Envirotest Systems Holding Corp.
2002 N. Forbes Blvd.
Tucson, AZ 85745

The Maryland Enhanced I/M Program
2015 On-road Remote Sensing Survey

March 2016

Prepared for:

Maryland Department of the Environment

Prepared by:

Peter M McClintock, Ph.D.
Applied Analysis
13700 Marina Pointe Drive, #301
Marina Del Rey, CA 90292
310-424-1340

Acknowledgements

The author wishes to acknowledge the support and input given by a number of individuals and organizations. Particular thanks are extended to the following contributors:

Peggy Courtright, Kathleen Field and Ayanna Miranda of MDE for providing many helpful comments and suggestions.

Envirotest Program Operations and the Envirotest Remote Sensing Business Unit for providing data access and operational information.

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I. Summary

The Maryland Department of the Environment (MDE) and Motor Vehicle Administration (MVA) are required by the Clean Air Act Amendments of 1990, to supplement Maryland's enhanced Inspection and Maintenance (I/M) program, known as the Vehicle Emissions Inspection Program (VEIP), with an on-road element. The on-road survey will be conducted every two years collecting measurements on 1% of the vehicles. The purpose of the survey is to determine the condition of the VEIP fleet and to evaluate the effectiveness of remote sensing devices in identifying gross polluters.

There were 4.2M registered vehicles in the I/M area and the scope of work required collection of 41,690 valid records (1% of I/M area) from VEIP county-registered vehicles and 10,000 valid records matched from non-VEIP counties. The non-VEIP county records were to be equally divided between the four non-VEIP counties.

Staff from Envirotest, the I/M contractor, conducted the 2015 survey on 30 days between May 12th and July 9th. Emission measurements were collected from on-road vehicles at 24 sites in 18 jurisdictions (17 counties and Baltimore City). Measurements were made using two RSD-4600 units capable of measuring hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO_x). The remote sensing units also measure vehicle speed and acceleration to permit determination of the vehicle operating condition and capture an image of the vehicle plate for identification.

Fleet Emissions

The average emissions of the vehicles measured on-road in Maryland and registered in I/M counties were 0.11% CO, 11 ppm HC hexane and 94 ppm NO_x. Results are sensitive to engine power output, which can vary from site-to-site, and the remote sensing equipment used. The RSD-4000 series of remote sensing equipment has been used since 2003.

The average HC, CO and NO_x emissions by model year for trucks and light passenger vehicles are shown in Figures I-1, I-2 and I-3. The trucks measured are virtually all 10,000 lbs GVWR or less. There were 92 trucks above 10,000 lbs GVWR with emissions measurements[i]

The charts show that newer model year vehicles have substantially lower emissions than older vehicles.

Impact of I/M Testing on Emissions

I/M area vehicles were divided into three groups based on their last identified I/M test result: fail or waiver, unmatched and pass. The dirtiest vehicles on-road were those that failed their most recent test or have obtained a waiver. The results for passenger vehicles and light trucks are provided in Section V.

[i] Heavy-duty trucks are not measured by RSD without a special set-up to measure elevated exhaust from vertical stacks.

