most recent data available.
- **Fuel burn** – The AEDT fuel burn estimates were updated and differences between EDMS will vary based on aircraft type. These differences along with changes discussed above will affect emission estimates.

Many of the changes in emissions estimates between EDMS and AEDT can be attributed to the differences between the models, as described above, specifically related to variations in the options for operational modes between the models, and the change in engine emission factors and fuel burn based on best available data. The FAA continues to update the AEDT tool to enhance the user interface and to improve the data when available in order to allow for increased accuracy.

E.1.2 Aircraft Fleet and Operational Data Used in AEDT 2d

The Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT), Version 2d (AEDT 2d) was used in support of the *2017 ESPR* air quality analysis. Appendix D, Noise, Table D-1 contains the data that were used in AEDT 2d to represent actual conditions at Hanscom Field in 2017 while Tables D-2 and D-3 contain 2025 and 2035 forecast conditions, respectively. These data include aircraft group, sector (i.e. civil or military), AEDT aircraft type, engine type, departures and landings by day and night in average annual day (AAD), annual landing takeoff cycles (LTOs), and annual touch and goes (TGOs).

E.2 Regulatory Context

This section describes relevant air quality regulations and programs at the state and federal levels in addition to the regulations discussed in Chapter 8, Air Quality.

E.2.1 Status of Lead Regulations and Research

Low-lead fuel, also known as aviation gasoline (avgas), used in some general aviation (GA) aircraft remains a source of airport-related lead in the atmosphere. Lead emissions can enter the body through inhalation or be ingested via plants, water or soil. The EPA is currently conducting an analysis, including modeling and monitoring, to evaluate whether lead emissions from avgas could cause or contribute to air pollution that endangers public health and welfare (also called an "endangerment finding") which could lead to additional regulations in the future.

The most recent lead NAAQS were set in 2008, when the EPA revised them from the previous level of 1.5 micrograms (μg) per cubic meter (m^3) to 0.15 μg/m^3 (measured over a rolling 3-month average), finding that serious health effects occur at much lower levels in the blood stream than previously identified. Since then, the EPA has reviewed the lead NAAQS, and in 2016 issued a determination confirming that the 2008 NAAQS will be retained.[1] Periodic strengthening of the standard is intended to protect public health, specifically protecting at-risk groups in the population, including children.

In March of 2012, the environmental group Friends of the Earth (FOE) filed a lawsuit against the EPA stating that EPA has unreasonably delayed its response to FOE's 2006 petition asking the agency to make an endangerment finding and propose standards for lead emissions of aircraft. The agency's position to delay making an endangerment finding was upheld by the courts. Since then, FOE and other environmental groups again petitioned the EPA in 2014 to request that the agency make an endangerment finding. In its January 2015 response, the EPA responded that it was delaying making an endangerment finding due to the need for additional research.[2]

As of April 2019, EPA has released no proposed endangerment finding and is still reviewing the issue.[3] If EPA does finalize an endangerment finding, the agency would then establish standards for lead emissions from piston engine aircraft. FAA ultimately would develop regulations to ensure compliance with the standards and would be required to establish fuel standards to control lead emissions.

In addition to the 2008 lead NAAQS update, the EPA mandated a 1-year lead monitoring study at 15 selected airports that emit less than one ton of lead annually. EPA requires lead monitoring by state agencies if airport emissions of lead exceed one ton.[4] Although initially

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[1] "Review of the National Ambient Air Quality Standards for Lead". Federal Register 81-201 (October 18, 2016), page 71906. Available from Government Publishing Office at www.govinfo.gov.

[2] U.S. EPA. January 2915. *Response Memorandum to the 2014 Petition from Friends of the Earth, et al.* *https://www.epa.gov/sites/production/files/2016-09/documents/ltr-response-av-ld-foe-psr-oaw-2015-1-23.pdf*

[3] U.S. EPA. August 2017. *Regulations for Lead Emissions from Aircraft*. https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-lead-emissions-aircraft

[4] U.S. EPA. January 2015. *Overview: Airport Lead Monitoring Program.* https://nepis.epa.gov/Exe/ZyPDF.cgi/P100LJDW.PDF?Dockey=P100LJDW.PDF

considered by the EPA, Hanscom Field was not included in the final study list. Nantucket Memorial Airport is the closest airport in proximity to Hanscom that was on the EPA list with an estimated lead emission level of 0.76 tons per year based on the 2008 National Emissions Inventory.[5] EPA and MassDEP commenced a yearlong lead monitoring program at Nantucket in February of 2012 and completed monitoring at the airport in February of 2013.

The highest reported 3-month lead concentration at the Nantucket airport was 0.0209 $\mu g/m^3$ and the highest 24-hour concentration was 0.04 $\mu g/m^3$, well below the 2008 standard of 0.15 $\mu g/m^3$. Most recent data collected by MassDEP shows a quarterly maximum concentration of 0.017 $\mu g/m^3$ in 2016 at the Boston - Harrison Avenue monitor location which is also well below the standard. This is the only site at which MassDEP currently monitors lead since Massachusetts is in attainment for lead, based on the NAAQS.

The EPA provided a summary of a full year of lead concentration data measured at 17 U.S. airports in January of 2015. The results show that "For all but one airport (the Reid-Hillview airport) the [lead] design value is unchanged from the EPA's 2013 Program Update on Airport Lead Monitoring, either because no more data were collected or because higher concentrations were not measured. Because of the concentrations measured, four airports will continue monitoring for lead.

The FAA issued interim guidance on mitigating public risks from lead emissions associated with avgas in June of 2013.[6] The guidance is provided for FAA identified airports of concern based on a review of the EPA monitoring results and for any operator concerned about lead emissions.

Hanscom is not identified as an airport of concern based on the FAA preliminary monitoring studies. The FAA continues to work with the aviation industry and EPA to develop a viable, safe, and economical unleaded fuel replacement as part of the transition from leaded avgas.

