Maryland
Department of the Environment

Wes Moore, Governor
Aruna Miller, Lt. Governor

Serena McIlwain, Secretary Designate
Suzanne E. Dorsey, Deputy Secretary

State of Maryland

Performance Standard Modeling

for

Modifications to the Vehicle Emission Inspection/Maintenance Program in Maryland

SIP # 23-04
Part II

Prepared for:

U.S. Environmental Protection Agency

Prepared by:

Maryland Department of the Environment

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1. Introduction

The Clean Air Act (CAA) requires I/M programs for areas that meet certain criteria, such as air quality status, population, and/or geographic locations. The CAA established two performance levels for I/M programs:

1. Basic I/M for ozone nonattainment areas classified as Moderate and,
2. Enhanced I/M that is required in the following areas:
    - All Serious or higher ozone nonattainment areas that had a 1980 population of 200,000 or more,
    - Metropolitan statistical areas (MSA) with a 1990 population of 100,000 or more in the Ozone Transport Region (OTR) regardless of air quality classification; and,
    - All Moderate or higher carbon monoxide (CO) nonattainment areas with a design value greater than 12.7 ppm at the time of classification that had a 1980 urban population of 200,000 or more.

Based on the above criteria, Maryland (MD) implements an Enhanced I/M program in the following 14 jurisdictions:

- The Baltimore ozone nonattainment area comprising of the MD counties of Anne Arundel, Baltimore, Carroll, Harford, and Howard and the City of Baltimore,
- The MD portion of the multi-state Washington DC ozone nonattainment area comprising of the MD counties of Calvert, Charles, Frederick, Montgomery, and Prince George's,
- The MD portion of the Philadelphia-Camden-Wilmington-Newark DE-MD-NJ-PA ozone nonattainment area comprising of MD's Cecil County,
- Queen Anne's County due to its inclusion in the Baltimore MSA; and,
- Washington County, Maryland, under the OTR provisions.

The EPA's I/M regulations allow states flexibility in designing state I/M programs. However, the state programs must meet I/M requirements including the respective performance standard as described above. Maryland's Enhanced I/M program, known as the Vehicle Emissions Inspection Program (VEIP), is a part of Maryland's State Implementation Plan (SIP). VEIP, along with other initiatives, has helped reduce emissions and improve air quality in Maryland.

2. Purpose

This Performance Standard Modeling (PSM) analysis is required to incorporate outstanding and recent changes to Maryland's I/M program that have occurred in the program to reflect advancements in vehicle technology. It is also required since Maryland's ozone nonattainment areas have been reclassified (or "bumped-up") from Marginal to Moderate for the 2015 ozone National Ambient Air Quality Standard (NAAQS) under EPA's final rule *Determinations of Attainment by the Attainment Date, Extensions of the Attainment Date, and Reclassification of*

Areas Classified as Marginal for the 2015 Ozone National Ambient Air Quality Standards, 87 FR 60,897, Friday, October 7, 2022.

The Moderate ozone classification requires implementation of a Basic I/M program. Consistent with the I/M regulations, states with existing I/M programs, need to conduct and submit a SIP and PSM analysis as well as make any necessary program revisions as part of their Moderate area SIP submissions to ensure that I/M programs are operating at or above the Basic I/M performance standard level. States that determine through the PSM analysis that an existing SIP-approved program would meet the performance standard for purposes of the 2015 ozone NAAQS without modification can submit a SIP revision with the PSM and a written statement certifying their determination.

Maryland is in a unique position in that its SIP-approved Enhanced I/M program is being modified and a SIP revision incorporating these changes was under development when the Basic I/M requirement related to the Moderate ozone designation came into effect. This means Maryland needs to submit two SIPs and PSM analyses at the same time. Normally, Maryland would first submit a SIP revision updating its Enhanced I/M program for EPA approval. This SIP requires Maryland's I/M program to demonstrate compliance with the enhanced performance standard. Once the updated SIP has been approved, Maryland would submit a second SIP revision addressing the Basic I/M requirement and demonstrating compliance with the basic performance standard. MDE and EPA Region 3 have discussed this situation and have agreed that the appropriate approach for satisfying these two concurrent SIP requirements is to use the Enhanced SIP and its associated enhanced performance standard modeling analysis to satisfy both SIP and PSM requirements related to the Enhanced SIP update and the Basic I/M program requirement under the Moderate SIP. Part IV of this SIP document contains a statement certifying that the Enhanced SIP and PSM meets the Basic I/M SIP requirement.

3. Performance Standard Modeling

3.1 Maryland VEIP Overview

Maryland's VEIP I/M program is a centralized, test only system operated by a Contractor under contract with the state. At least one VEIP station is located in each of the 14 jurisdictions affected by VEIP, for a total of 18 stations. Ten self-service VEIP kiosks provide additional convenient motorist test options. Testing is conducted on a biennial cycle. Table 1 depicts the model year and weight classes of gasoline and hybrid vehicles subject to VEIP testing along with the applicable test type.

Table 1
VEIP Subject Vehicles and Applicable Test Types

Gross Vehicle Weight (pounds)	Vehicle Model Year	Test Type
Less than or equal to 8,500	1996 and newer	On Board Diagnostics (OBD) test
8,501 - 14,000	1977 - 2007	Idle exhaust emissions test, Catalytic converter check, and Gas cap leak test
8,501 - 14,000	2008 and newer	On Board Diagnostics (OBD) test
14,001 - 26,000	1977 and newer	Idle exhaust emissions test, Catalytic converter check, and Gas cap leak test

Certain vehicles are exempted from VEIP testing. The exempted vehicles are specified in the VEIP regulations (COMAR 11.14.08.04). The VEIP allows for a delay in initial testing for the newest 6 model year vehicles as specified in COMAR 11.14.08.05. The current program also provides for Motorist Assistance Centers (MACs) that will help motorist and repair technicians better diagnose failures and allow for better, longer lasting repairs.

The VEIP also provides for repair waivers for motorists who demonstrate efforts to repair their vehicles to pass VEIP testing. Other exceptions are provided for motorists who are senior citizens, disabled, or out of state due to active military service and meet certain requirements (see Part I - Appendix 1). Implementing regulations for vehicle exemptions, repair waivers, and the other exceptions listed above can be found in Part I – Appendix 2 of this SIP document.