Figure I-1 On-Road Light Passenger Vehicle and Truck HC

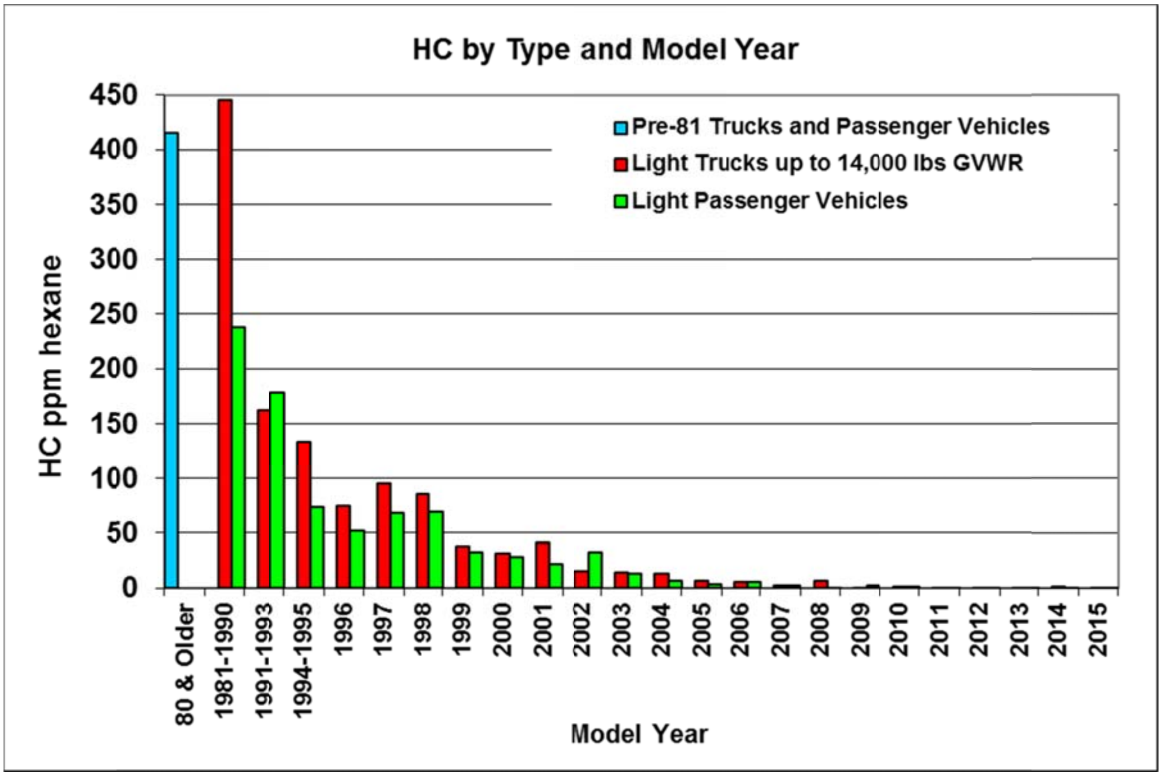


Figure I-2 On-Road Light Passenger Vehicle and Truck CO

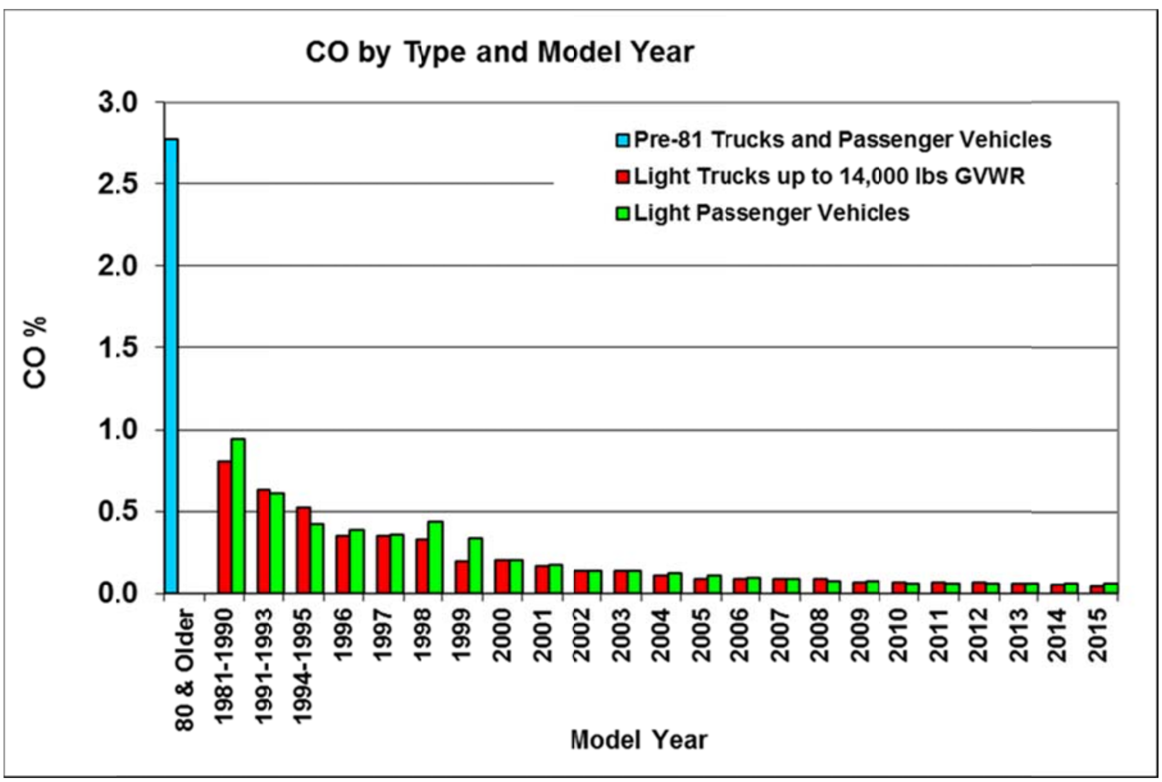
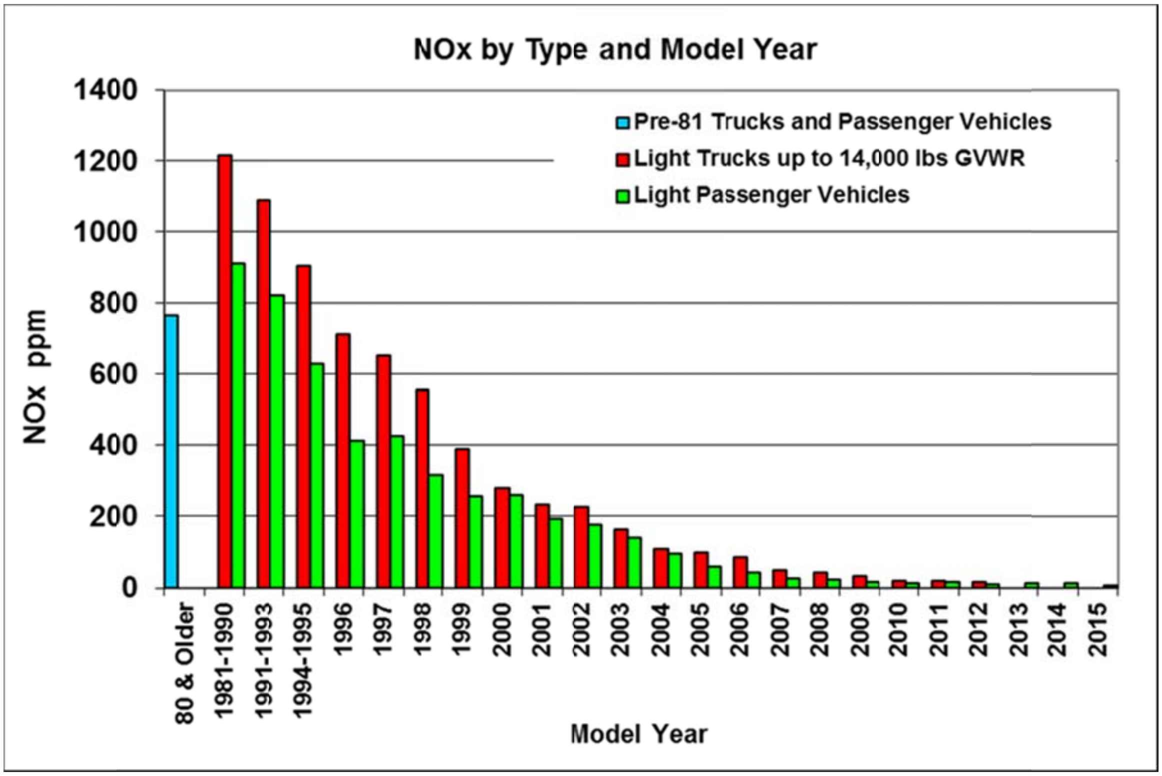


Figure I-3 On-Road Light Passenger Vehicle and Truck NO_x



High Emitters

In order to be considered a high emitter in Maryland, a vehicle must have two or more readings that exceed the standards for the same pollutant on different days. If the standard is exceeded by less than the tolerance of the RSD unit, a third measurement is required for confirmation. Vehicles with out-of-State registrations were not considered in the high emitter analysis because their type and model year was unknown.