Status of Lead Free Avgas in the United States

The FAA is currently working through a collaborative industry-government program, known as the Piston Aviation Fuels Initiative (PAFI), to facilitate and evaluate development of an alternate fuel for leaded aviation gasoline.[7] As of May 2019, development of PAFI fuels is ongoing; research and testing of alternatives continue at the FAA's William J. Hughes Technical Center in Atlantic City, NJ. Consideration of each alternative fuel involves thorough evaluation of its production viability, distribution, cost, and availability of alternatives, as well as possible

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[5] U.S. EPA. November 2010. *Memo: Selection of Airports for the Airport Monitoring Study.* https://www3.epa.gov/ttnamti1/files/ambient/pb/Memo-Selection-of-Airports.pdf

[6] Federal Aviation Administration. June 2013. *Interim Guidance on Mitigating Public Risks Associated with Lead Emissions from Avgas.* http://www.faa.gov/airports/environmental/policy_guidance/media/leadMitigationMemoJune2013.pdf

[7] FAA Unleaded AVGAS Transition Aviation Rulemaking Committee (UAT ARC). February 2012. *Final Report, Part I: Body Unleaded AVGAS Findings & Recommendations.* http://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/Avgas.ARC.RR.2.17.12.pdf

environmental and health impacts. Once a viable alternative is found, PAFI test data will serve as qualification and certification data for the fuel producer to obtain American Society for Testing and Materials (ASTM) Production Specification. The data will also serve as a basis for FAA to authorize aircraft and engines to operate on the unleaded alternative fuel.[8] PAFI plans to facilitate deployment of the alternative when a suitable alternative is identified.[9]

On June 10, 2013, FAA issued a request for candidate fuel producers to submit alternative fuel formulations to be evaluated as potential replacement to 100LL. This announcement resulted in a response from six fuel producers, proposing seventeen candidate fuels. Testing was planned in two phases: Phase 1 involved fuel testing, which includes laboratory testing, materials compatibility testing, limited engine testing, as well as environmental and toxicity assessment and Phase 2 involves full-scale engine and aircraft flight-testing. In September 2014, four of the alternatives were accepted into PAFI Phase 1 testing, which occurred from December 2014 through November 2015. Two fuels made it through to Phase 2 testing which began in March 2016.

Phase 2 evaluation continued through 2018 with half of the engine and one-third of the flight-testing component completed as of June 2018. Due to differences identified concerning performance of the alternative fuels compared to 100LL fuel, further evaluation by the fuel producers was warranted in order to mitigate issues, causing a delay in testing. As a result, the testing completion date for the PAFI replacement program was pushed from December 2018 to 2020. In September 2018, one of the producers announced that they would no longer pursue their PAFI fuel formulation, but the other producer continued to optimize their formula, and testing is slated to continue. As a result, the FAA is accepting and evaluating data from fuel producers outside of the PAFI program, and viable options may be pursued through Cooperative Research and Development Agreements.

In light of the necessity for airport operators to continue use of leaded Avgas until a replacement is found, the Airport Cooperative Research Program (ACRP) has published guidance and a tool to inventory lead emissions at general aviation airports and also presents strategies that may be employed to reduce lead emissions and mitigate emissions impacts once they are quantified. This guidance is contained within two reports: ACRP *Report 133: Best Practices Guidebook for Preparing Lead Emission Inventories from Piston-Powered Aircraft with the Emission Inventory Analysis Tool*, published in 2015, and *Report 162: Guidebook for Assessing Airport Lead Impacts*, published in 2016.[10]

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[8] PAFI Program. July 2017. *Presentation on the Future of Unleaded Aviation Gasoline*. https://www.faa.gov/about/initiatives/avgas/media/media/PAFI_2017.pdf

[9] FAA Unleaded AVGAS Transition Aviation Rulemaking Committee (UAT ARC). February 2012. *Final Report, Part I Body: Unleaded AVGAS Findings & Recommendations.* https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/Avgas.ARC.RR.2.17.12.pdf

[10] Airport Cooperative Research Program publications can be found at http://www.trb.org/ACRP/ACRP.aspx.

E.2.2 Ultrafine Particulate Matter and Black Carbon

To date, there are no federal or MassDEP air quality regulations that exist for UFP due to limited health studies to substantiate an air quality standard, however the EPA has begun to consider developing a standard for UFPs on the basis of unique physical attributes and potential human health hazards. The agency is currently reviewing existing NAAQS for PM_{10} and $PM_{2.5}$, which provides an opportunity to include UFPs; a determination is due by 2022. It is generally understood that smaller particles, which are inhaled into the lungs, pose a greater health risk impact compared to larger particles, but specific levels associated with impacts to human health of UFPs have not been determined. While studies are ongoing to examine the health impacts of UFP exposure, the results may not be sufficient or clear enough for the EPA to develop a standard. Therefore, there is continued need to research UFPs and their potential health effects.

There are a number of recent studies that examine air quality around airports which include consideration of UFPs. The Los Angeles World Airports (LAWA) released the first major airport air emissions apportionment study of its kind in 2013, the Air Quality and Source Apportionment Study (AQSAS). The airport spent over $5 million on the study and measured over 400 different species of air emissions to determine LAX's contributions to local air quality. Its major finding concerning UFP was that potential health effects of UFPs are not sufficiently understood to develop health-based ambient air quality standards, and that chemical differences between UFP emissions from jet and vehicle exhaust should be taken into account in future studies.[11]

Toronto Pearson International Airport released the results of its Air Quality and Human Health Risk Assessment (HHRA) Study in 2015. This study involved development of an emissions inventory and pollutant dispersion modeling for airport property and surrounding communities, to understand airport contributions. This information was used to assess the human health risks related to exposure to airport-related air pollutants, accounting for UFPs within assessment of $PM_{2.5}$. The HHRA study concluded that in some limited circumstances, predicted levels of certain air pollutants exceeded acceptable risk levels. However, the circumstances in which those levels were predicted to occur were based on exposure estimates that are highly unlikely in real-life (i.e. this scenario assumed the most sensitive populations were exposed to the highest measured pollutant levels on a consistent basis throughout their lifetime). The other circumstance in which predicted levels of certain air pollutants would exceed acceptable risk levels were based on very intermittent events. Ultimately, results show that the emissions from the airport do not represent a significant health risk.[12]

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[11] Los Angeles World Airports. June 2013. *LAX Air Quality and Source Apportionment Study, Volume 1. Executive Summary.* https://www.lawa.org/-/media/lawa-web/environment/files/vol-1---lax-aqsas-2014-03-06s.ashx?la=en&hash=6CF228F6BF492A610058352C8BAD5F520A04E5A3