Detailed information on Maryland's VEIP I/M program can be found in Part I of this SIP.

3.2 Performance Standard Modeling Analysis

The Performance Standard Modeling (PSM) analysis is designed to show that an I/M program, or modifications to an existing I/M program, meets the applicable performance standard. The performance standard establishes the level of emission reductions that a mandatory I/M program must meet or exceed.

An I/M performance standard is a collection of program design elements which defines the EPA benchmark program to which Maryland's program is compared in terms of its potential to

reduce emissions of the ozone precursors, VOCs, and NOx, by certain comparison dates. I/M program design elements include test frequency (annual or biennial), waiver/compliance rate, vehicle types tested, model year (MY) vehicles included in testing, network type (centralized or decentralized), and test type (idle or onboard diagnostic-OBD). The I/M performance standards are defined in the I/M regulations at 40 CFR 51.352 for Basic I/M programs and 40 CFR 51.351 for Enhanced I/M programs.

To perform a PSM analysis, two scenarios must be modeled:

1. Existing state program scenario – this scenario represents Maryland's VEIP program in operation today, including the delay in initial testing for the newest 6 model year vehicles, and includes all of the local parameters and control measures as well as the inputs required to define the existing VEIP; and,
2. EPA's Performance standard benchmark scenario – this scenario represents the applicable EPA defined benchmark program, which includes all of the local area parameters and control measures and the EPA's I/M program with the elements of the applicable performance standard.

The results of these scenarios are compared to determine whether the existing program's emissions rates are the same or lower than the EPA's performance standard benchmark scenario. For an Enhanced I/M program, if the existing program obtains the same or lower emissions levels for VOC and NOx as the EPA's performance standard benchmark program to within 0.02 grams-per-mile (g/mile), then it is considered to have met the enhanced performance standard.

Modeling for this PSM analysis was performed using the MOVES3.1 emissions model and reflected the latest planning assumptions (local fleet age distribution, vehicle miles travelled, meteorology, fuel parameters, etc.). The latest planning assumptions are based on 2020 data which are updated triennially in conjunction with the federal requirements for statewide National Emissions Inventory (NEI) development. The MOVES3.1 model inputs for the existing I/M program (reflecting delayed tested for the newest 6 model year vehicles) were developed using Maryland VEIP data for calendar years 2021 and 2022. The two most recent years of the biennial program for which data is available. The 2020-2021 Maryland VEIP data were not used in the modeling because VEIP testing was not performed from March 17, 2020 through October 18, 2020 due to COVID and is not representative of the VEIP's normal operations.

The analysis year of 2023 was selected for this PSM. It was selected because it is the year in which the newest VEIP program modifications are being implemented. It was also chosen since it is a year that will be used in determining attainment. Attainment of the ozone NAAQS is demonstrated by monitoring ambient air ozone concentrations in areas required to be

monitored by EPA (typically in and near large metropolitan areas). A monitoring location is considered in attainment if its design value (DV) is less than 71 parts per billion (ppb). The attainment date for Moderate ozone nonattainment areas is August 1, 2024.

Under EPA regulations, the 2015 NAAQS is attained when the 3-year average of the annual fourth-highest daily maximum 8-hour average ozone concentrations at an ozone monitor is less than or equal to 0.70 ppm. This 3-year average is referred to as the design value. Since the attainment date for Moderate ozone nonattainment areas is in the middle of the ozone season, the DV that will be used to determine attainment will be based on air monitoring data from the 2021-2023 ozone seasons. The 2023 analysis year is contained in the 3-years of air monitoring data that will be used to if Maryland's Moderate nonattainment areas attain the NAAQS.

3.2.1 Modeling Methodology

This section summarizes Maryland's methodology for estimating emissions from highway vehicles using EPA's Motor Vehicle Emission Simulator (MOVES) model and PPSuite, a custom pre- and post-processing system. This methodology is used for Maryland's official emission inventories and State Implementation Plans (SIP). It includes a summary of the methodology and data assumptions used for the PSM and the accompanying Section 110(l) demonstration. It provides details regarding the MOVES input parameters, vehicle miles traveled (VMT) and emission results for Maryland's 14 I/M jurisdictions.

Background:

The operation of highway vehicles has proven to be a significant contributor to air pollution, particularly to ground-level ozone, as they emit both volatile organic compounds (VOC) and oxides of nitrogen (NOx) during operation. Ground-level ozone is not created directly rather, it is formed through a chemical reaction between VOCs and NOx in the presence of sunlight. Given that both VOCs and NOx are emitted from the operation of highway vehicles, Maryland's ozone-related emission modeling efforts have been focused on these pollutants.

In order to estimate both the rate at which emissions are being generated and to calculate vehicle miles traveled (activity level), Maryland examines its road network and fleet to estimate vehicle activity. For ozone-related modeling and inventories, the analysis is done for a typical summer weekday. For emission modeling and inventories of other pollutants such as carbon monoxide (CO) or greenhouse gases (GHG), the analyses may be done for a typical winter weekday or annual conditions.

This PSM modeling was performed using the MOVES3.1 model, EPA's latest official version of Motor Vehicle Emission Simulator (MOVES) for estimating emissions from highway vehicles. This MOVES3 model version was released in November 2022 and contains a minor revision incorporating appropriate I/M benefits for some light heavy-duty Class 2b and 3 gasoline trucks. It also encompasses the latest data on vehicle populations, travel activity and emission rates as well as updated fuel data at the county level from the previous MOVES3 versions.

EPA's Guidance Resources for MOVES3 Modeling:

The following EPA guidance documents were used to develop the modeling methodology used in Maryland's official highway emissions inventory, SIPs and this PSM analysis. The documents include:

- *Policy Guidance on the Use of MOVES3 for State Implementation Plan Development, Transportation Conformity, General Conformity, and Other Purposes,* US EPA Office of Transportation and Air Quality, EPA-420-B-20-044, November 2020.
- *MOVES3 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity,* US EPA Office of Transportation and Air Quality, EPA-420-B-20-052, November 2020.
- *Performance Standard Modeling for New and Existing Vehicle Inspection and Maintenance (I/M) Programs Using the MOVES Mobile Source Emission model;* US EPA Office of Transportation and Air Quality, EPA-420-B-22-034, October 2022.