One thousand four hundred and eighty-three vehicles had 2 or more measurements. Of those, twenty-two (1.5%) had 2 or more valid readings for a pollutant that exceeded the high emitter cutpoints on both readings. Fourteen (14) of the nineteen met the criteria for high emitters with 2 readings that exceeded cutpoints by more than the analyzer tolerance and eight (8) met the criteria for high emitters with 2 readings that exceeded cutpoints by less than the analyzer tolerance. One of the seven that exceeded cutpoints by less than the analyzer tolerance had a third measurement that did not confirm high HC.

Details of high emitters and their identification are provided in section VI.

II. Description of the RSD Project

A. General

1. Project Requirements

The Maryland Department of the Environment (MDE) and Motor Vehicle Administration (MVA) are required by the Clean Air Act Amendments of 1990, to supplement Maryland's enhanced Inspection and Maintenance (I/M) program, known as the Vehicle Emissions Inspection Program (VEIP), with an on-road element to the program. The Clean Air Act Amendments require that a minimum of 0.5% of the eligible motor vehicle population in the enhanced program area be tested. The remote sensing surveys in Maryland are to be conducted every two years and are designed to collect at least a 1% sample on each occasion.

The Code of Federal Regulations *40 CFR, Part 51, Subpart S,* Section 51.371 covering Enhanced I/M programs defines on-road testing as testing of vehicles for conditions impacting emission of HC, CO, NO_x and/or CO_2 emissions on any road or roadside in the non-attainment area or the I/M program area. On road testing is required in enhanced I/M areas.

2. Contractor

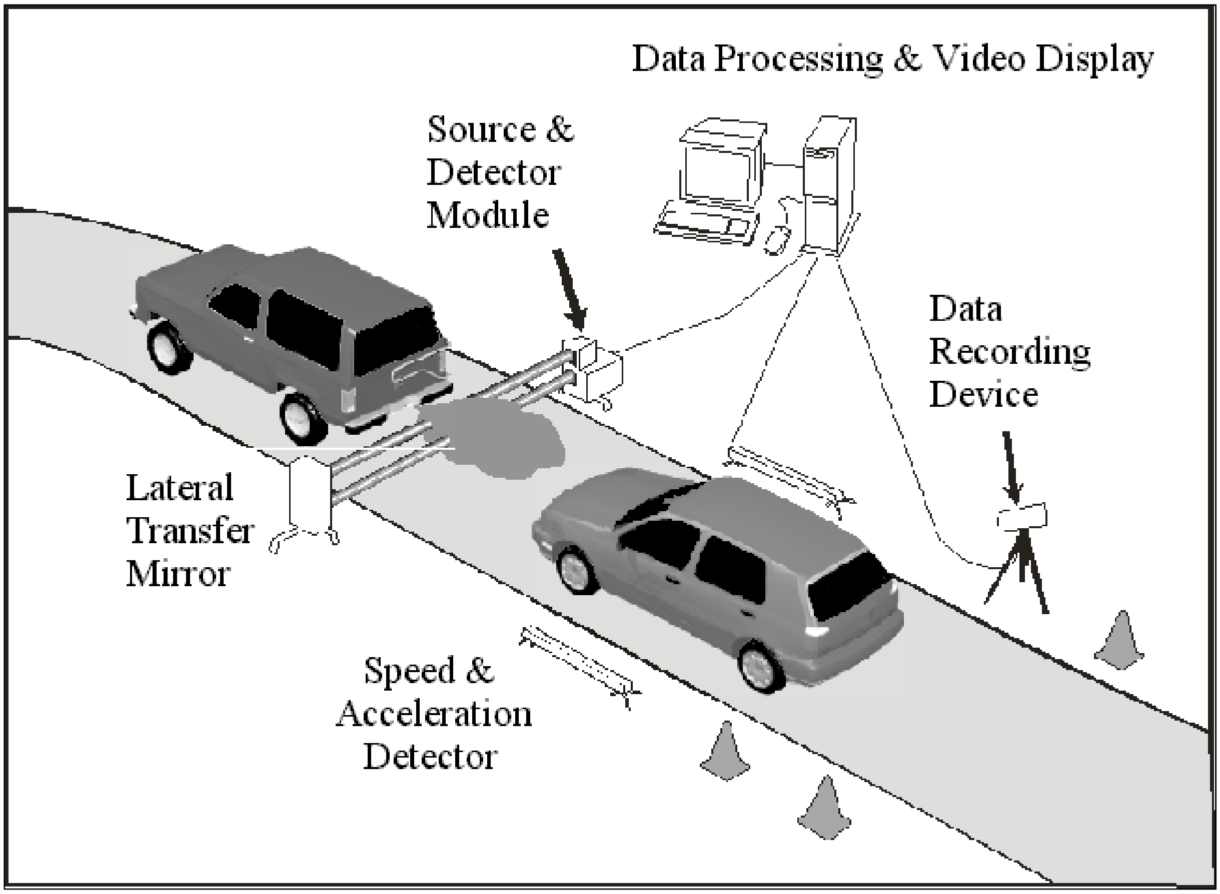
The Remote Sensing division of Envirotest has been responsible for this work. Envirotest has been developing and operating remote sensing equipment for over twenty years. Envirotest uses technology derived from that originally developed at the University of Denver with whom Envirotest has a royalty agreement. Envirotest is also the operator of the centralized inspection program in Maryland.