[12] Greater Toronto Airport Authority. August 2015. *Human Health Risk Assessment (HHRA) Report.* https://torontopearson.com/uploadedFiles/Pearson/Content/About_Pearson/Environment/Intrinsik%20Environmental%20Sciences%20-%20Toronto%20Pearson%20Air%20Quality%20Study%20-%20HHRA%20Report%20(Final%20-%20August%202015).pdf

In 2015, The Airport Cooperative Research Program (ACRP) published *Report 135: Understanding Airport Air Quality and Public Health Studies Related to Airports*. This report provides a concise review of air quality studies and related literature, in addition to identifying health impacts and risks, and putting these concepts in the airport air quality context. In relation to UFP, the study concludes that based on reviewed public health literature, "ultrafine concentrations tend to be highly elevated near an airport (near runways) with persistence above background levels at distances of 600 meters downwind of an airport. As such, ultrafine [particulate matter] generated by airports is suspected of having a broader impact than that generated by roadway vehicles."

Zurich Airport, located in Switzerland, conducted a recent study to understand the UFP concentrations near the airport and how to monitor these types of particles. Results of the study were released in 2017; it determined that UFP concentrations vary greatly over time and space and are heavily affected by wind direction and speed. It determined that short-term monitoring is not sufficient due to high variability of particle concentration, and that long-term measurement is preferable to capture airport activity levels and weather changes over time, also ensuring that wind speed and direction is simultaneously captured.[13]

The FAA Center of Excellence for Alternative Jet Fuels & Environment (ASCENT) funded ongoing project, *Project 18: Community Measurements of Aviation Emissions Contribution to Ambient Air Quality* studies the impacts and distribution of UFP specifically associated with arrival flight paths into Boston Logan International Airport. Boston University School of Public Health researchers who designed and implemented new near-airport monitoring protocols intended to determine the impact of arriving aircraft on UFP concentrations leads the study. Researchers will utilize regression analysis to account for lags between flight activity and weather conditions, and their effect on UFP concentrations. Field monitoring and analysis for this study is ongoing.[14]

Black Carbon

While particulate matter at all sizes is comprised of multiple components, one of the more significant components is Black Carbon (BC). BC particles, also referred to as soot, form as a result of incomplete combustion, particularly at the higher temperatures at which aircraft burn fuel. Therefore, BC emissions are common from aircraft. BC from aviation activities largely contributes to an increase in smaller particle concentrations (i.e., $PM_{2.5}$ and UFPs). BC is known to have negative impacts on both human health and the environment. According to the EPA, BC is associated with respiratory distress, cardiovascular disease, cancer and birth defects. A

[13] Flughafen Zürich AG. 2017. *Ultrafine Particle Measurements at Zurich Airport*. https://www.zurich-airport.com/~/media/flughafenzh/dokumente/das_unternehmen/laerm_politik_und_umwelt/2017-03_zurich-airport_ufp_study.pdf

[14] ASCENT. 2017. *Project 18: Community Measurements of Aviation Emissions Contribution to Ambient Air Quality, Annual Report 2017.* https://ascent.aero/documents/2018/06/ascent-018-2017-annual-report.pdf/

2009 study using air quality monitors near an airport showed that airports can contribute between 24 and 28 percent of total BC within 4 kilometers.[15] However, modeling studies, commonly used to ascertain the extent of impacts on human health and the environment have shown the level of contribution by an airport to be less, or between 2 – 5 percent. Research has been undertaken to determine whether monitoring or modeling BC is more effective for evaluating BC contributions from airports.[16] To understand the extent of impacts from airport related BC emissions, more research is needed. Research should focus on improving emissions estimates of BC from airports and improving modeling techniques. FAA conducts research on BC through the ASCENT program.

E.2.3 Federal Mobile Source Emissions Standards and Regulations

The EPA has enacted various vehicle emissions standards and fuel standards to improve air quality and reduce airborne pollutant emissions from mobile sources.

As described in Chapter 8, the Corporate Average Fuel Economy (CAFE) standards were enacted in 1975 with the intention of improving the average fuel economy of passenger cars and light trucks, and decreasing national fuel consumption. Today, the standards set fleet-wide average fuel economy requirements for automakers manufacturing passenger cars and light trucks, as well as medium and heavy-duty vehicles. The standards are regulated by the National Highway Traffic Safety Administration (NHTSA) and supported by EPA GHG standards.[17]

In 2011, the federal government and thirteen major automakers agreed to incremental tightening of the CAFE standards with a goal to increase fuel economy of cars and light trucks to 54.5 miles per gallon by model year 2025. This resulted in updated CAFE standards for model years 2017-2025, published in August 2012. The agreement also included a requirement for a midterm evaluation of the updated standards in order to review available technologies, acknowledge market trends, and assess industry progress.

This review included a draft technical assessment report, published collaboratively by the EPA, NHTSA, and California Air Resources Board (CARB) and released in July of 2016. The report evaluated whether the industry could reach the forthcoming 2022 to 2025 model year standards. The results of the assessment show that the initial goal of 54.5 miles per gallon is

[15] Dodson R.E.; Houseman E.A; Morin B.; Levy J.I. *An Analysis of continuous black carbon concentrations in proximity to an airport and major roadways.* Atmos. Environ. 2009, 43243764-3773.

[16] Arunachalam S.; Valencia A.; Yang D.; Davis N, Baek B.H.; Dodson R.E.; Houseman A.E.; Levy J.I.; *Comparing Monitoring-Based an Modeling-Based Approaches for Evaluating Black Carbon Contributions from a US Airport.* Air Pol. Mod. 2011, 619-623.