Analysis Methodology:

The methodologies used to produce the emission results conform to the recommendations provided in EPA's technical guidance documents. A mix of local and national default (internal to MOVES3) data has been used for this work. All the MOVES3 modeling input parameters are summarized in Table 2 entitled, "Maryland I/M SIP Modeling Inputs Checklist for 2023". Local data has been used for the primary data items that have a significant impact on emissions and reflects the latest available planning assumptions developed by the Maryland Department of the Environment (MDE) using data obtained from the Maryland Department of Transportation Motor Vehicle Administration (MDOT MVA), the Maryland Department of Transportation State Highway Administration (MDOT SHA), the local Metropolitan Planning Organizations (MPOs) and other local/national sources as identified in the table.

A detailed explanation of the model, how the inputs in the table below were developed and the emissions methodology used in determining on-road mobile source emissions for MDE's official inventories and SIPs can be found in Appendix E of Maryland's Moderate Nonattainment Area 0.070 ppm 8-Hour Ozone State Implementation Plan Attainment Demonstration for the Baltimore Area. The mobile modeling methodologies in this document are applicable to all of MDE's official modeling efforts.

Table 2
Maryland I/M SIP Modeling Inputs Checklist for 2023

Data Item	2023 Emission Inventory Inputs Assumptions (SHA-PPSuite Process with MOVES3.1)
Traffic Data	
Highway Network	2020 MD-MDOT SHA Universal Highway Database
Seasonal/Daily Adjustments	2020 MD-MDOT SHA Traffic Trends Report
County HPMS VMT Adjustments	2020 MD-HPMS Adjustments
Mapfile	Use MOVES3 national defaults VMT distributions for Maryland to disaggregate light duty vehicles/buses/trucks to the 13 MOVES source types
Hourly Patterns	MPO Modified hourly distributions to be used for MD hourly patterns
Vehicle Mixes	1. 2020 Vehicle Classification by Functional Class 2. 2020 TMS & hourly distribution from SHA traffic count data 3. Truck percentage assumption consistent with MPO travel modeling
VMT Growth Forecast	2000-2019 HPMS growth trend, applied to 2019 HPMS Base Year Applied forecasted VMT growth factor to obtain 2023 VMT
Vehicle Population Growth Forecast	1. Source Type 11, 21, 31, 32, 41, 42, 43, 51 & 54: max of population, household and VMT 2. Trucks (source type 52, 53 ,61 & 62): Estimated by using VMT, MOVES3 national default VMT and population ratios
MOVES Inputs	
Month VMT Fractions	Calculated based on 2020 seasonal adjustment factors
Day VMT Fractions	Calculated based on 2020 seasonal adjustment factors
Hourly VMT Fractions	Calculated by PPSUITE
Average Speed Distribution	Calculated by PPSUITE

Source Type Population	1. Source Type 11, 21, 31, 32, 41, 42, 43, 51 & 54: Applied 2023 VPOP growth to 2020 base year inputs developed using VIN-Decoded data 2. Trucks (source type 52, 53 ,61 & 62): Estimated by using 2023 modeled VMT, MOVES3 national default VMT, and population ratios
Vehicle Age Distribution	Developed in-house using MDOT MVA vehicle registration data as of July 1, 2020. VIN decoding was done by ESP Data Solutions, a commercial VIN decoding service. MOVES3 defaults were used for heavy-duty vehicle types 61 and 62.
Fuel Supply	MOVES3 inputs developed in-house using MD's Fuel Data
Fuel Formulation	MOVES3 inputs developed in-house using MD's Fuel Data
Fuel Usage Fraction	MOVES3 inputs developed from the MOVE3 default database
Temperatures/Humidity	2020 inputs developed in-house using meteorological data for local airports through NOAA
I/M Parameters	Two separate I/M Programs for 2023; 1) the current I/M program, and 2) the enhanced performance standard
Early NLEV / CALLEV	Early NLEV and CALEV program databases developed with MOVES3
AVFT	Developed in-house by MDE from 2020 MVA data (2020 light-duty electric vehicle Sales%)
Federal Fuel & Emissions Standards	Controlled Measures included in MOVES3

The analysis methodology is consistent with statewide inventory efforts including the 2020 National Emissions Inventory (NEI) submission. This includes the use of statewide traffic roadway data and custom post-processing software (PPSUITE) to calculate hourly speeds and prepare key traffic input files to the MOVES3 emission model. PPSUITE consists of a set of programs that perform the following functions:

- Analyzes highway operating conditions,
- Calculates highway speeds,
- Compiles vehicle miles of travel (VMT) and vehicle type mix data,
- Pre-processes MOVES inputs and MOVES Run Specs,

- Runs MOVES in batch mode, and
- Post-processes MOVES outputs and develops Excel reports and Summaries.

PPSUITE is a widely used and accepted tool for estimating speeds and processing emissions rates. It has been used for past SIP highway inventories in Maryland, Pennsylvania, and New Jersey. The software is based upon accepted transportation engineering methodologies. For example, PPSUITE utilizes speed and delay estimation procedures based on planning methods provided in the Highway Capacity Manual, a report prepared by the Transportation Research Board (TRB) summarizing current knowledge and analysis techniques for capacity and level-of-service analyses of the transportation system.

MOVES Runs:

After calculating speeds and aggregating VMT and VHT, PPSUITE prepares traffic-related inputs needed to run EPA's MOVES3 model. Additional required MOVES inputs are tapped from the folders already prepared/stored external to the processing software such as meteorology, I/M program parameters, fuel characteristics, vehicle fleet age distributions and source type population.

The MOVES County importer is run in batch mode. This program converts all data files into the MariaDB formats used by the MOVES model. At that point a MOVES run specification file (*.mrs) is created which specifies options and key data locations for the run. MOVES is then run in batch mode.

