Appendix G

Air Quality and Climate

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APPENDIX G:
Air Quality and Climate

The following attachments are included in this appendix to support the air quality and climate analysis:

- Attachment 1: *Criteria Pollutant Emissions Inventory Assumptions and Methodology,* July 2019.
- Attachment 2: *Greenhouse Gas (GHG) Emissions Inventory Assumptions and Methodology,* July 2019.
- Attachment 3: Addendum to Emissions Analysis, July 2019.

Attachment 1:

Criteria Pollutant Emissions Inventory (EI)

Assumptions and Methodology

July 2019

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Attachment 1
Criteria Pollutant Emissions Inventory Assumptions and Methodology

1 Introduction

Attachment 1 presents the overall data, assumptions, approach, and methodology for preparing criteria pollutant and pollutant precursor emissions inventories for Baltimore/Washington International Thurgood Marshall Airport (BWI Marshall). The emissions inventories were prepared for an existing year (2018) and two future years (2022 and 2027) with and without the proposed improvements at the airport.

The emissions 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 in diameter (coarse or PM_{10}), and particulate matter less than 2.5 micrometers in diameter (fine or $PM_{2.5}$). Although lead (Pb) is a criteria pollutant, it was not evaluated because the proposed project would have no impacts on lead emissions.

For the purpose of disclosing the increase or decrease in pollutant and pollutant precursor emissions with the improvements to the airport, the inventories were prepared only for the emission sources that would be affected by the improvements – aircraft and construction activity.

2 Aircraft

The aircraft-related emission inventories were prepared using FAA's Aviation Environmental Design Tool (AEDT, Version 2d). For consistency, the aircraft operational data (i.e., fleet, aircraft engine assignments, and runway use) input to the AEDT were data developed in support of the analysis presented in Section 4.10 (Noise and Compatible Land Use) of this EA. Because it is customary for criteria air pollutant and pollutant precursor inventories to be reported in tons on an annual basis, the number of operations used in the noise analysis were factored to reflect the actual annual (year 2018) and future forecast (year 2022 and 2027) level of operations (see *Appendix C, Fleet Mix Forecast*, of this EA).

With the exception of ground-based taxi-in/taxi-out, including apron idling and departure runway queue delay, the default aircraft operating times in AEDT by aircraft mode (e.g., approach, take-off, and climb-out) were used. For the year 2018, airport-specific times-in-mode for taxi-in and taxi-out for the same period as the fleet mix forecast were obtained from the FAA Aviation System Performance Metrics (ASPM) database which indicates that during 2018, the airfield-wide average taxi-in time was 5.52 minutes and the average taxi-out time was 14.29 minutes. For consistency with emission inventories prepared historically for BWI, these taxi times were adjusted to account for the emission benefit (i.e., reduction in air pollutant/precursor emissions) associated with Southwest Airlines' routine procedure of single-engine taxiing (i.e., the ASPM values were adjusted so that the reduction in emissions due to single-engine taxiing was accounted for in AEDT).

The adjusted year 2018 taxi times were also used to prepare the future year 2022 and 2027 emission inventories for the No Action Alternative. For the Action Alternative, the change in taxi times for arrivals on Runway 28 and departures of Runway 10 that would result from the proposed improvements to Taxiways F and R were derived (assuming an aircraft taxi speed of 20 miles per hour) and the result was added to the year 2018 taxi times. **Table 1** provides the taxi-in/taxi-out times by year and alternative. As shown, the taxiway improvements would increase taxi-in times slightly (0.03 minutes) and taxi-out times would remain the same.

Table 1
Aircraft Taxi Times (minutes)

Year	Scenario	Taxi-	Taxi-out
2018	Existing	4.46	13.82
2022	No Action	4.46	13.82
	Action	4.49	13.82
2027	No Action	4.46	13.82
	Action	4.49	13.82

Source: FAA's ASPM, HNTB and KBE Inc, 2019.

3 Construction

For this assessment, construction-related emissions are primarily associated with the exhaust from heavy equipment (i.e., backhoes, bulldozers, graders, etc.), delivery trucks (i.e., cement trucks, dump trucks, etc.) and construction worker vehicles getting to and from the airport construction site(s); dust from site preparation, land clearing, material handling, equipment movement on unpaved areas, and demolition activities; and fugitive emissions from the storage/transfer of raw materials. These emissions are temporary in nature and generally confined to the construction site and the access/egress roadways.

Emissions from construction activities were estimated based on the projected construction activity schedule, the number of vehicles/pieces of equipment, the types of equipment/type of fuel used, vehicle/equipment utilization rates, and the year construction occurs. For this assessment, emissions of CO, VOC, NO_x, SO_2, PM_{10} and $PM_{2.5}$ were evaluated. Emission factors for each type of equipment were developed using the Motor Vehicle Emissions Simulator (MOVES, version 2014a)[1] model required by USEPA, in accordance with model parameters utilized by the

[1] The NAAQS represent concentrations of pollutants in the ambient air over which detriment to human health and environmental welfare is likely to be incurred, based on available scientific evidence evaluated by EPA.