[17] U.S. Department of Transportation. August 2014. *Corporate Average Fuel Economy (CAFE) Standards*. https://www.transportation.gov/mission/sustainability/corporate-average-fuel-economy-cafe-standards

not realistic, and that a revised goal of 50 to 52.6 miles per gallon is more achievable.[18] In April of 2018, EPA announced that the midterm evaluation process was complete and published a final determination that the model year 2022-2025 standards under the Clean Air Act are no longer appropriate based on available information. The EPA proposes revisions to the CAFE standards published in 2012 to make them less stringent. As of fall 2018, the EPA continues collaboration with NHTSA on an updated standard to submit through the public rulemaking process, including public notice and comment periods, before a final agency action is taken.[19]

In 2014, EPA finalized a rule, which set new emissions standards, including provisions that reduce the allowable sulfur content of gasoline starting in 2017. This rule, the Tier 3 Vehicle Emission and Fuel Standards, places stricter limits on tailpipe exhaust and reduces gasoline sulfur content down to 10-ppm average. The rule is expected to reduce sulfur content in gasoline by 60 percent compared to the existing Tier 2 sulfur gasoline standard of 30 ppm. Based on EPA estimates, the rule will decrease nitrogen oxides and volatile organic compounds by 80 percent and per-vehicle particulate matter by 70 percent.[20]

E.2.4 Massachusetts Mobile Source Emissions Standards and Regulations

MassDEP has enacted various vehicle emissions and fuel standards designed to improve air quality and reduce airborne pollutant emissions from mobile sources, such as the enhanced Motor Vehicle Emissions Inspection and Maintenance (I/M) Program, which requires annual emissions and safety tests. The program, known as Massachusetts Vehicle Check, requires vehicles to pass an annual emissions test if they have an onboard diagnostic system and were manufactured after model year 2002.[21] The inspection consists of an on-board diagnostic test (OBD) which assesses the vehicles' on-board computer, downloads the data, and identifies any systems malfunctions. It also includes an opacity test for medium and heavy-duty vehicles that are not equipped with OBD systems. Under the enhanced I/M program, testing is conducted annually and is designed to ensure vehicles are operating efficiently, while identifying and requiring repairs to high polluting vehicles.

As described in Chapter 8, the Commonwealth of Massachusetts has also adopted other state programs to reduce emissions from mobile sources, including the California Low Emissions Vehicle (LEV) program and the California Zero Emissions Vehicle (ZEV) program:

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[18] U.S. EPA, NHTSA, and CARB. July 2016. *Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025*. https://nepis.epa.gov/Exe/ZyPDF.cgi/P100OXEO.PDF?Dockey=P100OXEO.PDF

[19] U.S. EPA. October 2018. *Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emissions Standards for Model Years 2022-2025*. https://www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-greenhouse-gas

[20] U.S. EPA. April 2014. *40 CFR Parts 79, 80, 85, et al. Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards; Final Rule*. https://www.gpo.gov/fdsys/pkg/FR-2014-04-28/pdf/2014-06954.pdf

[21] Mass.gov. *Basic Inspection Information*. https://www.mavehiclecheck.com/motorists-basicinfo

- The California Low Emissions Vehicle (LEV) program imposes emission limits that are more stringent than the Federal Motor Vehicle Control Program (FMVCP). The program requires that most new vehicles be equipped with certified advanced emission control systems, including passenger cars, light-duty trucks, and sport utility vehicles (1995 and newer). Massachusetts' law requires the Commonwealth to adopt the stricter of the federal or California emission standards for motor vehicles.
- California Zero Emissions Vehicle (ZEV) program, effective in 2007. This program requires an increasing percentage of new vehicles sold in Massachusetts be certified to meet certain emissions limits. The MassDEP revised the ZEV program in 2009, requiring automobile manufacturers to comply with lower fleet average greenhouse gas (GHG) emissions levels.
- Massachusetts recently updated the ZEV action plan in 2018 along with eight other states, reaffirming their commitment to ZEV implementation with a goal of 5 million more ZEVs on their collective roads by 2025.[22]

These regulations and standards are intended to further reduce mobile source emissions while increasing the prevalence of alternative fuel vehicles such as hybrid, electric, and biodiesel vehicles in the fleet mix. Alternative fuel vehicles are more efficient, resulting much lower emissions, compared to conventional gasoline and diesel vehicles. As these vehicles replace older, less efficient vehicles, emissions are expected to decrease.

Diesel Engines

In 2004, the EPA implemented a rule that requires more stringent controls for non-road diesel engines. These standards followed the Tier 3 emissions standards for nitrogen oxides and hydrocarbons for non-road vehicles that were introduced in 1998 and were phased into use between 2006 and 2008. The Tier 4 exhaust emission standards, were phased-in between 2008 and 2014, and intended to cut air pollution emissions from both on-road and non-road diesel engines by over 90 percent. As part of these regulations, ultra-low sulfur diesel fuel, containing no more than 15 ppm sulfur content, for on-road diesel vehicles was phased-in from 2006 to 2010.

Reformulated Gasoline and Vapor Recovery Systems

Massachusetts has adopted the federal regulations for reformulated gasoline, although it is not a required area under the Clean Air Act. Reformulated gasoline (RFG) is designed to produce lower emissions of toxic substances from evaporation and burn cleaner than conventional gasoline, resulting in improved air quality and less smog-forming pollutants.

[22] Massachusetts Department of Environmental Protection. *Multi-State ZEV Action Plan: Accelerating the Adoption of Zero Emissions Vehicles*. 2018-2021. https://www.mass.gov/files/documents/2018/06/21/zevplan18_0.pdf

In 2000, Phase II of the reformulated gasoline program went into effect, implementing more stringent standards.[23] In 2006, Massachusetts phased out the use of methyl tert-butyl ether (MTBE), a gasoline additive designed to boost octane levels, due to environmental and health concerns. MTBE was found in groundwater due to leaky underground tanks, leading to drinking water safety concerns, and resulting in legislation to substitute MTBE with ethanol. Currently, RFG is being blended with ethanol in Massachusetts.

MassDEP Stage I and II Vapor Recovery Program is intended to prevent gasoline evaporation during fuel deliveries and while filling vehicles at gasoline dispensing stations. In January of 2015, amendments to the program required that Stage II gasoline vapor recovery systems be decommissioned at gasoline dispensing stations by early 2017. This regulation was based on the EPA rule that Stage II vapor recovery was no longer cost effective. In addition, Massachusetts finalized Stage I regulatory revisions requiring that gas dispensing facilities with Stage I systems must meet the California Air Resource Board requirements for Stage I Enhanced Vapor Recovery (CARB EVR), as well as maintain monitoring systems for vapor leaks.[24]

Massport does not own or operate fuel distribution facilities at Hanscom Field. A survey of fixed based operators (FBOs) at Hanscom Field found that vapor recovery is being used on all fuel storage tanks subject to MassDEP regulation and that Stage II vapor controls are used at all gasoline-dispensing facilities.