3. Description of RSD

a) Theory of operation

The remote sensing device (RSD) is a system designed for a non-intrusive measurement of vehicle emissions. It generates and monitors a non-dispersive infrared and ultra-violet beam emitted and reflected approximately 10 to 18 inches above ground preferably across a single lane road. Gasoline, diesel, or other fossil fuel powered vehicles drive through this beam and the exhaust interferes with this transmission of the beam. Quantifying the interference enables the calculation of tailpipe concentrations of carbon monoxide (CO), hydrocarbons (HC), carbon dioxide (CO_2), and nitrogen oxides (NO_x). A camera simultaneously captures a digitized video image of the rear of the vehicle and its license plate. The general arrangement is illustrated in Figure II-1.

Figure II-1 On-road Remote Sensing Setup



b) Equipment

The particular equipment deployed in Maryland in the 2015 study was the RSD-4600 mobile unit also called AccuScan™. The RSD-4600 is the successor to the RSD-3000 (used in the 2001 RSD study) that was based on a technical platform developed at the University of Denver by Dr. Donald Stedman. The RSD-4600 is an improved version of the RSD-3000 with more stable and more sensitive electronic components.

Each mobile unit includes the equipment required to provide measurement of emissions as well as speed and acceleration readings and license plate recognition. Five main components comprise the RSD-4600 system:

- Infrared (IR) and ultraviolet (UV) source detector module (SDM);
- Video system;
- Control console with computer system;
- Laser based speed and acceleration measurement system;
- Specialized license plate image transcription software.

The system captures emissions readings and a camera simultaneously captures a digitized video image of the rear of the vehicle and its license plate. The video and emissions readings taken are stored directly on a removable media disk and can be used for future reference.

c) Emissions Measurements

The primary combustion gases HC, CO, NO_x and CO_2 are measured simultaneously along the same optic path to ensure the proper application of the combustion gas equations. To avoid interference between vehicles, the RSD unit is capable of completing the vehicle emission measurement within 0.5 second and of completing all measurements for a vehicle including emissions, speed, acceleration and plate image within one second.

The RSD unit takes multiple rapid readings of the exhaust plume for each vehicle to evaluate whether a valid measurement of a vehicle's exhaust has been achieved. At least 5 measurements of the plume with CO_2 elevated above ambient by a minimum threshold are required. Up to 48 measurements may be made depending on the exhaust volume, vehicle speed, wind and other factors. The measured values are corrected to account for background concentrations of emissions.

The RSD-4600 continually measures the ambient background. As a vehicle drives by the system, the vehicle blocks the IR/UV beam. When this beam block occurs, the computer stores the current ambient background.

When the exhaust plume is observed by RSD it is already mixing with the surrounding air so that absolute concentrations of exhaust pollutant cannot be measured directly. Rather, it is the ratios of HC/CO_2, CO/CO_2 and NO_x/CO_2 combined with combustion equations that are used to calculate the pollutant concentrations.

RSD units are factory certified to meet accurate measurement of dry calibration gas. Although ambient humidity has an effect on the NO_x emissions performance of vehicles, gaseous H_2O present in the atmosphere and created as a combustion product has no effect on the RSD measurement of emissions.

After every 4,000 operating hours the units are returned to the factory for preventive maintenance and re-certification. A specially modified vehicle dispenses calibration gas blends of CO_2, HC, CO and NO_x past the RSD unit under controlled conditions. Four separate multi-gas blends are used with ten passes per blend. A typical set of certification gases is shown in Table II-1.

Table II-1 Typical Set of Certification Gas Blends

Blend	CO %	CO_2 %	HC ppm propane	NO ppm
1	0.50	15.00	500	3,000
2	1.00	14.50	3,000	2,000
3	2.75	13.00	2,000	500
4	5.00	11.50	6,000	250

The RSD tolerance for each pollutant is:

- Carbon monoxide (CO): ±0.25% CO or ±10% of the expected CO concentration {whichever is greater} for all expected concentrations less than or equal to 3.0%, and ±15% for all CO expected concentrations above 3.0% CO.

- Hydrocarbon (HC): ±150 parts-per-million (ppm) or ±15% of the expected HC concentration {whichever is greater} throughout the range of HC concentrations. In this report Hydrocarbon measurements are reported in their hexane equivalent measurement.

- Oxides of nitrogen (NO): ±250 parts-per-million (ppm) or ±15% of the expected NO concentration {whichever is greater} throughout the range of NO concentrations.

d) NO vs. NO_x

The vast majority of nitric oxides emitted from the vehicle tailpipe are in the form of NO. The NO is later oxidized to NO_2 and other oxides of nitrogen, which are collectively referred to as NO_x. The RSD unit measures NO. To convert from NO to NO_x, a factor of 1.03 is applied. For simplicity we refer to NO_x measurements when reporting results. Charts in sections IV, V and VI report NO_x values.

e) NO_x and Humidity

Higher humidity reduces vehicle NO_x emissions. When vehicles were inspected (Prior to August 2009) in the I/M program, humidity correction factors were applied to adjust NO_x measurements to values that would have been achieved when the water vapor content was 75 grains per lb. For temperatures above 75 F:

Correction factor = e^(.004977*(H-75) - .004447*(T-75))

For temperatures below 75F:

Correction factor = 1/(1.0 - .0047*(H - 75.0))

Where:
H = absolute humidity in grains of water/lb dry air
T = Temperature (F)

Both of these are capped at 2.19.

The on-road NO_x emissions reported in sections IV, V and VI report the NO_x emissions adjusted for humidity.