Maryland Department of the Environment (MDE) for development of their State Implementation Plan (SIP).

Data regarding the number of pieces and types of construction equipment to be used on the project, the deployment schedule of equipment (monthly and annually), and the approximate daily operating time (including power level/usage factors) were estimated for each individual construction project based on a schedule of construction activity.

Table 2 lists improvement projects at BWI Marshall as well as the scheduled year of construction.

Table 2

Construction Schedule for Construction Projects at BWI Marshall

ID	Project	Description	Anticipated Construction Schedule
P7	Second FBO	Construction of additional general aviation facilities.	March 2021-August 2021
P9	Northrop Grumman Hangar	Construction of additional hangar, apron pavement, and Taxilane W improvement.	May 2020 (site prep) – Nov 2021
P10	Existing ARFF Expansion Bays	Construction of two additional parking bays.	May 2020-Oct 2020
P11	New Airline Maintenance Facility	Construction of additional aircraft maintenance facility.	May 2020-April 2022
P13	Runway Deicing Chemical Storage and Access Road	Additional 20,000 gallon glycol storage tank and pavement of an access road.	Dec 2020-Mar 2021
P30	Airport Maintenance Complex	Airport maintenance complex relocation and consolidation.	March 2022-Nov 2022
P45	Relocate Fire Training Facility	Replace the fire training facility and provide roadway access to serve the facility.	August 2021-Sept 2022
D113	Building 113 Demolition	Removal of former maintenance building.	Oct 2020-Nov 2020
1	Relocate Taxiways F and R	Taxiway F and R demolition and relocation.	July 2020-Nov 2022
2	Taxiway U3	Construction of new taxiway U3.	Dec 2021-March 2022
3	International Terminal Area Taxiway Fillet/Shoulders	Terminal Area pavement improvements to substandard fillets and areas of pavement rehabilitation. Temporary remain-overnight area converted to a taxiway.	March 2021-Sept 2021
P14	ALV Relocation	A new airfield lighting vault (ALV) is proposed to be constructed adjacent to future Taxiway P (decommissioned Runway 4-22) and the Runway 28 deicing pad.	May 2020-July 2020
D101	Airfield Lighting Vault Demolition	Removal of existing ALV.	June 2020
D101A	Glycol Pump Control Building Demolition	Removal of existing glycol pump control building near existing ALV.	July 2020-August 2020
4	New Infill Pavement Near Taxiways T, P, and Future P	New infill pavement to former ALV site and the area bounded by Taxiways T, P, P1, and C.	September 2020-Feb 2021
6	Relocate Taxiways K and L	Demolition and relocation of Taxiways K and L.	March 2021-June 2021
7	Isolation/RON Apron	Decommissioned Runway 4 end and Taxiway Y will be converted to a parking apron and isolation area for aircraft, and associated VSRs relocated.	Dec 2021-Aug 2022
8	Runway 28 Deicing Pad Expansion	Expansion of R28 Deicing Pad includes reconstruction of the apron located on existing pad and reconfiguration of infrastructure.	Dec 2020-June 2021

10	Part 77 Obstruction Removal	Obstruction removal in accordance with the ALP.	--
12	Taxiway H Relocation	Relocation of exit Taxiway H and demolition of any the existing pavement no longer needed.	Oct 2021-March 2022
14	New Sky Bridge C	Construction of Concourse C Sky Bridge to provide direct access from hourly garage to terminal.	Dec 2021-Dec 2022
15	Terminal Roadway Widening and Access Improvements	Widening terminal road including reconfiguring the roadway for service vehicle access, construction of additional lane for hotel/garage access and closing existing employee access roadway.	Nov 2020-April 2021
17	Taxiway V Relocation	Taxiway V will be demolished and reconstructed.	May 2020-Jan 2021
18	Runway 15R Deicing Pad Expansion	The existing Runway 15R deicing pad will be expanded and associated facilities will be removed or relocated.	Oct 2020-May 2022
19	Upper Level Roadway Widening at Concourse E	Widening the outer lanes of the terminal roadway at Concourse E.	Dec 2021-Nov 2022
PMP	Pavement Management Program projects	Pavement rehabilitation, reconstruction and mill and overlay.	2020-2022

Source: ADCI Preliminary Engineering schedule (2017) and MDOT MAA Construction Schedule updates, 2019.