E.2.5 Massachusetts Climate Change and Greenhouse Gas Emissions Regulatory Framework

Massachusetts acknowledges climate change as an important environmental and economic issue, and has taken a number of actions designed to address both the Commonwealth's contribution to climate change as well as preparing for the anticipated effects of climate change. State regulatory actions addressing climate change include:

- The Massachusetts Climate Protection Plan, first developed in 2004, aimed to address GHG emissions and improve energy efficiency. The plan supported near-term actions to protect the climate, reduce pollution and energy demand, and to stimulate job growth through the development of sustainable energy resources. Massport was one of 15 state agencies and authorities that participated in development of the initial action plan.
- Massachusetts Global Warming Solutions Act (GWSA), which was signed into law in 2008, and established a comprehensive regulatory program to address climate change. The GWSA set targets for GHG emissions reductions of 10- 25 percent by 2020 and 80

[23] U.S. EPA. August 2018. *Reformulated Gasoline*. https://www.epa.gov/gasoline-standards/reformulated-gasoline

[24] MassDEP. January 2015. *Fact Sheet: MassDEP's Revised Stage I & II Regulations*. https://www.mass.gov/files/documents/2016/08/tv/s1and2-fs15.pdf

percent by 2050 compared to 1990 levels.[25] To aid in implementing the GWSA, the MassDEP issued rules in December of 2008 for mandatory GHG reporting requirements from a wide array of sources. The rule required certain facilities to register with the MassDEP by April of 2009 and report, certify, and verify emissions annually starting in April of 2010.

- Executive Order 569, signed by Governor Baker in 2016 to address climate change and the increasing threat of extreme weather events to the state's economy.[26] The Order acknowledges that the transportation sector continues to be a significant contributor of GHG emissions in Massachusetts, and is the only sector identified in the GWSA in which emissions have increased over time. The Order tasks transportation agencies with collaborating to develop regional policies aimed at reducing GHG emissions.
- As required by Executive Order 569, the state published a Climate Adaptation Plan, which was adopted in September 2018 as the State Hazard Mitigation and Climate Adaptation Plan.[27]

In addition, the Massachusetts Executive Office of Energy and Environmental Affairs revised the "MEPA Greenhouse Gas Emissions Policy and Protocol" effective May of 2010. The revised policy requires certain projects under MEPA review, not specific to this *2017 ESPR*, to quantify potential annual GHG emissions for the baseline and preferred alternative. It requires analysis of project specific impacts and evaluation of possible mitigation measures intended to minimize or mitigate potential GHG emissions from the preferred alternative.

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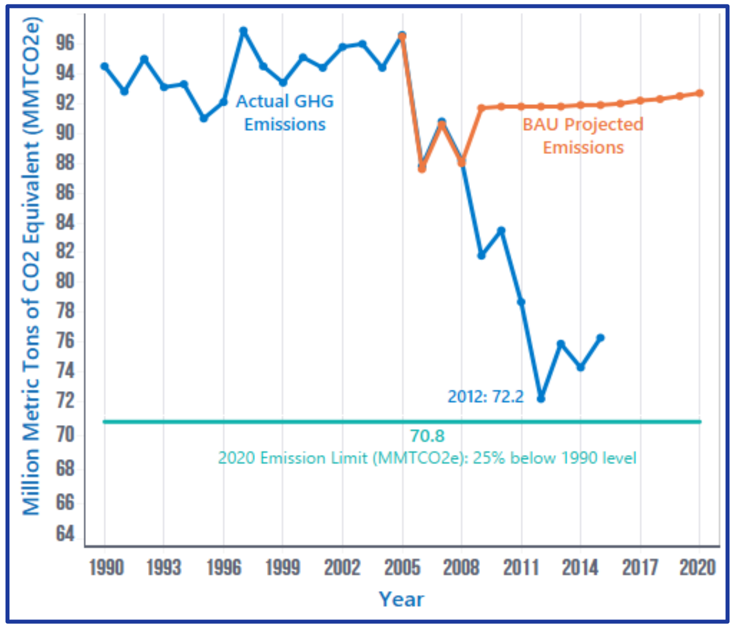
[25] Commonwealth of Massachusetts. 2008. *An Act Establishing the Global Warming Solutions Act*. https://malegislature.gov/Laws/SessionLaws/Acts/2008/Chapter298

[26] Mass.gov. September 2016. *Governor Charlie Baker, Executive Order No. 569: Establishing an Integrated Climate Change Strategy for the Commonwealth*. https://www.mass.gov/executive-orders/no-569-establishing-an-integrated-climate-change-strategy-for-the-commonwealth

[27] Mass.gov. 2018. Massachusetts Integrated State Hazard Mitigation and Climate Adaptation Plan. https://www.mass.gov/service-details/massachusetts-integrated-state-hazard-mitigation-and-climate-adaptation-plan

MassDEP recently conducted a state-wide GHG emissions inventory of data from 1990 to 2015, which determined that GHG emissions have decreased 19 percent from approximately 94 million metric tons, or MTs (MMT) of CO_2 equivalent to less than 75 MMT, as shown in Figure 8-4. The decline in emissions is attributable to numerous factors including the economic downturn, changing fuel prices, and implementation of energy efficient measures. Based on the 2015 inventory for Massachusetts, the transportation sector comprised approximately 39% of the GHG emissions, followed by residential at 26 percent, commercial at 19 percent, industrial at 13 percent, and other at 2 percent.[28]

Figure E-1 Massachusetts GHG Emissions [Actual vs. Business as Usual (BAU)]



Source: https://www.mass.gov/service-details/ma-ghg-emission-trends)

While not required under the listed regulations to prepare an annual GHG emissions inventory, the Secretary's Scope Certificate for the *2017 ESPR* included this as a component of the air quality analysis. The methodology used to develop the Hanscom Field GHG emissions inventory mirrors the methodology used by Massport for Logan Airport, and is described in Chapter 8.