Correction factors were calculated using weather information recorded by the weather station attached to the RSD van. Water vapor grains per lb were determined using the temperature, relative humidity and barometric pressure:

Saturated Vapor Pressure = (-4.14438 x 10^{-3} + 5.76645 x 10^{-3} x [Temp F] - 6.32788 x 10^{-5} x [Temp F]^2 + 2.12294 x 10^{-6} x [Temp F]^3 - 7.85415 x 10^{-9} x [Temp F]^4 + 6.55263*10^{-11} x [Temp F]^5)*25.4

Grains per lb = (43.478 x [Relative Humidity] x [Saturated Vapor Pressure]) / (([Barometric pressure Hg mm])-([Saturated Vapor Pressure]*[Relative Humidity]/100))

4. On-road Puff Calibrations and Puff Audits

Units are equipped with an internal calibration gas cell, which has a specific set of concentrations. As part of standard procedure, the operator must first set up the retro reflector on the far side of the road and conduct a mirror alignment check. The RSD unit sends infrared and ultraviolet beams across the roadway. These beams are reflected by the mirror and detected by the RSD unit. The RSD detectors create a voltage in response to particular infrared and ultraviolet frequencies. The presence of proper voltages across all detectors verifies that the RSD unit and the mirror are properly aligned. Second, the unit is calibrated to the calibration cell values.

The next step is to verify the unit calibration. This is referred to as a puff audit. Calibration gas is introduced into the IR/UV path. This is accomplished through a calibration gas cylinder, a stainless steel gas regulator, fittings and tubing to deliver the calibration gas to the source detector module (SDM). The operator will then introduce the calibration gas into the IR/UV path via a spray nozzle at the end of the tube. The instrument displays the readings on the screen. The RSD unit response is automatically compared to the calibration gas and required to be within specification limits.

Operators are instructed to audit approximately every hour and must audit within two hours or the records will be flagged with a CVA session status of "L" meaning lock out. The records marked with an "L" are not considered valid. Three puffs within specification are required. It may be repeated for verification at operator discretion and depending on traffic conditions. If the audits indicate the unit is operating outside the accuracy specification, then the operator is to recalibrate and re-audit.

5. Speed and Acceleration Measurements

The mobile unit is equipped with a speed and acceleration measurement system that uses extremely accurate low energy lasers to calculate the speed of the vehicle to within +/- 1 mile per hour and acceleration to within +/- 0.5 miles per hour per second at the moment exhaust is measured. The speed and acceleration measurement systems are tested at the time of system certification for functionality, do not contain any moving parts and do not require calibration.

6. Data Collected

For each vehicle the following information is collected:

- Plate number;
- HC, CO, CO_2, and NO emission concentrations;
- Maximum CO_2;
- Speed and acceleration;
- Temperature, barometric pressure, and humidity.

B. Overview of 1.0% Sample

1. Sample Design Criteria

The objective is to obtain the 1.0% sample from sites that will be generally representative of vehicles operating in the I/M program area.

As shown in Table II-2: 'RSD Sites', a total of 24 sites were used to collect RSD data in the state. The intent is to collect tests on a random sample that is representative of all the on-road vehicle traffic. Measurements are distributed both geographically and temporally with no one area or period of the day receiving an undue amount of testing.

2. Description of Sample Site Characteristics

Site selection is critical to obtaining RSD measurements that are representative of vehicle operation. Recommended site attributes include:

- Absence of cold start vehicle operating conditions that would cause atypically high emissions
- Sites where vehicles will generally be accelerating or driving at a steady speed uphill to avoid the highly variable tailpipe emissions that can occur under deceleration. Road grade is considered in order to preclude deceleration and assure light load on the engine.
- Absence of high engine loads that could result in atypically high emissions
- Single lane operation to unambiguously isolate individual vehicles
- High volume traffic for productivity
- Unobtrusive positioning of the remote sensing equipment to avoid motorists braking suddenly
- Multi-year stability in the traffic mix to facilitate evaluation of year-to-year trends
- Adequate median space for safe operation of the RSD equipment.

To improve the chances of multi-year stability in the traffic mix, Envirotest tries to avoid sites that are excessively influenced by temporary operations such as a large development under construction. These can change the traffic and may result in the conversion of the one-lane remote sensing site to a multiple-lane highway that is unsuitable for remote sensing.

The road grade at each site is measured during the equipment set-up. The measured grade may vary slightly at each site depending on the precise positioning of the RSD equipment along the roadside

The percentages of beam blocks resulting in valid measurements within the desired VSP range are reported in the rightmost column of Table II-2. Measurements made at site AL13 were eliminated due to wet weather. Other sites had acceptable valid rates of 39% and higher.

Table II-2 RSD Sites

Site Code	Location	City	County	Degrees of Grade	Valid RSD in Desired VSP Range	% of Beam Blocks Valid
AA13	Rte 450 West St. and Jennifer Rd SB to Hwy 301 W	Annapolis	Anne Arundel	1.00	1,274	54%
AA14	Rte. 2 Richie Hwy NB to I-895 North / I-695 West / I-97 South	Glen Burnie	Anne Arundel	2.50	5,336	77%
AL12	From Salem St/Center St to I-68 West	Cumberland	Allegany	3.50	4,022	79%
AL13	S Mechanic St / Howard St to I-68 East	Cumberland	Allegany	3.50	-	0%
BA03	Rte. 25 (Falls Rd) North, just pass Tufton Ave / Shawan Rd	Essex	Baltimore County	0.50	1,776	67%
BA05	Rte. 295 N to I-895 North	Halethorpe	Baltimore County	1.97	10,599	48%
BA20	Eastern Ave. WB to I-95 SB	Baltimore	Baltimore City	1.90	777	68%
BA25	US 40 (Pulaski Hwy) West to I-95 South	Baltimore	Baltimore City	1.96	3,424	77%
CE04	Rte 222 South towards I-95	Port Deposit	Cecil	1.00	1,826	62%
CH11	Post Office Rd SB just past Industrial Park Dr	Waldorf	Charles	1.10	1,179	37%
CL13	Southern Connector Blvd East, past Mill Creek Middle School	Lusby	Calvert	3.20	1,120	79%
CR01	Railroad Ave. NB Just South of Tuc Rd	Westminster	Carroll	4.60	2,544	85%
FR14	W Patrick St to US 15 Catoctin Mtn Hwy NB	Frederick	Frederick	1.02	4,733	77%
HA13	Rte. 543 Riverside Rd NB past Brass Mill Rd	Belcamp	Harford	1.90	3,556	70%
HO13	From Rte. 175 EB to I-95 North	Jessup	Howard	0.80	3,478	39%
KE11	Augustine Herman Hwy SB btwn entrances to Washington Sq. Shopping Cntr.	Chestertown	Kent	0.40	3,416	73%
MO10	Rte. 198 Spencerville Rd. East before Burtonville Dr.	Burtonville	Montgomery	0.50	2,594	40%
MO11	Rte. 185 Connecticut Ave. NB to I-495 East	Chevy Chase	Montgomery	4.26	7,943	72%
PG10	Rte 197 Collington Rd. North, past Lyle Ln.	Bowie	Prince George's	0.90	3,874	45%
PG11	Rte. 197 Laurel Bowie Rd North, past American Holly Dr / Powder Mill Rd	Laurel	Prince George's	3.08	4,351	52%
QA05	Rte. 213 S Commerce St. NB, past Little Kidwell Ave	Centreville		3.50	1,088	90%
SM13	Rte. 5 NB just past Rte. 246	Great Mills	St. Mary's	0.40	4,001	57%
TA01	Rte. 322 Easton Pkwy NB past Marlboro Ave	Easton	Talbot	0.30	3,768	53%
WA12	US 11 NB, past Massey Blvd	Hagerstown	Washington	3.00	2,598	84%
					79,277	59%