3.1 On-road Vehicles

For on-road vehicles, the anticipated vehicle-miles-traveled (VMT) were estimated to determine annual emissions. In deriving the VMT (**Table 3**), the following was assumed:

- VMT by dirt haul trucks was based on the number of trips and a travel distance of 45 miles roundtrip for Backfill Crews and Mobilization Crews.
- In deriving the VMT for laborers/commuters-it was assumed that light pickup trucks would commute 100 miles roundtrip with two laborers per truck.
- VMT for on-site material delivery trucks and pickup trucks were based on hours of operations and an assumed/conservative travel speed of 25 miles per hour.

Table 3
Construction Equipment VMT

Vehicles	MOVES On-road	Miles Travelled		
		2020	2021	2022
Laborers	Passenger Truck	1,637,875	2,835,375	1,440,775
Pickup Trucks	Passenger Truck	803,800	1,184,800	750,200
Material Delivery Trucks	Short-haul Single Unit Truck	428,300	707,500	692,300
Haul Trucks	Short-haul Single Unit Truck	2,561,715	4,347,675	1,321,695

Source: HNTB Analysis, 2019.

The following equation was used to obtain annual emission rates for on-road vehicles:

Emissions (tons/year) for on-road vehicles = Emission Factor (g/mile) x vehicle miles travelled per day x days/year x (1 pound/453.59 grams) x (1 ton/2,000 pounds)

Emission factors associated with the MOVES model are presented in **Table 4** for laborer, pickup, material delivery, and haul trucks.

Table 4
On-road Vehicle Emission Factors (grams/mile)

Vehicles	MOVES On-road	Pollutant	2020	2021	2022
Laborers & Pickup Trucks	Passenger Truck	CO	6.10	5.64	5.23
		VOC	0.50	0.46	0.42
		NO_x	0.45	0.40	0.35
		SO_2	0.00	0.00	0.00
		PM_{10}	0.06	0.05	0.05
		$PM_{2.5}$	0.03	0.02	0.02
		CO_2	459.47	450.61	433.50
		CH_4	0.03	0.03	0.03
		N_2O	0.01	0.01	0.01
Material Delivery & Dirt Haul Trucks	Short-Haul Single Unit Truck	CO	6.20	5.85	5.58
		VOC	0.39	0.36	0.32
		NO_x	1.82	1.61	1.44
		SO_2	0.01	0.01	0.01
		PM_{10}	0.19	0.18	0.16
		$PM_{2.5}$	0.09	0.08	0.07
		CO_2	1104.33	1104.33	1088.89
		CH_4	0.08	0.08	0.08
		N_2O	0.01	0.01	0.01

Source: MOVES emission factors, KB Environmental Sciences, Inc. analysis, 2017.

3.2 Off-road Construction Equipment

EPA's NONROAD 2008 model is used to estimate off-road equipment emissions and is embedded within the latest version of MOVES. **Table 5** presents the off-road equipment included in the analysis along with the corresponding category description used within MOVES, the usage factors, and horsepower (hp) that was assigned to each type of construction equipment. Emissions factors (grams/hp-hour) for each equipment type were applied to the anticipated work output (hp-hours) of expected equipment use. Operating times for the equipment were based on a five-day workweek and an eight-hour workday during which the equipment may be operating. Usage factors accounting for the percentage of daily operation were applied to each type of equipment (i.e. a usage factor of 0.75 equates to 6 hours of operation).

Table 5
Construction Equipment Information

Equipment	MOVES Description	Usage Factor	Horsepower
200 HP Dozer	Crawler Tractors/Dozers	0.590	259.9
Compact Roller	Rollers	0.590	92.3
300 HP Dozer	Crawler Tractors/Dozers	0.590	259.9
Aerial Lift Truck	Aerial Lifts	0.210	48.8
Air Compressor	Air Compressors	0.900	82.9
Arc Welder	Welders	0.900	44.1
Asphalt Paver	Pavers	0.590	124.3
Backhoe	Tractors/Loaders/Backhoes	0.210	93.5
Cement Finisher	Paving Equipment	0.590	69.5
Compressor	Air Compressors	0.900	82.9
Concrete Pump	Paving Equipment	0.590	69.5
Crane	Cranes	0.430	231.0
Crane, 150 Ton	Cranes	0.430	231.0
Crane, 80 Ton	Cranes	0.430	231.0
Fence Post Auger	Bore/drill rigs	0.430	175.5
Front End Loader	Tractors/Loaders/Backhoes	0.210	93.5
Front End Loader, 1-3/4 CY	Tractors/Loaders/Backhoes	0.210	93.5
Front End Loader, 2.5 CY	Tractors/Loaders/Backhoes	0.210	93.5
Vibrating Compactor	Plate Compactors	0.430	7.5
Grader, 30,000 Lbs.	Graders	0.590	204.4
Hammer, 15K Ft. Lbs	Bore/drill rigs	0.430	175.5
Large Excavator	Excavators	0.590	171.2
Pavement Profiler	Surfacing Equipment	0.590	110.6
Paving Machine	Paving Equipment	0.590	69.5
Pile Driver	Bore/drill rigs	0.430	175.5
Pneumatic Wheel Roller	Rollers	0.590	92.3
Steel Wheel Roller	Rollers	0.590	92.3
Tandem Roller	Rollers	0.590	92.3
Thermo Striper, Truck Mounted	Other General Industrial Equipment	0.430	116.4
Vibratory Roller	Rollers	0.590	92.3
Walk Behind Compactor	Plate Compactors	0.430	7.5

Source: MOVES emission factors, KB Environmental Sciences, Inc. analysis, 2017.