MOVES can be run using either the *inventory* or *rate-based* approach. For this I/M SIP work, MOVES is run using the *inventory-based* approach. Under this method, actual VMT and population are provided as inputs to the model; MOVES is responsible for producing the total emissions for the modeling domain.

MOVES Output Summary:

After all the MOVES 14 individual jurisdiction runs (separate run for each scenario) are completed, quality assurance checks are done to ascertain that there are no data import errors or execution errors. Then PPSuite's Summary module is used to aggregate the 14 individual jurisdiction emissions results into one comprehensive, I/M domain-wide summary of daily VOC and NOx emissions in grams per day (gpd), and VMT by jurisdiction by various modes such by source type, by roadway type, etc.

The emissions in grams per day (gpd), by pollutant, are then converted to tons per day (tpd) for each jurisdiction by applying a conversion factor. The same approach is applicable to the area wide emissions.

Emission factors in grams per mile (gpm) are developed for each jurisdiction by dividing the total emissions (gpd) by the associated total VMT in miles per day. The same approach is applicable to the area wide emission factors used use in this Enhanced I/M PSM.

The MOVES3.1 model is equipped with an SQL script-based function that can be used to obtain the gpm emissions factor. This function can only be used in the stand-alone mode which is a time-consuming process and is counter to the automated PPSuite-based process MDE uses. MDE used the SQL script-based function for one county and found the results matched very well to the MDE approach described above. In consultation with EPA OTAQ, MDE was given approval to use MDE's gpm emissions factor approach for calculating the emissions factors used to demonstrate compliance with the Enhanced Performance Standard.

Quality Assurance:

Quality assurance checks have been applied throughout the development of MOVES inputs, MOVES import operations, and MOVES runs through a review of feedback reports after each county run. The MOVES3 integrated into the PPSuite software, has been validated and produces the same emissions/VMT results when compared to a stand-alone MOVES run.

A sample run for 2023 for Baltimore County (current I/M with 6MY delay scenario) is included in the MOVES3 output folder demonstrating a near perfect match between results of MOVES stand-alone and PPSuite runs.

Modeling Data Description:

Per EPA Guidance on Performance Standard Modeling for New and Existing Vehicle Inspection and Maintenance (I/M) Programs Using the MOVES Mobile Source Emission model, all required data, and descriptions to support the conclusion that the I/M program meets the applicable performance standard, the following MOVES files and/or databases are being provided with this SIP.

- MOVES Run Specification (RunSpec) files – these files define the scope of the MOVES run by defining elements such as time period(s), geographical area, source types, etc. included in the modeling.

- MOVES Input MariaDB Databases – input databases provide vehicle characteristics, vehicle activity, and other local conditions.

- MOVES Output MariaDB Databases – output databases contain the results of the MOVES analysis.

• MOVES Output MS-Excel Spreadsheets: MOVES output tables processed into Excel with a sample case for quality assurance demonstrating match with MOVES standalone operation.

• Post-processed MS-Excel Spreadsheets: Containing emissions and emission factor tables by scenario, by jurisdictions, by pollutant and by I/M Area demonstrating how the I/M program meets the applicable performance standard in the I/M regulations.

3.2.2 Development of Inspection and Maintenance (I/M) Program Input Table – Current Program Evaluated in 2023

The I/M evaluation consists of many parameters. This section describes MDE's approach to each parameter of the I/M input table in MOVES. Section 4.9 of EPA's MOVES Technical Guidance document explains the appropriate input assumptions and sources of data for using MOVES in State Implementation Plans and Transportation Conformity Determinations[1]. The MOVES I/M input table was developed following the assumptions and methods described in Section 4.9.

Pollutant Process ID

Maryland's I/M program includes exhaust and evaporative OBD tests as well as an exhaust idle test and evaporative gas cap pressure check. All tests provide emission benefits for hydrocarbons/volatile organic compounds (VOCs) and the OBD tests provide additional emission benefits for nitrogen oxides (NO_x). For exhaust emissions, I/M programs can affect both running and starting emissions. For evaporative emissions, I/M programs affect hydrocarbon emissions from fuel vapor venting and fuel leaks. For the relevant test types, Pollutant Process IDs in this input include 101, 102, 112, 113, 301 and 302.

Source Type ID

Maryland's I/M program includes passenger cars and trucks with a gross vehicle weight rating of 26,000 pounds or less. Therefore, the MOVES source type IDs included in the I/M input table are passenger cars, passenger trucks, and light commercial trucks. (IDs = 21, 31, and 32, respectively). Maryland's I/M program covers heavy duty vehicles, and this would include source type 51, and 52. The benefit from including these in the I/M inputs are negligible and MDE, after discussions with EPA, was advised not to include them.

[1] https://www.epa.gov/sites/default/files/2020-11/documents/420b20052.pdf

Fuel Type ID

Maryland's I/M program applies to gasoline and flex fuel vehicles. MOVES calculates an I/M emissions benefit for these vehicles. Therefore, two MOVES fuel type IDs were included in the I/M input table (ID = 1 for regular gasoline, and ID = 5 for E85 gasoline).

Inspection Frequency

Maryland's I/M program requires emission tests every two years. Therefore, the MOVES inspection frequency ID that represents biennial tests (ID = 2) was used in the I/M input table.

Test Standards

Maryland's I/M program is a centralized program with OBD tests for exhaust and evaporative systems, as well as an idle test with gas cap pressure check. Therefore, the MOVES test standard IDs for exhaust OBD check, evaporative system OBD check, idle test, and gas cap pressure test (IDs = 43, 51, 11, and 41, respectively), were used.

I/M Program ID

This is an arbitrary number developed by the MOVES user to define a unique test given for vehicles within a range of model years. I/M program IDs were arbitrarily assigned to the various unique tests within the I/M program.

Beginning and Ending Model Years

Maryland's I/M program applies to light duty gasoline vehicles with a model year of 1996 and newer, and to heavy duty (8,501-26,000 GVWR) vehicles 1977 and newer. In the MOVES input, light duty vehicles cover 1996-2017. Heavy duty vehicles cause a split, as OBD was introduced for vehicles under 14,000 lbs in 2008. Heavy duty vehicles from 1977-1995 are pre-OBD and entirely idle tested, 1996-2007 of the commercial trucks are <8,500 and are modeled as OBD tested, and 2008-2017.
Not included in the model are 1996 and newer idle tested vehicles. Source Types 31 & 32 have minority segments that are heavy duty pre-OBD; since MOVES considers additional rows covering the same Year/Source Type combination as double-counting, these were not included in the I/M inputs to prevent errors.