Appendix A shows the location and layout of each of the RSD sites.

3. Weather Considerations

Rain, dense fog, and wet pavement resulting in spray from tires all prevent effective operation of the remote sensing unit since the beam is partially blocked under these conditions. Similarly, cold humid conditions that cause condensation of exhaust plumes are also not productive.

As mentioned earlier, humidity corrections are made to NO_x emissions measurements to account for ambient weather conditions. No corrections are required for HC or CO.

As noted earlier, some data were excluded because of suspected cold starts. These are described in section 3.B.

C. Sources of Data and Description of Elements

Data used in the analyses in this report come from three primary sources; the RSD unit measurements, the registration records maintained by the Motor Vehicle Administration, and the I/M test database maintained on the contractor host computer system.

The following description gives a summary of the main tables and data used in the analyses.

1. RSD Measurements

For each measurement record the following information is collected:

RSD unit
Date and time
License plate image
HC, CO, CO_2, and NO measurement
Speed and acceleration
Temperature, barometric pressure, and humidity
Measurement quality indicators: V-valid, X-invalid, E-invalid system exception, O-invalid other, N-NO out of range, S-suspect
Ambients[ii]

2. Data Collection Statistics

Unit
Site
Date
Start time
End time

3. RSD Sites

Site reference
Description of location
Slope of site in degrees

4. Vehicle Registration Data

The license plates of vehicles measured by RSD were matched by plate to registration records maintained by the Motor Vehicle Administration to determine the vehicle identification number (VIN) and additional vehicle information:

Vehicle identification number (VIN)
Vehicle license plate
Model year
Make
Body style
Gross Vehicle Weight Rating (GVWR)
City
County
Zip code

The registration vehicle body styles and GVWR values were used to classify vehicles into passenger vehicles, trucks up to 10,000 lbs GVWR and trucks over 10,000 lbs GVWR. This

[ii] Ambient background levels of HC, CO, CO2 and NO emissions are measured continuously and are deducted from the emissions levels measured in exhaust plumes of passing vehicles.

classification scheme is consistent with Maryland's in-use testing standards. For comparison purposes it is useful to classify vehicles using the same scheme to report on-road emissions. The Enhanced I/M test standard truck classes are:

- LDGT1: 0-6,000 lbs GVWR;
- LDGT2: 6,001-8,500 lbs GVWR;
- HDGT1: 8,501-10,000 lbs GVWR;
- HDGT2: 10,001-14,000 lbs GVWR;
- HDGT3: 14,001-26,000 lbs GWVR.

Since 99.6% of all trucks were 10,000 lbs GVWR or less, trucks are treated as a single class in most sections of this report. There were 68 measurements of trucks between 10,000-14,000 lbs GVWR and 24 measurements of trucks greater than 14,000 lbs.

5. I/M Data

I/M test dates, times and test results were extracted from the VEIP database for VINs matching vehicles measured by RSD. The data were used to identify RSD measured vehicles that had been inspected and their most recent VEIP status prior to the RSD measurement.

D. Data Limitations

1. Remote Sensing Unit Accuracy

As described in Section II.A.4, each remote sensing device is audited periodically each day by dispensing known HC, CO, CO_2 and NO blends into the optical path and comparing the measured values to the known values. If the results are outside the RSD audit tolerances, the unit is re-calibrated and another series of audit measurements are run. Passing traffic can influence individual audit measurements, in which case additional audits may be performed.

The RSD software now includes a computer verified audit (CVA) flag on each record that indicates the RSD unit had successfully completed an audit within the specified audit times. Audit time used for the study was 1-hour; however, the operator has an additional hour of grace time to perform an acceptable audit. Therefore, audit flags of "G" status insure that a successful audit has been performed within the prior two hours. Other values of the CVA flag are 'L' meaning lock out, 'S' meaning start and 'X' meaning the system is not ready to collect data. The 'S' status is used on the last successful audit record that preceded normal data collection.

2. Limitations Due to Registration Process and Data Processing

Using RSD, vehicles are first identified using the vehicle plate, which is then matched to vehicle registration data to determine the vehicle information. In a situation where upon purchase of a new vehicle, an owner may transfer the same plate from the old vehicle to the new vehicle, a data processing delay can result in incorrect identification of the vehicle measured by RSD. This delay is the time between the RSD measurement and the matching of the measurement to the registration data.

III. Summary of Data Collection

A. RSD Sample Quantity

The number of subject vehicles registered in the Enhanced I/M area was estimated to be 4.2M and the scope of work required collection of 41,690 valid records (1% of I/M area) from VEIP county-registered vehicles and 10,000 valid records matched from non-VEIP counties. The non-VEIP county records were to be equally divided between the four non-VEIP counties.