Because the age of the equipment is entirely dependent on the preferences of the contractor, a conservative estimate of average equipment age was applied. For example, although newer Tier III and IV equipment less than six years old may be used, the construction emissions inventory utilized Tier I and II equipment for a portion of the fleet. However, Tier III and IV may be incorporated in greater quantities depending on the contractor's fleet.

The following equations were used to obtain emission estimates for off-road construction equipment:

Construction Equipment Emissions (tons/year) = Emission Factor (grams/hp-hour) x Horsepower (hp) x hours per year x Usage Factor x (1 pound/453.59 grams) x (1 ton/2,000 pounds)

Tables 6 through 8 present the construction equipment emission factors (grams per horsepower-hour) for 2020 through 2022, respectively. Note, the NO_2 emission factor has not been included because the MOVES model does not calculate NO_2 emissions for construction equipment.

Table 6
2020 Construction Equipment Factors (grams/hp-hour)

Description	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO_2	CH_4
Aerial Lifts	4.23	4.60	<0.01	0.58	0.57	0.94	692.99	0.03
Air Compressors	0.90	2.16	<0.01	0.13	0.12	0.21	573.78	0.02
Bore/drill rigs	0.96	3.22	<0.01	0.17	0.16	0.28	539.56	0.01
Cranes	0.38	1.41	<0.01	0.06	0.06	0.18	532.86	0.01
Crawler Tractors/Dozers	0.48	1.21	<0.01	0.06	0.06	0.17	539.35	0.01
Excavators	0.28	0.77	<0.01	0.04	0.04	0.16	541.51	0.01
Graders	0.26	0.73	<0.01	0.04	0.04	0.16	537.27	0.01
Other General Industrial Equipment	0.54	1.52	<0.01	0.09	0.09	0.19	546.34	0.01
Pavers	0.48	1.25	<0.01	0.07	0.07	0.17	550.36	0.01
Paving Equipment	0.91	1.81	<0.01	0.14	0.13	0.21	556.16	0.02
Plate Compactors	3.76	4.45	<0.01	0.37	0.35	0.60	588.65	0.05
Rollers	0.70	1.49	<0.01	0.10	0.10	0.19	559.22	0.02
Surfacing Equipment	1.25	2.70	<0.01	0.17	0.16	0.24	554.75	0.02
Tractors/Loaders/Backhoes	2.86	3.03	<0.01	0.44	0.42	0.57	664.40	0.03
Welders	3.59	4.30	<0.01	0.52	0.50	0.76	692.60	0.03

Source: MOVES emission factors, KB Environmental Sciences, Inc. analysis, 2017.

Table 7
2021 Construction Equipment Factors (grams/hp-hour)

Description	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO_2	CH_4
Aerial Lifts	3.93	4.42	<0.01	0.54	0.52	0.86	693.23	0.03
Air Compressors	0.79	1.97	<0.01	0.11	0.10	0.20	573.82	0.01
Bore/drill rigs	0.88	3.00	<0.01	0.15	0.15	0.27	539.60	0.01
Cranes	0.32	1.21	<0.01	0.05	0.05	0.17	532.87	0.01
Crawler Tractors/Dozers	0.41	1.06	<0.01	0.05	0.05	0.17	539.36	0.01
Excavators	0.24	0.65	<0.01	0.03	0.03	0.16	541.52	0.01
Graders	0.22	0.60	<0.01	0.03	0.03	0.16	537.28	0.01
Other General Industrial Equipment	0.47	1.33	<0.01	0.08	0.08	0.18	546.36	0.01
Pavers	0.39	1.10	<0.01	0.05	0.05	0.17	550.38	0.01
Paving Equipment	0.81	1.64	<0.01	0.12	0.12	0.20	556.19	0.02
Plate Compactors	3.76	4.42	<0.01	0.36	0.35	0.59	588.67	0.05
Rollers	0.58	1.32	<0.01	0.08	0.08	0.18	559.24	0.01
Surfacing Equipment	1.14	2.50	<0.01	0.15	0.15	0.23	554.78	0.02
Tractors/Loaders/Backhoes	2.64	2.77	<0.01	0.39	0.38	0.52	664.54	0.03
Welders	3.31	4.14	<0.01	0.47	0.46	0.69	692.79	0.03

Source: MOVES emission factors, KB Environmental Sciences, Inc. analysis, 2017.