Compliance Factor

The I/M Compliance Factor was calculated according to the MOVES guidance document using Equation 1.

Equation 1:

$$Compliance\ Factor = compliance\ rate\ \times (1 - waiver\ rate\ \times failure\ rate)\ \times regulatory\ class\ coverage\ adjustment$$

To calculate the compliance factor for each MOVES source type ID included in Maryland's I/M program (IDs = 21, 31, and 32, respectively), the compliance rate, failure rate, waiver rate, and regulatory class coverage adjustment were determined as follows:

Compliance Rate, Failure Rate, and Waiver Rate

The Compliance Rate is the percentage of vehicles that either pass a test or receive a waiver compared to the total number of vehicles in the program. MDE's Mobile Program keeps track of vehicles that were sent a test notice but did not receive an initial test, Mobile refers to these vehicles as "no shows". "No show" vehicles are included in the denominator of the compliance rate calculation. The Failure Rate is the percentage of vehicles that fail their initial test compared to all vehicles that receive an initial test. The Waiver Rate is the number of vehicles that receive a waiver divided by the number of vehicles that fail their initial test. Because Maryland's I/M program is a biennial program, meaning half the vehicles were tested in 2021 and half in 2022, the combined data from the 2021-2022 was used.

Table 3
I/M Data and MOVES Compliance, Waiver, and Failure Rates

Parameter	Total
Subject Vehicles	2,352,376
No Shows	14,365
Compliance Rate	95.55%
Total Initial Fails	193,799
Failure Rate	8.29%
Total Waivers	21,950
Waiver Rate	11.3%

Regulatory Class Coverage Adjustment

The regulatory class coverage adjustment accounts for the fraction of vehicles within a source type that are included in Maryland's I/M program. Because Maryland's I/M tests non-OBD heavy, duty vehicles, the regulatory class coverage adjustment factor is split up differently depending on what model year range is being modeled. Mobile used Table A.1 in the Appendix of the MOVES technical guidance document to develop the regulatory class coverage adjustment factor, as shown in the Table 4.

Table 4
Regulatory Class Coverage Adjustment Factors

MOVES Vehicle Classification	MOVES Source Type ID	Model Year Range	Regulatory Class Coverage Adjustment Factor
Passenger Cars	21	1996-2017	100%
Passenger Trucks	31	1977-1995	3.88%
"	"	1996-2007	96.12%
"	"	2008-2017	100%
Light Commercial Trucks	32	1977-1995	24.74%

“	“	1996-2007	75.26%
“	“	2008-2017	100%

Calculating the Compliance Factor

Using these values for the compliance rate, waiver rate, failure rate, and regulatory class coverage adjustment, the compliance factors for the following three MOVES vehicle types were calculated using Equation 1.

Equation 1:

$$Passenger\ Cars\ Compliance\ Factor = \left(\frac{95.55\%}{100\%}\right) \times \left(1 - \frac{8.29\%}{100\%} \times \frac{11.33\%}{100\%}\right) \times \frac{100\%}{100\%} = 94.65\%$$

$Passenger\ Trucks\ Compliance\ Factor$

1977-1995

$$= \left(\frac{95.55\%}{100\%}\right) \times \left(1 - \frac{8.29\%}{100\%} \times \frac{11.33\%}{100\%}\right) \times \frac{3.88\%}{100\%} = 3.67\%$$

1996-2007

$$= \left(\frac{95.55\%}{100\%}\right) \times \left(1 - \frac{8.29\%}{100\%} \times \frac{11.33\%}{100\%}\right) \times \frac{96.12\%}{100\%} = 90.98\%$$

2008-2017

$$= \left(\frac{95.55\%}{100\%}\right) \times \left(1 - \frac{8.29\%}{100\%} \times \frac{11.33\%}{100\%}\right) \times \frac{100\%}{100\%} = 94.65\%$$

$Light\ Commercial\ Trucks\ Compliance\ Factor$

1977-1995

$$= \left(\frac{95.55\%}{100\%}\right) \times \left(1 - \frac{8.29\%}{100\%} \times \frac{11.33\%}{100\%}\right) \times \frac{24.74\%}{100\%} = 23.42\%$$

1996-2007

$$= \left(\frac{95.55\%}{100\%}\right) \times \left(1 - \frac{8.29\%}{100\%} \times \frac{11.33\%}{100\%}\right) \times \frac{75.26\%}{100\%} = 71.24\%$$

2008-2017

$$= \left(\frac{95.55\%}{100\%}\right) \times \left(1 - \frac{8.29\%}{100\%} \times \frac{11.33\%}{100\%}\right) \times \frac{100\%}{100\%} = 94.65\%$$

Combining these values provides the MOVES I/M input table as shown in Table 5 for one Maryland I/M county.