Table III-1 summarizes the number of measurements made. In total, 133,493 measurements were taken. Out of the total measurements, 80,710 (60%) were reported valid records in the desired operating mode (range). A total of 2 measurements were excluded for CO values less than -0.25% and 6 measurements were excluded for NO_x values of less than -250 ppm. A further 1,425 records were excluded as being possibly contaminated, cold start or having water plumes. The result was 79,277 (59%) valid records in the desired VSP range. Further screening of the valid records excluded 7,856 records without readable plate images. The net result was 71,421 (54% of total measurements) valid records with readable plates.

The valid records with readable plates were then screened for MD plates only. The result was 58,095 valid MD records. These records were then matched to the MVA registration database. The matching resulted in 55,618 records, or a match of 97% of all valid MD records. Of these, 44,901 were collected in the Enhanced I/M area and the 1% survey goal was therefore satisfied.

Table III-1 Collection Summary

Item	Quantity	%
Beam blocks	133,493	
RSD valid HC, CO, NOx, Speed & Acceleration		
and in desired operating mode (VSP)	80,710	60%
Additional screening:		
CO values less than -0.25 %	2	0.0%
NOx values less than -250 ppm	6	0.0%
Possible cold start	1,425	1.1%
Valid and in desired VSP range after screening	79,277	59%
Valid with readable plate	71,421	54%
Of which:		
Out of State License Plate	13,326	19%
Maryland License Plate	58,095	81%
Of which:		
Matched to MVA Registration	56,618	97%

Table III-2 shows the measurements collected by county with valid HC, CO, NO, speed, acceleration and a plate. The statistics include multiple results for vehicles measured more than once.

Table III-3 shows for each county:

- The number of vehicles registered in the county;
- The number of valid on-road measurements collected in the county;
- On-road measurements collected in the county as a percentage of registrations;
- The number of on-road measurements collected at any site matching vehicles registered in the county;
- The number of on-road measurements collected at any site matching vehicles registered in the county as a percentage of registrations;
- The collection site;
- The number of on-road measurements collected at the site matching vehicles registered in the state.

The 1% collection goal was achieved for the I/M area. The number of registrations matched in I/M counties was 1.1% of registrations.

Table III-2 RSD Measurements Collected by County

RSD County	Beam Blocks	Valid: Gases, Speed & Accel & in VSP Range	Valid w Readable MD Plate	Valid w Out Of State Plate	Total Complete Records	%	Valid w MD Plate Matched to Registration	Plate Match %
Allegany	5,408	4,022	2,677	1,030	3,707	69%	2614	98%
Anne Arundel	9,288	6,610	5,300	609	5,909	64%	5084	96%
Baltimore City	5,584	4,201	3,079	276	3,355	60%	3005	98%
Baltimore County	24,932	12,375	6,674	4,852	11,526	46%	6503	97%
Calvert	1,413	1,120	965	74	1,039	74%	948	98%
Carroll	3,004	2,544	1,991	383	2,374	79%	1949	98%
Cecil	2,968	1,826	1,301	392	1,693	57%	1267	97%
Charles	3,214	1,179	984	93	1,077	34%	943	96%
Frederick	6,133	4,733	3,695	523	4,218	69%	3630	98%
Harford	5,054	3,556	2,723	435	3,158	62%	2660	98%
Howard	8,875	3,478	2,857	363	3,220	36%	2807	98%
Kent	4,655	3,416	2,823	284	3,107	67%	2762	98%
Montgomery	17,520	10,537	7,493	2,130	9,623	55%	7325	98%
Prince George's	16,930	8,225	6,942	644	7,586	45%	6761	97%
Queen Anne's	1,208	1,088	895	46	941	78%	873	98%
St. Mary's	7,060	4,001	2,907	258	3,165	45%	2799	96%
Talbot	7,169	3,768	2,927	386	3,313	46%	2858	98%
Washington	3,078	2,598	1,862	548	2,410	78%	1830	98%
Total	133,493	79,277	58,095	13,326	71,421	54%	56,618	97%

Table III-3 On-road Measurements by County as % of Registrations

County	2014 Registered Vehicles	Valid On-Road Measurements Collected	Collected / Registered	Matches to a Registration in This County (Collected Anywhere)	Matched / Registered	Site	Valid Matched to Maryland Registration
Subject to I/M:							
Anne Arundel	509,844	5,909	1.2%	5,440	1.1%	AA13	962
						AA14	4,122
Baltimore City	305,403	3,355	1.1%	4,816	1.6%	BA20	548
						BA25	2,457
Baltimore County	653,367	11,526	1.8%	4,988	0.8%	BA03	1,357
						BA05	5,146
Calvert	83,230	1,039	1.2%	1,116	1.3%	CL13	948
Carroll	157,594	2,374	1.5%	2,471	1.6%	CR01	1,949
Cecil	82,782	1,693	2.0%	1,333	1.6%	CE04	1,267
Charles	131,994	1,077	0.8%	1,003	0.8%	CH11	943
Frederick	211,162	4,218	2.0%	3,212	1.5%	FR14	3,630
Harford	218,786	3,158	1.4%	3,401	1.6%	HA13	2,660
Howard	251,783	3,220	1.3%	2,321	0.9%	HO13	2,807
Montgomery	750,567	9,623	1.3%	4,861	0.6%	MO10	2,172
						MO11	5,153
Prince George's	644,610	7,586	1.2%	7,634	1.2%	PG10	3,185
						PG11	3,576
Queen Anne's	45,447	941	2.1%	1,352	3.0%	QA05	873
Washington	122,405	2,410	2.0%	2,149	1.8%	WA12	1,830
Subtotal I/M Area	4,168,974	58,129	1.4%	46,097	1.1%		45,585
Non-I/M:							
Allegany	55,593	3,707	6.7%	2,427	4.4%	AL12	2,614
Kent	17,846	3,107	17.4%	2,071	11.6%	KE11	2,762
St. Mary's	95,710	3,165	3.3%	2,744	2.9%	SM13	2,799
Talbot	35,973	3,313	9.2%	1,884	5.2%	TA01	2,858
Other	230,520	n/a	n/a	1,395	0.6%	n/a	n/a
Total	4,604,616	71,421	1.6%	56,618	1.2%		56,618

B. RSD Sample Description

1. Measurements and Conditions by Site and Time of Day

Table III-4 'Measurements by Site and Time of Day' shows for each day, unit and site the hourly measurements. The column header shows the hour in which the measurements were made. The hourly counts are for measurements reported by the remote sensing unit having valid emissions, speed, acceleration and a visible plate. Most measurements were made between 6:00 a.m. and 5:00 p.m.