E.3 Motor Vehicle Emissions

For the *2017 ESPR* analysis, the motor vehicle emission factor model MOVES2014a was used. The resultant emission factors were multiplied by average daily vehicle miles to calculate daily emissions. Emissions factors from the mesoscale traffic analysis done in MOVES2014a are included as Table E-1, Table E-2, and Table E-3 for existing conditions in 2017, as well as forecast conditions in 2025 and 2035, respectively.

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[28] Mass.gov. *Massachusetts greenhouse gas emission trends*. https://www.mass.gov/service-details/ma-ghg-emission-trends

Table E-1 2017 Mesoscale Analysis – Hanscom Field Traffic

Link	Distance (miles)	AM Peak	PM Peak	ADT	Daily VMT	Speed (mph)	Vehicle Emission Factors 2017 (g/mile)							
							CO	CO_2	VOC	NO_X	PM_{10}	$PM_{2.5}$	CH_4	N_2O
Airport Road	0.32	0	0	0	0	30	2.599	364.247	0.069	0.254	0.010	0.009	0.004	0.105
Bedford Road	0.35	6	7	70	24.5	35	2.508	349.315	0.063	0.255	0.010	0.009	0.004	0.100
Concord Turnpike	0.6	21	16	210	126	40	2.447	341.062	0.060	0.260	0.010	0.009	0.004	0.097
Hanscom Drive	0.65	74	73	740	481	30	2.599	364.247	0.069	0.254	0.010	0.009	0.004	0.105
Hartwell Ave	1.24	7	4	70	86.8	40	2.447	341.062	0.060	0.260	0.010	0.009	0.004	0.097
Hartwell Road	1.62	0	0	0	0	25	2.777	402.444	0.077	0.275	0.012	0.011	0.005	0.118
Mass Ave	0.36	2	2	20	7.2	35	2.508	349.315	0.063	0.255	0.010	0.009	0.004	0.100
Old Bedford Road 1	0.31	26	29	290	89.9	30	2.599	364.247	0.069	0.254	0.010	0.009	0.004	0.105
Old Bedford Road 2	0.49	10	2	100	49	30	2.599	364.247	0.069	0.254	0.010	0.009	0.004	0.105
Old Mass Ave	0.53	7	4	70	37.1	35	2.508	349.315	0.063	0.255	0.010	0.009	0.004	0.100
Route 2A (1)	0.46	27	23	270	124.2	40	2.447	341.062	0.060	0.260	0.010	0.009	0.004	0.097
Route 2A (2)	1.67	11	13	130	217.1	40	2.447	341.062	0.060	0.260	0.010	0.009	0.004	0.097
Route 2A (3)	1.08	32	29	320	345.6	40	2.447	341.062	0.060	0.260	0.010	0.009	0.004	0.097
Route 2A (4)	0.23	38	36	380	87.4	40	2.447	341.062	0.060	0.260	0.010	0.009	0.004	0.097
Route 2A (5)	0.92	36	37	370	340.4	40	2.447	341.062	0.060	0.260	0.010	0.009	0.004	0.097
Route 2A (6)	0.11	36	37	370	40.7	40	2.447	341.062	0.060	0.260	0.010	0.009	0.004	0.097
Route 2A (7)	0.15	29	33	330	49.5	40	2.447	341.062	0.060	0.260	0.010	0.009	0.004	0.097
Route 2A (8)	0.18	24	26	260	46.8	40	2.447	341.062	0.060	0.260	0.010	0.009	0.004	0.097
Route 62 (1)	1.46	0	0	0	0	35	2.508	349.315	0.063	0.255	0.010	0.009	0.004	0.100
Route 62 (2)	1.64	10	22	220	360.8	35	2.508	349.315	0.063	0.255	0.010	0.009	0.004	0.100
Route 62 (3)	1.12	10	22	220	246.4	30	2.599	364.247	0.069	0.254	0.010	0.009	0.004	0.105
Route 4/225 (1)	2.1	0	0	0	0	35	2.508	349.315	0.063	0.255	0.010	0.009	0.004	0.100
Route 4/225 (2)	0.56	2	2	20	11.2	40	2.447	341.062	0.060	0.260	0.010	0.009	0.004	0.097
Route 4/225 (3)	0.16	0	0	0	0	25	2.777	402.444	0.077	0.275	0.012	0.011	0.005	0.118
South Road (1)	0.58	0	0	0	0	30	2.599	364.247	0.069	0.254	0.010	0.009	0.004	0.105
South Road (2)	0.85	0	0	0	0	30	2.599	364.247	0.069	0.254	0.010	0.009	0.004	0.105
Virginia Road	2.13	19	18	190	404.7	30	2.599	364.247	0.069	0.254	0.010	0.009	0.004	0.105

Notes:
1. AM and PM peak volumes are Hanscom Traffic only.
2. ADT based on worst case AM or PM hours which represent approximately 10 percent of daily traffic.
3. Vehicle emissions in kg/yr were based on daily emissions and scaled by 365 days.
4. Total kg/1000 kg were divided by 1,000 for consistency with 2005 ESPR