Table 8
2022 Construction Equipment Factors (grams/hp-hour)

Description	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO_2	CH_4
Aerial Lifts	3.65	4.24	<0.01	0.49	0.48	0.78	693.45	0.03
Air Compressors	0.69	1.82	<0.01	0.09	0.09	0.19	573.85	0.01
Bore/drill rigs	0.81	2.79	<0.01	0.14	0.14	0.26	539.64	0.01
Cranes	0.27	1.04	<0.01	0.04	0.04	0.17	532.89	0.01
Crawler Tractors/Dozers	0.35	0.93	<0.01	0.04	0.04	0.17	539.37	0.01
Excavators	0.22	0.58	<0.01	0.02	0.02	0.16	541.52	0.01
Graders	0.20	0.49	<0.01	0.02	0.02	0.16	537.28	0.01
Other General Industrial Equipment	0.40	1.16	<0.01	0.06	0.06	0.18	546.38	0.01
Pavers	0.33	0.99	<0.01	0.04	0.04	0.16	550.39	0.01
Paving Equipment	0.71	1.49	<0.01	0.10	0.10	0.20	556.21	0.02
Plate Compactors	3.76	4.40	<0.01	0.36	0.35	0.59	588.68	0.05
Rollers	0.49	1.18	<0.01	0.06	0.06	0.17	559.25	0.01
Surfacing Equipment	1.04	2.33	<0.01	0.14	0.13	0.22	554.81	0.02
Tractors/Loaders/Backhoes	2.43	2.52	<0.01	0.36	0.35	0.48	664.68	0.03
Welders	3.04	4.00	<0.01	0.43	0.42	0.63	692.97	0.03

Source: MOVES emission factors, KB Environmental Sciences, Inc. analysis, 2017.

Fugitive dust emissions for PM and VOC were calculated and included in the total construction emissions. A fugitive dust PM_{10} emission factor of 1.2 tons per acre disturbed per month during construction activity was used, assuming that fugitive dust is generated throughout the construction period such that 25 percent of the project area would be disturbed per construction month and 10 percent of the project area would be disturbed per year. Based on EPA's AP-42, $PM_{2.5}$ emissions were assumed to be 10 percent of PM_{10} emissions. Erosion control measures and water programs are typically taken into account to minimize fugitive dust and particulate emissions at construction sites. For this analysis, a dust control efficiency of 75 percent due to daily watering and other measures (limiting vehicle speed, stockpile control) was assumed.

Evaporative VOC emissions associated with the application of hot mix asphalt on areas requiring paving were estimated using raw materials quantities listed in the projected construction schedule, as well as an emission factor of 0.053 tons of VOC per acre of asphalt material laid, following methodology outlined by the National Association of Clean Air Agencies (NACAA, formerly STAPPA-ALAPCO).

3.3 Estimated Construction Emissions

The estimated year 2020 through year 2022 criteria and precursor emissions estimated to occur with implementation of the proposed improvements are presented in **Table 9**. As shown, emissions would vary by year and pollutant depending on the level and type of construction activity and the greatest annual emissions of CO, NO_x, SO_2, PM and VOC are estimated to occur in the year 2021.

Table 9
Construction Emissions (tons/year)

Year	CO	NO_X	SO_2	PM_{10}	$PM_{2.5}$	VOC
2020	38.6	11.1	0.06	53.3	5.8	5.2
2021*	60.5	16.9	0.11	88.2	9.6	6.8
2022	26.5	7.4	0.05	59.4	6.3	6.2

Note: *See *Attachment 3, Addendum to Emissions Analysis* for revised 2021 construction emissions.

Source: HNTB analysis, 2019.

Attachment 2:

Greenhouse Gas (GHG) Emissions Inventory (EI)

Assumptions and Methodology

July 2019

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Attachment 2
GHG Emissions Inventory Assumptions and Methodology

1 Introduction

Attachment 2 presents the data, assumptions, approach, and methodology for preparing greenhouse gas (GHG) emissions inventories for Baltimore/Washington International Thurgood Marshall Airport (BWI Marshall). As was prepared for the criteria air pollutants/precursors inventories (Attachment 1 of Appendix G), the GHG inventories were estimated for the existing year (2018) and two future years (2022 and 2027) with and without the proposed improvements at the airport and the inventories were prepared only for the emission sources that would be affected by the improvements – aircraft and construction activity.