Table 5: I/M Input Table for One Maryland County

Pol Process ID	State ID	County ID	Year ID	Source type ID	Fuel Type ID	IM Program ID	Inspect Freq	Test Standards ID	Begin Model Year ID	End Model Year ID	Use IM (y/n)	Compliance Factor
101	24	24003	2023	21	1	21511	2	51	1996	2017	Y	94.65
102	24	24003	2023	21	1	21511	2	51	1996	2017	Y	94.65
201	24	24003	2023	21	1	21511	2	51	1996	2017	Y	94.65
202	24	24003	2023	21	1	21511	2	51	1996	2017	Y	94.65
301	24	24003	2023	21	1	21511	2	51	1996	2017	Y	94.65
302	24	24003	2023	21	1	21511	2	51	1996	2017	Y	94.65
112	24	24003	2023	21	1	21431	2	43	1996	2017	Y	94.65
113	24	24003	2023	21	1	21431	2	43	1996	2017	Y	94.65
101	24	24003	2023	31	1	31511	2	51	1996	2007	Y	90.98
102	24	24003	2023	31	1	31511	2	51	1996	2007	Y	90.98
201	24	24003	2023	31	1	31511	2	51	1996	2007	Y	90.98
202	24	24003	2023	31	1	31511	2	51	1996	2007	Y	90.98
301	24	24003	2023	31	1	31511	2	51	1996	2007	Y	90.98
302	24	24003	2023	31	1	31511	2	51	1996	2007	Y	90.98
112	24	24003	2023	31	1	31431	2	43	1996	2007	Y	90.98
113	24	24003	2023	31	1	31431	2	43	1996	2007	Y	90.98
101	24	24003	2023	31	1	31512	2	51	2008	2017	Y	94.65
102	24	24003	2023	31	1	31512	2	51	2008	2017	Y	94.65
201	24	24003	2023	31	1	31512	2	51	2008	2017	Y	94.65
202	24	24003	2023	31	1	31512	2	51	2008	2017	Y	94.65
301	24	24003	2023	31	1	31512	2	51	2008	2017	Y	94.65
302	24	24003	2023	31	1	31512	2	51	2008	2017	Y	94.65
112	24	24003	2023	31	1	31432	2	43	2008	2017	Y	94.65
113	24	24003	2023	31	1	31432	2	43	2008	2017	Y	94.65
101	24	24003	2023	32	1	32511	2	51	1996	2007	Y	71.24

102	24	24003	2023	32	1	32511	2	51	1996	2007	Y	71.24
201	24	24003	2023	32	1	32511	2	51	1996	2007	Y	71.24
202	24	24003	2023	32	1	32511	2	51	1996	2007	Y	71.24
301	24	24003	2023	32	1	32511	2	51	1996	2007	Y	71.24
302	24	24003	2023	32	1	32511	2	51	1996	2007	Y	71.24
112	24	24003	2023	32	1	32431	2	43	1996	2007	Y	71.24
113	24	24003	2023	32	1	32431	2	43	1996	2007	Y	71.24
101	24	24003	2023	32	1	32512	2	51	2008	2017	Y	94.65
102	24	24003	2023	32	1	32512	2	51	2008	2017	Y	94.65
201	24	24003	2023	32	1	32512	2	51	2008	2017	Y	94.65
202	24	24003	2023	32	1	32512	2	51	2008	2017	Y	94.65
301	24	24003	2023	32	1	32512	2	51	2008	2017	Y	94.65
302	24	24003	2023	32	1	32512	2	51	2008	2017	Y	94.65
112	24	24003	2023	32	1	32432	2	43	2008	2017	Y	94.65
113	24	24003	2023	32	1	32432	2	43	2008	2017	Y	94.65
101	24	24003	2023	31	1	31111	2	11	1977	1995	Y	3.67
102	24	24003	2023	31	1	31111	2	11	1977	1995	Y	3.67
201	24	24003	2023	31	1	31111	2	11	1977	1995	Y	3.67
202	24	24003	2023	31	1	31111	2	11	1977	1995	Y	3.67
112	24	24003	2023	31	1	31411	2	41	1977	1995	Y	3.67
101	24	24003	2023	32	1	32111	2	11	1977	1995	Y	23.42
102	24	24003	2023	32	1	32111	2	11	1977	1995	Y	23.42
201	24	24003	2023	32	1	32111	2	11	1977	1995	Y	23.42
202	24	24003	2023	32	1	32111	2	11	1977	1995	Y	23.42
112	24	24003	2023	32	1	32411	2	41	1977	1995	Y	23.42
101	24	24003	2023	21	5	1	2	51	1996	2017	Y	94.65
102	24	24003	2023	21	5	1	2	51	1996	2017	Y	94.65
201	24	24003	2023	21	5	1	2	51	1996	2017	Y	94.65
202	24	24003	2023	21	5	1	2	51	1996	2017	Y	94.65
301	24	24003	2023	21	5	1	2	51	1996	2017	Y	94.65
302	24	24003	2023	21	5	1	2	51	1996	2017	Y	94.65

112	24	24003	2023	21	5	2	2	43	1996	2017	Y	94.65
113	24	24003	2023	21	5	2	2	43	1996	2017	Y	94.65
101	24	24003	2023	31	5	3	2	51	1996	2007	Y	90.98
102	24	24003	2023	31	5	3	2	51	1996	2007	Y	90.98
201	24	24003	2023	31	5	3	2	51	1996	2007	Y	90.98
202	24	24003	2023	31	5	3	2	51	1996	2007	Y	90.98
301	24	24003	2023	31	5	3	2	51	1996	2007	Y	90.98
302	24	24003	2023	31	5	3	2	51	1996	2007	Y	90.98
112	24	24003	2023	31	5	4	2	43	1996	2007	Y	90.98
113	24	24003	2023	31	5	4	2	43	1996	2007	Y	90.98
101	24	24003	2023	31	5	5	2	51	2008	2017	Y	94.65
102	24	24003	2023	31	5	5	2	51	2008	2017	Y	94.65
201	24	24003	2023	31	5	5	2	51	2008	2017	Y	94.65
202	24	24003	2023	31	5	5	2	51	2008	2017	Y	94.65
301	24	24003	2023	31	5	5	2	51	2008	2017	Y	94.65
302	24	24003	2023	31	5	5	2	51	2008	2017	Y	94.65
112	24	24003	2023	31	5	6	2	43	2008	2017	Y	94.65
113	24	24003	2023	31	5	6	2	43	2008	2017	Y	94.65
101	24	24003	2023	32	5	7	2	51	1996	2007	Y	71.24
102	24	24003	2023	32	5	7	2	51	1996	2007	Y	71.24
201	24	24003	2023	32	5	7	2	51	1996	2007	Y	71.24
202	24	24003	2023	32	5	7	2	51	1996	2007	Y	71.24
301	24	24003	2023	32	5	7	2	51	1996	2007	Y	71.24
302	24	24003	2023	32	5	7	2	51	1996	2007	Y	71.24
112	24	24003	2023	32	5	8	2	43	1996	2007	Y	71.24
113	24	24003	2023	32	5	8	2	43	1996	2007	Y	71.24
101	24	24003	2023	32	5	9	2	51	2008	2017	Y	94.65
102	24	24003	2023	32	5	9	2	51	2008	2017	Y	94.65
201	24	24003	2023	32	5	9	2	51	2008	2017	Y	94.65
202	24	24003	2023	32	5	9	2	51	2008	2017	Y	94.65
301	24	24003	2023	32	5	9	2	51	2008	2017	Y	94.65