Table E-2: 2025 Mesoscale Analysis – Hanscom Field Traffic

Link	Distance (miles)	AM Peak	PM Peak	ADT	Daily VMT	Speed (mph)	Vehicle Emission Factors 2025 (g/mile)							
							CO	CO_2	VOC	NO_X	PM_{10}	$PM_{2.5}$	CH_4	N_2O
Airport Road	0.32	0	0	0	0	30	1.66	278.9	0.032	0.1	0.005	0.005	0.003	0.075
Bedford Road	0.35	6	7	70	24.5	35	1.62	267.7	0.030	0.11	0.005	0.004	0.003	0.072
Concord Turnpike	0.6	25	17	250	150	40	1.60	261.5	0.029	0.11	0.005	0.004	0.003	0.071
Hanscom Drive	0.65	59	77	770	500.5	30	1.66	278.9	0.032	0.10	0.005	0.005	0.003	0.075
Hartwell Ave	1.24	11	10	110	136.4	40	1.60	261.5	0.029	0.11	0.005	0.004	0.003	0.071
Hartwell Road	1.62	11	15	150	243	25	1.76	308	0.036	0.11	0.006	0.005	0.003	0.083
Mass Ave	0.36	5	7	70	25.2	35	1.62	267.7	0.030	0.11	0.005	0.004	0.003	0.072
Old Bedford Road 1	0.31	30	34	340	105.4	30	1.66	278.9	0.032	0.11	0.005	0.005	0.003	0.075
Old Bedford Road 2	0.49	11	2	110	53.9	30	1.66	278.9	0.032	0.10	0.005	0.005	0.003	0.075
Old Mass Ave	0.53	7	5	70	37.1	35	1.62	267.7	0.030	0.11	0.005	0.004	0.003	0.072
Route 2A (1)	0.46	32	24	320	147.2	40	1.60	261.5	0.029	0.11	0.005	0.004	0.003	0.071
Route 2A (2)	1.67	13	13	130	217.1	40	1.60	261.5	0.029	0.11	0.005	0.004	0.003	0.071
Route 2A (3)	1.08	38	30	380	410.4	40	1.60	261.5	0.029	0.11	0.005	0.004	0.003	0.071
Route 2A (4)	0.23	55	37	550	126.5	40	1.60	261.5	0.029	0.11	0.005	0.004	0.003	0.071
Route 2A (5)	0.92	42	40	420	386.4	40	1.60	261.5	0.029	0.11	0.005	0.004	0.003	0.071
Route 2A (6)	0.11	42	40	420	46.2	40	1.60	261.5	0.029	0.11	0.005	0.004	0.003	0.071
Route 2A (7)	0.15	35	35	350	52.5	40	1.60	261.5	0.029	0.11	0.005	0.004	0.003	0.071
Route 2A (8)	0.18	30	28	300	54	40	1.60	261.5	0.029	0.11	0.005	0.004	0.003	0.071
Route 62 (1)	1.46	4	4	40	58.4	35	1.62	267.6	0.030	0.11	0.005	0.004	0.003	0.072
Route 62 (2)	1.64	15	27	270	442.8	35	1.62	267.6	0.030	0.11	0.005	0.004	0.003	0.072
Route 62 (3)	1.12	14	26	260	291.2	30	1.66	278.9	0.032	0.11	0.005	0.005	0.003	0.075
Route 4/225 (1)	2.1	0	0	0	0	35	1.62	267.6	0.030	0.11	0.005	0.004	0.003	0.072
Route 4/225 (2)	0.56	3	4	40	22.4	40	1.60	261.5	0.029	0.11	0.005	0.004	0.003	0.071
Route 4/225 (3)	0.16	0	0	0	0	25	1.76	308	0.036	0.11	0.006	0.005	0.003	0.083
South Road (1)	0.58	0	0	0	0	30	1.66	278.9	0.032	0.10	0.005	0.005	0.003	0.075
South Road (2)	0.85	4	5	50	42.5	30	1.66	278.9	0.032	0.10	0.005	0.005	0.003	0.075
Virginia Road	2.13	46	48	480	1022.4	30	1.66	278.9	0.032	0.10	0.005	0.005	0.003	0.075

Notes:
1. AM and PM peak volumes are Hanscom Traffic only.
2. ADT based on worst case AM or PM hours which represent approximately 10 percent of daily traffic.
3. Vehicle emissions in kg/yr were based on daily emissions and scaled by 365 days.
4. Total kg/1000 kg were divided by 1,000 for consistency with 2005 ESPR

Table E-3: 2035 Mesoscale Analysis - Hanscom Field Traffic

Link	Distance (miles)	AM Peak	PM Peak	ADT	Daily VMT	Speed (mph)	Vehicle Emission Factors 2035 (g/mile)							
							CO	CO_2	VOC	NO_X	PM_{10}	$PM_{2.5}$	CH_4	N_2O
Airport Road	0.32	0	0	0	0	30	0.91	218.959	0.020	0.042	0.003	0.003	0.002	0.052
Bedford Road	0.35	8	8	80	28	35	0.91	210.313	0.019	0.048	0.003	0.003	0.002	0.050
Concord Turnpike	0.6	30	19	300	180	40	0.92	205.635	0.019	0.053	0.003	0.003	0.002	0.048
Hanscom Drive	0.65	104	90	1040	676	30	0.91	218.959	0.020	0.042	0.003	0.003	0.002	0.052
Hartwell Ave	1.24	13	11	130	161.2	40	0.92	205.635	0.019	0.053	0.003	0.003	0.002	0.048
Hartwell Road	1.62	17	16	170	275.4	25	0.95	241.690	0.022	0.044	0.004	0.003	0.002	0.057
Mass Ave	0.36	7	9	90	32.4	35	0.91	210.313	0.019	0.048	0.003	0.003	0.002	0.050
Old Bedford Road 1	0.31	36	38	380	117.8	30	0.91	218.959	0.020	0.042	0.003	0.003	0.002	0.052
Old Bedford Road 2	0.49	14	2	140	68.6	30	0.91	218.959	0.020	0.042	0.003	0.003	0.002	0.052
Old Mass Ave	0.53	8	5	80	42.4	35	0.91	210.313	0.019	0.048	0.003	0.003	0.002	0.050
Route 2A (1)	0.46	37	28	370	170.2	40	0.92	205.635	0.019	0.053	0.003	0.003	0.002	0.048
Route 2A (2)	1.67	16	16	160	267.2	40	0.92	205.635	0.019	0.053	0.003	0.003	0.002	0.048
Route 2A (3)	1.08	46	35	460	496.8	40	0.92	205.635	0.019	0.053	0.003	0.003	0.002	0.048
Route 2A (4)	0.23	54	43	540	124.2	40	0.92	205.635	0.019	0.053	0.003	0.003	0.002	0.048
Route 2A (5)	0.92	50	47	500	460	40	0.92	205.635	0.019	0.053	0.003	0.003	0.002	0.048
Route 2A (6)	0.11	50	47	500	55	40	0.92	205.635	0.019	0.053	0.003	0.003	0.002	0.048
Route 2A (7)	0.15	42	42	420	63	40	0.92	205.635	0.019	0.053	0.003	0.003	0.002	0.048
Route 2A (8)	0.18	35	33	350	63	40	0.92	205.635	0.019	0.053	0.003	0.003	0.002	0.048
Route 62 (1)	1.46	5	7	70	102.2	35	0.92	210.313	0.019	0.048	0.003	0.003	0.002	0.050
Route 62 (2)	1.64	20	33	330	541.2	35	0.92	210.313	0.019	0.048	0.003	0.003	0.002	0.050
Route 62 (3)	1.12	18	29	290	324.8	30	0.905	218.959	0.020	0.042	0.003	0.003	0.002	0.052
Route 4/225 (1)	2.1	0	0	0	0	35	0.908	210.313	0.019	0.048	0.003	0.003	0.002	0.050
Route 4/225 (2)	0.56	3	5	50	28	40	0.92	205.635	0.019	0.053	0.003	0.003	0.002	0.048
Route 4/225 (3)	0.16	0	0	0	0	25	0.95	241.690	0.022	0.044	0.004	0.003	0.002	0.057
South Road (1)	0.58	0	0	0	0	30	0.91	218.959	0.020	0.042	0.003	0.003	0.002	0.052
South Road (2)	0.85	5	6	60	51	30	0.91	218.959	0.020	0.042	0.003	0.003	0.002	0.052
Virginia Road	2.13	47	59	590	1256.7	30	0.91	218.959	0.020	0.042	0.003	0.003	0.002	0.052