The GHG emissions inventory was conducted using the following three commonly used and widely accepted guidelines:

- Transportation Research Board (TRB), Airport Cooperative Research Program (ACRP) Report 11, *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*[1];

- United States Environmental Protection Agency (USEPA) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Optional Emissions from Commuting, Business Travel and Product Transport[2]; and the

- Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories.[3]

The GHGs inventoried were carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). As is customary for GHG emissions inventories, the results are reported in units of metric tons (MT) of carbon dioxide equivalents (CO_2e), by source, and on an annual basis. The GHG emission results were converted to CO_2e values using the Global Warming Potential (GWP) values of 1 for CO_2, 25 for CH_4, and 265 for nitrous oxide (N_2O), based on a 100-year period. GWP values are relative measures of how much heat a GHG traps in the atmosphere when compared to carbon dioxide (e.g., CH_4 is 25 times as potent a GHG than CO_2). For this purpose, estimates of CH_4 and N_2O emissions are multiplied by their respective GWP values (25 for CH_4 and 265 for N_2O) to determine the CO_2e.

2 Aircraft

The level of GHG emissions from aircraft activity is directly attributable to the level of fuel consumption by the aircraft. For the purpose of preparing the BWI Marshall-related GHG inventories, estimates of fuel consumption for the year 2018 and both future years were obtained from the Aviation Environmental Design Tool (AEDT 2d) output that was prepared for the air quality analysis presented in this EA. The aircraft operational levels, fleet, and aircraft times-in-mode assumptions that resulted in the fuel estimates used in the GHG analysis are described in Appendix C of this EA.

For the purpose of calculating aircraft-related GHG emissions, the AEDT fuel usage was segregated by aircraft that are powered by Jet A fuel (i.e., aircraft with jet or turboprop engines) and those that are powered by AvGas (piston aircraft). These fuel use estimates are provided in **Table 1**.

Table 1

Aircraft Fuel Usage (gallons)

Year	Scenario	Jet A	AvGas
2018	Existing	24,514,708	7,676
2022	No-Action	28,865,781	6,613
	Action	28,884,665	6,615
2027	No Action	32,525,287	5,700
	Action	32,545,035	5,702

Source: KB Environmental Sciences, Inc and HNTB analyses, 2019.

The aircraft-related GHG inventories were prepared using Method 2 of the ACRP Report 11 Guidebook in which aircraft are categorized as Category 2 (Scope 3) emissions under airline/tenant owned/controlled. The emissions were calculated using emission factors from the USEPA's GHG Emissions Factors Hub (November 2015 v2). **Table 2** presents the GHG emission factors that were used to prepare the emission estimates.

Table 2

Aircraft GHG Emissions Factors

Fuel	CO_2	N_2O	CH_4	Units
Jet A	21.50	0.00066	0.00[1]	lb/gallon
AvGas	18.32	0.00024	0.01556	lb/gallon

Source: USEPA, Center for Corporate Climate Leadership GHG Emission Factors Hub, November 2015, v2.
[1]Assumes CH_4 emissions are negligible.

3 Construction

GHG emissions were estimated for construction activities categorized as off-road (e.g., graders, excavators, forklifts, paving equipment) and for the on-road vehicles associated with construction (e.g., laborer/worker) trips commuting to and from the worksite and haul trucks.

3.1 On-road Construction Vehicles

Table 3 provides the GHG emission factors for on-road vehicles for each year during which construction activities would be scheduled. These emissions factors (grams/mile) were multiplied by the vehicle-miles-traveled (VMT) presented in Table 3 of Appendix G, Attachment 1 to derive the estimated GHG emissions and the CO_2e for this component of the proposed improvements.

Table 3
On-Road Construction Vehicle Emission Factors (grams/mile)

Vehicles	MOVES On-road	Pollutant	2020	2021	2022
Laborers & Pickup Trucks	Passenger Truck	CO_2	460	451	434
		CH_4	0.03	0.03	0.03
		N_2O	0.01	0.01	0.01
Material Delivery & Dirt Haul Trucks	Short-Haul Single Unit Truck	CO_2	1104	1104	1089
		CH_4	0.1	0.1	0.1
		N_2O	0.01	0.01	0.01

Source: MOVES emission factors, KB Environmental Sciences, Inc. analysis, 2017.

3.2 Off-road Construction Equipment

Table 4 provides the GHG emission factors for off-road equipment for all construction years. The emission factors (grams per horsepower) for each equipment type were applied to the anticipated equipment work output (horsepower-hour) of expected equipment use.

Table 4
Construction Equipment Emission Factors (grams/hp-hour)

Description	2020		2021		2022	
	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4
Aerial Lifts	693	0.03	693	0.03	693	0.03
Air Compressors	574	0.02	574	0.01	574	0.01
Bore/drill rigs	540	0.01	540	0.01	540	0.01
Cranes	533	0.01	533	0.01	533	0.01
Crawler Tractors/Dozers	539	0.01	539	0.01	539	0.01
Excavators	542	0.01	542	0.01	542	0.01
Graders	537	0.01	537	0.01	537	0.01
Other General Industrial Equip.	546	0.01	546	0.01	546	0.01
Pavers	550	0.01	550	0.01	550	0.01
Paving Equipment	556	0.02	556	0.02	556	0.02
Plate Compactors	589	0.05	589	0.05	589	0.05
Rollers	559	0.02	559	0.01	559	0.01
Surfacing Equipment	555	0.02	555	0.02	555	0.02
Tractors/Loaders/Backhoes	664	0.03	665	0.03	665	0.03
Welders	693	0.03	693	0.03	693	0.03

Source: MOVES emission factors, KB Environmental Sciences, Inc. analysis, 2017.