302	24	24003	2023	32	5	9	2	51	2008	2017	Y	94.65
112	24	24003	2023	32	5	10	2	43	2008	2017	Y	94.65
113	24	24003	2023	32	5	10	2	43	2008	2017	Y	94.65
101	24	24003	2023	31	5	15	2	11	1977	1995	Y	3.67
102	24	24003	2023	31	5	15	2	11	1977	1995	Y	3.67
201	24	24003	2023	31	5	15	2	11	1977	1995	Y	3.67
202	24	24003	2023	31	5	15	2	11	1977	1995	Y	3.67
112	24	24003	2023	31	5	16	2	41	1977	1995	Y	3.67
101	24	24003	2023	32	5	17	2	11	1977	1995	Y	23.42
102	24	24003	2023	32	5	17	2	11	1977	1995	Y	23.42
201	24	24003	2023	32	5	17	2	11	1977	1995	Y	23.42
202	24	24003	2023	32	5	17	2	11	1977	1995	Y	23.42
112	24	24003	2023	32	5	18	2	41	1977	1995	Y	23.42

3.2.3 Development of Enhanced Performance Standard Input Table

Along with EPA's November 2022 Performance Modeling Guidance document, EPA provided templates that states can use to develop the basic and/or enhanced performance standard input table to be used in their PSM modeling. MDE used the enhanced performance standard template which only requires the user to provide the following information into the excel-based template:

- state-specific information that includes state ID (state-level 2-digit FIPS code),
- county ID (county-level 5-digit FIPS code that share 2-digits with the state code), and
- analysis year.

A segment of the MOVES enhanced performance standard I/M input table used in this modeling is shown in Table 6.

Table 6: Sample MOVES Enhance Performance Standard I/M Input Table

Pol Process ID	State ID	County ID	Year ID	Source Type ID	Fuel Type ID	IM Program ID	Inspect Freq	Test Standards ID	Beg Model Year ID	End Model Year ID	Use IM (y/n)	Compliance Factor
101	24	24003	2023	21	1	111	1	11	1968	2000	y	95.7696
101	24	24003	2023	31	1	111	1	11	1968	2000	y	92.05374
101	24	24003	2023	32	1	111	1	11	1968	2000	y	72.0762
102	24	24003	2023	21	1	111	1	11	1968	2000	y	95.7696
102	24	24003	2023	31	1	111	1	11	1968	2000	y	92.05374
102	24	24003	2023	32	1	111	1	11	1968	2000	y	72.0762
301	24	24003	2023	21	1	111	1	11	1968	2000	y	95.7696
301	24	24003	2023	31	1	111	1	11	1968	2000	y	92.05374
301	24	24003	2023	32	1	111	1	11	1968	2000	y	72.0762
302	24	24003	2023	21	1	111	1	11	1968	2000	y	95.7696
302	24	24003	2023	31	1	111	1	11	1968	2000	y	92.05374
302	24	24003	2023	32	1	111	1	11	1968	2000	y	72.0762
101	24	24003	2023	21	1	151	1	51	2001	2022	y	95.7696
101	24	24003	2023	31	1	151	1	51	2001	2022	y	92.05374
101	24	24003	2023	32	1	151	1	51	2001	2022	y	72.0762
102	24	24003	2023	21	1	151	1	51	2001	2022	y	95.7696
102	24	24003	2023	31	1	151	1	51	2001	2022	y	92.05374
102	24	24003	2023	32	1	151	1	51	2001	2022	y	72.0762
301	24	24003	2023	21	1	151	1	51	2001	2022	y	95.7696
301	24	24003	2023	31	1	151	1	51	2001	2022	y	92.05374
301	24	24003	2023	32	1	151	1	51	2001	2022	y	72.0762
302	24	24003	2023	21	1	151	1	51	2001	2022	y	95.7696
302	24	24003	2023	31	1	151	1	51	2001	2022	y	92.05374
302	24	24003	2023	32	1	151	1	51	2001	2022	y	72.0762
112	24	24003	2023	21	1	143	1	43	2001	2022	y	95.7696
112	24	24003	2023	31	1	143	1	43	2001	2022	y	92.05374
112	24	24003	2023	32	1	143	1	43	2001	2022	y	72.0762
101	24	24003	2023	21	5	111	1	11	1968	2000	y	95.7696
101	24	24003	2023	31	5	111	1	11	1968	2000	y	95.7696
101	24	24003	2023	32	5	111	1	11	1968	2000	y	95.7696
102	24	24003	2023	21	5	111	1	11	1968	2000	y	95.7696
102	24	24003	2023	31	5	111	1	11	1968	2000	y	95.7696
102	24	24003	2023	32	5	111	1	11	1968	2000	y	95.7696
301	24	24003	2023	21	5	111	1	11	1968	2000	y	95.7696
301	24	24003	2023	31	5	111	1	11	1968	2000	y	95.7696
301	24	24003	2023	32	5	111	1	11	1968	2000	y	95.7696
302	24	24003	2023	21	5	111	1	11	1968	2000	y	95.7696
302	24	24003	2023	31	5	111	1	11	1968	2000	y	95.7696