Notes:
1. AM and PM peak volumes are Hanscom Traffic only.
2. ADT based on worst case AM or PM hours which represent approximately 10 percent of daily traffic.
3. Vehicle emissions in kg/yr were based on daily emissions and scaled by 365 days.
4. Total kg/1000 kg were divided by 1,000 for consistency with 2005 ESPR

E.4 Greenhouse Gas (GHG) Emissions Inventory

The *2017 ESPR* Scope Certificate requires the development of the first airport-wide GHG emissions inventory for Hanscom Field, to be used as a baseline to measure and compare future GHG emissions. This aligns with Massport's actions to prepare and update GHG emissions inventories for other facilities, including Logan Airport.

E.4.1 GHG Emissions Inventory Methodology

Airport GHG emissions are calculated in much the same way as criteria pollutants, through the use of input data such as activity levels or material throughput rates (i.e., fuel usage, VMT, electrical consumption) that are applied to appropriate emission factors (i.e., in units of GHG emissions per gallon of fuel). In this case, the input data were either based on Massport records, or data and information derived from the latest version of the FAA AEDT (AEDT 2.0d). Table E-5 summarizes the data and information used in the 2017 GHG inventory.

Table E-4 Hanscom Field GHG Inventory Input Data and Information for 2017

Source Description	Activity	Fuel Type	Value	Unit
Aircraft				
Tenant - Mobile	Aircraft – Ground (Taxi and Idle)	Jet A	640,978	gal
		AvGas	447,276	gal
	Aircraft - Ground to 3000 ft. (Mixing Height)	Jet A	794,953	gal
		AvGas	32,558	gal
	Aircraft - Total	Jet A	1,435,932	gal
		AvGas	479,834	gal
Aircraft Support Equipment				
Massport - Mobile	GSE	Propane Gas	158	gal
Tenant - Mobile	GSE	Propane Gas	100	gal
	GSE	Gasoline	10,528	gal
	GSE	Diesel	19,317	gal
Stationary - Boilers/Heaters/Generators				
Massport - Stationary	Boilers/Heaters	Fuel Oil #2	9,114	gal
	Boilers/Heaters	Natural Gas	1,747	MMBtu
Tenant - Stationary	Boilers/Heaters	Natural Gas	7,501	MMBtu
	Boilers/Heaters	Diesel	1,500	gal
	Emergency Generators	Diesel	100	gal
	Emergency Generators	Diesel	45	hours
Off-Airport Vehicle Use				
Massport - Mobile	Motor Vehicles - Employee Commute	Vehicle Miles Traveled	492,069	miles
Tenant - Mobile	Motor Vehicles - Employee Commute	Vehicle Miles Traveled	3,352,569	miles
Public	Motor Vehicles	Vehicle Miles Traveled	1,159,350	miles
Electrical Consumption				
Massport Electricity	Electricity Consumption		2,070,722	kWh
Tenant Electricity	Electricity Consumption		3,299,495	kWh

Emission factors were obtained from the U.S. Energy Information Administration, the Intergovernmental Panel on Climate Change (IPCC), EPA's MOVES, and the most recent version of EPA's GHG Emission Factors Hub (March 2018).[29,30,31,32] Table E-6 presents emission factors for carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and carbon dioxide equivalent (CO_2e) for 2017.

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[29] IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, 2006, www.ipccnggip.iges.or.jp/public/2006gl/index.html.
[30] U.S. Energy Information Administration, Voluntary Reporting of Greenhouse Gases Program. Fuel and Energy Source Codes and Emission Coefficients, www.eia.doe.gov/oiaf/1605/coefficients.html.
[31] EPA, GHG Emissions Factors Hub (March 2018) https://www.epa.gov/climateleadership/center-corporate-climateleadership-ghg-emission-factors-hub. The most recent version of the Emission Factors Hub includes updates to emission factors for stationary and mobile combustion sources, new electricity emission factors from EPA's Emissions & Generation Resource Integrated Database (eGRID) and the IPCC Fifth Assessment Report (AR4/AR5)
[32] U.S. Environmental Protection Agency, MOVES Emissions Model, http://www.epa.gov/otaq/models/moves/

Table E-5: GHG Emissions Factors for 2017

Sources	Fuel	CO_2	N_2O	CH_4	CO_2e	Unit
Aircraft	Jet A	21	0.00	0.00	21.67	lb/gallon
	AvGas	18	0.00	0.02	18.82	lb/gallon
Ground Support Equipment/ Auxiliary Power Units	Propane	13	0.00	0.00	12.65	lb/gallon
	Gasoline	19	0.00	0.00	19.56	lb/gallon
	Diesel	23	0.00	0.00	22.69	lb/gallon
Stationary/Portable	Natural Gas	146	0.00	0.00	146.38	lb/MMBtu
	Fuel Oil #2	23	0.00	0.00	22.75	lb/gallon
	Diesel - Generators by Hour	0	0.00	0.00	1.15	lb/hp-hour
	Diesel	23	0.00	0.00	22.69	lb/gallon
Motor Vehicles	Composite - Employee Commuting	343	0.01	0.02	346.45	g/mile
	Composite - Public Owned/ Controlled Roadway Use	354	0.10	0.00	381.38	g/mile
Electrical Consumption	Electricity	1	0.00	0.00	0.92	lb/kWh