3.3 Estimated GHG Construction Emissions

With the implementation of the proposed improvements, the estimated GHG emissions estimated to occur during year 2020 through year 2022 are presented in **Table 5**. As shown, emissions vary by year and pollutant depending on the level and type of construction activity. The greatest annual emissions of CO_2, CH_4, and N_2O are estimated to occur in the year 2021.

Table 5
Construction Emissions (MT CO_2e/year)

Year	CO_2	CH_4	N_2O	Total
2020	6,486.8	9.6	15.9	6,512.2
2021*	10,983.4	15.9	26.5	11,025.8
2022	5,116.8	7.2	12.3	5,136.3

Note: *See *Attachment 3, Addendum to Emissions Analysis* for revised 2021 GHG construction emissions.

Source: HNTB analysis, 2019.

Endnotes

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[1] Transportation Research Board, *ACRP Report 11, Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*, 2009, http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_011.pdf.

[2] United States Environmental Protection Agency, Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Optional Emissions from Commuting, Business Travel and Product Transport, May 2008, https://nepis.epa.gov/Exe/ZyNET.exe/P1001177.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2006+Thru+2010&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C06thru10%5CTxt%5C00000003%5CP1001177.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL.

[3] IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, 2006, http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html.

Attachment 3:

Addendum to Emissions Analysis

July 2019

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Attachment 3
Addendum to Emissions Analysis

1 Introduction

Following the completion of the overall project construction schedule for use in the air quality and climate emissions analysis, preliminary design for the Airline Maintenance Facility was advanced and a new alternative (Alternative 4) was developed for inclusion in the EA. The overall project construction schedule utilized for the emissions analysis was completed in March 2017 using Airline Maintenance Facility Alternative 1.[1] Alternative 4 is now carried forward as the Sponsor's Preferred Alternative. The project quantities for Alternative 4 were compared to the project quantities for Alternative 1 utilized in the development of the construction schedule and emissions calculations. Alternative 4 has a smaller overall footprint than Alternative 1, including a reduction in clearing and grubbing, and a reduction in net impervious areas. However, Alternative 4 includes a larger volume of cut at the project site. **Table 1** summarizes the project quantities for the two alternatives.

Table 1
Airline Maintenance Facility Project Quantities

Project Component	Alternative 1	Alternative 4 (New)	Change
Cut	1,092,900 CY	1,473,700 CY	+380,800 CY
Clearing and Grubbing	51.3 acres	116 acres	+64.7 acres
Impervious Removal	3,600 SY	2,650 SY	-950 SY
New Impervious	131,200 SY	119,750 SY	-11,450 SY

Source: ADCI Preliminary Engineering Project Quantities (see *Appendix D*), 2017, and JMT Preliminary Engineering Project Quantities, 2018.

2 Construction Emission Assumptions

The Airline Maintenance Facility is proposed to be constructed over three years (mid 2020-mid 2022). Assumptions for the construction schedule and crew production rates utilized in the original analysis remain the same in the analysis of Alternative 4. Construction emissions related to pavement removal and new paving would be less with Alternative 4, as compared to Alternative 1. As a conservative approach to updating the construction emissions analysis, only the increase in cut volume and clearing and grubbing area is analyzed for Alternative 4 construction emissions.

[1] The original project construction schedule utilized for construction emissions analysis was completed in March 2017. The overall project schedule was updated in June 2019 to reflect the shift in analysis years to proposed construction years 2020-2022. The original construction duration and resources allocated for each project were assumed to stay the same for purposes of construction emissions analysis.

Additionally, the increase in cut volume and clearing and grubbing area is assumed to occur during 2021, the year of greatest annual emissions related to the EA projects.

Cut Volume

Emissions due to the increase in Alternative 4 cut volume would come from on-road vehicles and off-road equipment from additional operation of the Backfill Crew (BKFLC). The on-site Backfill Crew includes 4 laborers with 2 crew trucks, 1-200 H.P Dozer, and 1-2K Lbs Compact Roller.

For earthwork for cut and fill operations, an initial assumption was made for all projects that hauling fill materials involves a crew of twenty [20] 16-CY heavy-duty dump trucks with a roundtrip haul of 45 miles. Each truck is projected as hauling 3 trips/day for 5 days/week X 20 trucks = 4,800 CY per week per hauling crew.