302	24	24003	2023	32	5	111	1	11	1968	2000	y	95.7696
101	24	24003	2023	21	5	151	1	51	2001	2022	y	95.7696
101	24	24003	2023	31	5	151	1	51	2001	2022	y	95.7696
101	24	24003	2023	32	5	151	1	51	2001	2022	y	95.7696
102	24	24003	2023	21	5	151	1	51	2001	2022	y	95.7696
102	24	24003	2023	31	5	151	1	51	2001	2022	y	95.7696
102	24	24003	2023	32	5	151	1	51	2001	2022	y	95.7696
301	24	24003	2023	21	5	151	1	51	2001	2022	y	95.7696
301	24	24003	2023	31	5	151	1	51	2001	2022	y	95.7696
301	24	24003	2023	32	5	151	1	51	2001	2022	y	95.7696
302	24	24003	2023	21	5	151	1	51	2001	2022	y	95.7696
302	24	24003	2023	31	5	151	1	51	2001	2022	y	95.7696
302	24	24003	2023	32	5	151	1	51	2001	2022	y	95.7696
112	24	24003	2023	21	5	143	1	43	2001	2022	y	95.7696
112	24	24003	2023	31	5	143	1	43	2001	2022	y	95.7696
112	24	24003	2023	32	5	143	1	43	2001	2022	y	95.7696
101	24	24005	2023	21	1	111	1	11	1968	2000	y	95.7696
101	24	24005	2023	31	1	111	1	11	1968	2000	y	92.05374
101	24	24005	2023	32	1	111	1	11	1968	2000	y	72.0762
102	24	24005	2023	21	1	111	1	11	1968	2000	y	95.7696
102	24	24005	2023	31	1	111	1	11	1968	2000	y	92.05374

4. Performance Standard Modeling Results

The emissions rates from Maryland's VEIP need to be compared to the emissions rates from the EPA's enhanced performance benchmark standard to determine if the Maryland VEIP meets the enhanced performance standard. For an Enhanced I/M program, if the existing program obtains the same or lower emissions levels for NOx and VOC as the EPA's performance standard benchmark program to within 0.02 grams-per-mile (g/mile), then it is considered to have met the enhanced performance standard. The EPA's October 2022 PSM Guidance provides an example results table, provided here as Table 7, to demonstrate compliance.

Table 7. Summary of July Weekday Emission Rates (in grams per mile) for the Example Nonattainment Area

Scenario	NOX	VOC
Proposed/existing Program	0.4549	0.2132
Performance Standard Benchmark	0.4552	0.2153
Performance Standard Benchmark with 0.02 gpm Buffer	0.4752	0.2353

Tables 8-12 follow the example in Table 7 to show the results of the enhanced performance standard modeling for the Maryland jurisdictions required to operate an enhanced performance I/M program.

Table 8
Enhanced Performance Standard Modeling Results
2023 July Weekday Emissions Rates (gpm) for Baltimore Ozone Nonattainment Area

	Scenario 1 Current I/M Program		Scenario 2 EPA's Enhanced Performance Standard		Scenario 3 EPA's Performance Standard with Buffer		Overall Results Scenario 1 is less than Scenario 3	
Pollutant	NOx	VOC	NOx	VOC	NOx	VOC	NOx	VOC
Anne Arundel	0.326	0.198	0.325	0.192	0.345	0.212	Pass	Pass
Baltimore	0.328	0.178	0.327	0.173	0.347	0.193	Pass	Pass
Carroll	0.390	0.316	0.389	0.307	0.409	0.327	Pass	Pass
Harford	0.337	0.202	0.336	0.196	0.356	0.216	Pass	Pass
Howard	0.309	0.134	0.307	0.129	0.327	0.149	Pass	Pass
Baltimore City	0.339	0.174	0.339	0.169	0.359	0.189	Pass	Pass
Baltimore Area	0.329	0.184	0.328	0.178	0.348	0.198	Pass	Pass

Table 9
Enhanced Performance Standard Modeling Results
2023 July Weekday Emissions Rates (gpm) for Washington Ozone Nonattainment Area

County	Scenario 1 Current I/M Program		Scenario 2 EPA's Enhanced Performance Standard		Scenario 3 EPA's Performance Standard with Buffer		Overall Results Scenario 1 is less than Scenario 3	
Pollutant	NOx	VOC	NOx	VOC	NOx	VOC	NOx	VOC
Calvert	0.330	0.277	0.330	0.269	0.350	0.289	Pass	Pass
Charles	0.326	0.259	0.325	0.252	0.345	0.272	Pass	Pass
Frederick	0.344	0.186	0.343	0.181	0.363	0.201	Pass	Pass
Montgomery	0.300	0.194	0.299	0.188	0.319	0.208	Pass	Pass
Prince George's	0.319	0.175	0.318	0.170	0.338	0.190	Pass	Pass
Washington Area	0.317	0.191	0.316	0.186	0.336	0.206	Pass	Pass

Table 10
Enhanced Performance Standard Modeling Results
2023 July Weekday Emissions Rates (gpm) for Cecil County

County	Scenario 1 Current I/M Program		Scenario 2 EPA's Enhanced Performance Standard		Scenario 3 EPA's Performance Standard with Buffer		Overall Results Scenario 1 is less than Scenario 3	
Pollutant	NOx	VOC	NOx	VOC	NOx	VOC	NOx	VOC
Cecil	0.567	0.197	0.566	0.192	0.586	0.212	Pass	Pass

Table 11
Enhanced Performance Modeling Results
2023 July Weekday Emissions Rates (gpm) for Queen Anne's County

County	Scenario 1 Current I/M Program		Scenario 2 EPA's Enhanced Performance Standard		Scenario 3 EPA's Performance Standard with Buffer		Overall Results Scenario 1 is less than Scenario 3	
Pollutant	NOx	VOC	NOx	VOC	NOx	VOC	NOx	VOC
Queen Anne's	0.499	0.159	0.498	0.155	0.518	0.175	Pass	Pass

Table 12
Enhanced Performance Modeling Results
2023 July Weekday Emissions Rates (gpm) for Washington County

County	Scenario 1 Current I/M Program		Scenario 2 EPA's Enhanced Performance Standard		Scenario 3 EPA's Performance Standard with Buffer		Overall Results Scenario 1 is less than Scenario 3	
Pollutant	NOx	VOC	NOx	VOC	NOx	VOC	NOx	VOC
Washington	0.642	0.207	0.642	0.203	0.662	0.223	Pass	Pass

5. Conclusion

The enhanced performance modeling results in Tables 8 through 12 demonstrate that the gram per mile emissions from Maryland's current I/M program, both at the ozone nonattainment area wide level as well as at the individual jurisdiction level, are below the EPA's Enhanced performance standard benchmark.