Further planning and design for the Airline Maintenance Facility included identification of the stockpile location to be used to haul fill material: the existing BWI stockpile in the southwest quadrant of the Airport which is now included in the LOD for Alternative 4. This results in an assumed (conservative) roundtrip haul of 8 miles.

Clearing and Grubbing

Emissions due to the increase in Alternative 4 clearing and grubbing would come from on-road vehicles and off-road equipment from additional operations of the Clear and Grubbing Crew (CLEAR). The on-site Clear and Grubbing Crew includes 2 laborers with 1 crew truck and 1-300 H.P. Dozer. For the purposes of Clearing and Grubbing, it is assumed that there are 200 trees per acre and that 100 trees are cleared per day (per crew). An assumption was made that hauling trees off-site involves a crew of two heavy duty trucks with a roundtrip haul of 45 miles. Each truck is projected as hauling 25 trees/trip, each making 2 trips/day to clear the projected 100 trees/day.

2.1 On-Road Vehicles

Additional Backfill Crew Time

= 380,800 CY/4,800 CY/week = *79.3 weeks = 397 days =* 3,176 hours

Additional Clearing and Grubbing Crew Time

= 64.7 acres x 200 trees/acre = 12,940 trees / 100 trees/day = 130 days = 1,040 hours

Hauling Miles

Backfill = 397 days x 3 trips/day x 20 trucks x 8 miles = *190,560 miles*

Clearing and Grubbing = 130 days = 2 trips/day x 2 trucks x 45 miles = *23,400 miles*

Commuting Miles

- 100-mile roundtrip commute
- 2 laborers/pickup

Backfill = 4 laborers x 397 days x 100 miles / 2 laborers/pickup = *79,400 miles*

Clearing and Grubbing = 2 laborers x 130 days x 100 miles / 2 laborers/pickup = *13,000 miles*

On-Site Truck Miles

- Conservative travel speed of 25 miles/hour

Backfill = 2 on-site trucks x 3,176 hours x 25 miles/hour = *158,800 miles*

Clearing and Grubbing = 1 on-site trucks x 1,040 hours x 25 miles/hour = *26,000 miles*

Emissions for hauling, commuting, and on-site truck miles were calculated using the on-road vehicle emission factors for 2021 provided in *Attachment 1, Table 4*. **Table 2** summarizes the increase in emissions (including GHG emissions) due to on-road vehicle miles.

Table 2
Alternative 4 Increase in On-Road Vehicle Emissions (tons/year)

Year	CO	NO_X	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO_2	CH_4	N_2O
2021	3.1	0.50	<0.01	0.06	0.02	0.23	398.2	0.03	0.01

Source: HNTB analysis, 2019.

2.2 Off-Road Construction Equipment

Emissions for off-road equipment were calculated using the off-road equipment usage factors, horsepower, and 2021 emission factors provided in *Attachment 1, Tables 5* and *8*. **Table 3** summarizes the increase in emissions (including GHG emissions) due to the off-road equipment hours (200 H.P Dozer, 2K Lbs Compact Roller, and 300 H.P. Dozer).

Backfill = 200 H.P. Dozer and 2K Lbs Compact Roller = 3,176 hours

Clearing and Grubbing = 300 H.P Dozer = 1,040 hours

Table 3
Alternative 4 Increase in Off-Road Equipment Emissions (tons/year)

Year	CO	NO_X	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO_2	CH_4	N_2O
2021	0.40	1.01	0.01	0.05	0.05	0.16	491.0	0.01	n/a

Source: HNTB analysis, 2019.

2.3 Revised Estimated Construction Emissions

Table 4 summarizes the construction emissions for year 2021 estimated to occur with implementation of the proposed improvements at BWI Marshall Airport, including the increase in emissions due to the additional cut volume proposed for Airline Maintenance Facility Alternative 4.

Table 4

2021 Construction Emissions (tons/year)

Year	CO	NO_X	SO_2	PM_{10}	$PM_{2.5}$	VOC
2021	60.5	16.9	0.11	88.2	9.6	6.8
Increase due to Alternative 4	3.5	1.5	0.01	0.1	0.1	0.4
2021 Total	**64.0**	**18.4**	**0.12**	**88.3**	**9.7**	**7.2**

Source: HNTB analysis, 2019.

Table 5 summarizes the construction GHG emissions for year 2021 estimated to occur with implementation of the proposed improvements at BWI Marshall Airport, including the increase in GHG emissions due to the additional cut volume proposed for Airline Maintenance Facility Alternative 4.

Table 5

2021 Construction GHG Emissions (MT CO_2e/year)

Year	CO_2	CH_4	N_2O	Total
2021	10,983.4	15.9	26.5	11,025.8
Increase due to Alternative 4	889.1	0.9	1.4	891.5
2021 Total	**11,872.5**	**16.8**	**27.9**	**11,917.3**

Source: HNTB analysis, 2019.