On several days the survey session was shorter than normal:

5/18/2015 rain stopped testing at 12:41p.m.
5/20/2015 on completion of collection for Queen Anne's County at QA05 the equipment was moved to Baltimore County site BA25.
5/21/2014 rain stopped testing at 9:26 a.m.
5/22/2015 collection ended on completion of the requirement for the jurisdiction.
6/2/2015 there was intermittent rain during the session.
6/4/2015 rain stopped testing at 6:25 a.m.
6/5/2015 testing did not start until mid-day due to a generator failure
6/11/2015 unit 4620 failed during testing and was replaced with 4615
6/26/2015 on completion of collection for Prince George's County at PG11 the equipment was moved to Baltimore County site BA05.
6/30/2015 collection ended on completion of the requirement for the jurisdiction.
7/8/2015 collection ended on completion of the requirement for the jurisdiction.

Tables III-5 to III-9 show the average hourly speed, acceleration, CO, HC and NO measured each day by each unit. Table III-8 highlights high average HC emissions in the early morning of 5/13.

Table III-10 shows the percentage of 2010 and newer models with HC greater than 150 ppm HC hexane[iii]. Few new model vehicles are expected to have high emissions once they have warmed up. If more than 5% of these newer vehicles have high emissions, which occurred on a number of occasions, it is possible there were an excessive number of cold starts or cold temperature effects. Table III-10 shows more than 5% of 2010 models having emissions greater then 150pm HC on the afternoon of 5/12, on 6/2 and the morning of 7/1.

Table III-11 shows the average temperature measured at the RSD van varying between 15 degrees Celsius and 42 degrees Celsius.

The results from Tables III-8, III-10 flagged a number of hours with suspiciously high HC values. The exhaust plume data from periods with exceptional HC were reviewed with the following results:

5/12/2015 site CH11 from about 12:30 p.m. onward the site appears to have been contaminated. Measurements recorded erratic and sometimes high ambient HC. Data from noon through the rest of the session was flagged as invalid.

5/13/2015 site SM13 from 7:00 a.m. to 8:00 a.m. several high HC emitters were recorded and the exhaust plumes looked normal.

6/2/2015 site AL13 was a short session with few valid measurements. Two plumes were identified as having water signatures. All data collected on 6/2 was flagged as invalid.

7/1/2015 site HA13 water signatures were detected in plumes before 7:00 a.m. Records before 7:00 a.m. were flagged as invalid.

Based on these findings, 1,425 measurements were invalidated.

[iii] The percentages of 2010 and newer models with HC greater than 150 ppm HC hexane are shown in Table III-10 only for hours in which more than ten RSD records were available for these models.

Table III-4 Measurements with Plate by Site and Time of Day

Hourly Valid Measurements with Plates (before screening for abnormal results)															
Date	**Van**	**Site**	**06 & earlier**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**later**
5/12/2015	__06064615	CH11	57	103	192	209	239	277	271	251	291	181			
5/13/2015	__06064615	SM13	185	225	229	214	210	187	275	265	324	473	578		
5/14/2015	__06064615	AA14	342	417	396	355	329	402	483	494	443	488	543	109	
5/15/2015	__06064615	PG11	220	495	390	248	227	249	211	229	334	375	112		
5/18/2015	__06064615	BA25	431	365	309	165	171	158	124						
5/19/2015	__06064615	BA05	210	242	249	232	290	283	289	332	442	352	316	282	2
5/20/2015	__06064615	BA25						15	163	176	124	232	195	142	
5/20/2015	__06064615	QA05	190	353	343	55									
5/21/2015	__07064620	MO11	339	554	635	33									
5/22/2015	__07064620	BA20	323	178	84										
5/26/2015	__07064620	CE04	723	586	374	10									
5/27/2015	__07064620	MO10	249	289	360	236	215	176	207	230	248	137			
5/28/2015	__07064620	BA03	43	60	61	53	47	78	84	93	152	228	288	302	139
5/29/2015	__07064620	PG10	199	420	376	321	284	352	396	466	366	388	14		
6/1/2015	__06064615	AL12		59	304	309	289	291	347	267	449	497	478	415	2
6/2/2015	__07064620	AL13				4	65	29	1						
6/3/2015	__07064620	WA12	170	242	289	242	305	322	356	345	139				
6/4/2015	__07064620	FR14	178												
6/5/2015	__06064615	CR01							275	316	358	434	554	433	4
6/8/2015	__07064620	KE11	135	284	331	220	269	275	348	349	343	347	206		
6/11/2015	__06064615	TA01									104	318	304	255	85
6/11/2015	__07064620	TA01	115	137	172	172	186	182	176	23	8				
6/25/2015	__07064620	MO11	250	422	527	418	498	481	445	649	1,016	1,009			
6/26/2015	__06064615	BA05						215	363	414	295	229	237	227	1,005
6/26/2015	__07064620	PG11	236	313	304	61									
6/29/2015	__07064620	HO13	146	213	226	177	192	186	236	276	282	212	516	558	
6/30/2015	__07064620	AA13	232	235	273	254	114								
7/1/2015	__07064620	HA13	227	221	241	213	199	310	391	279	212	485	607		
7/2/2015	__07064620	CL13	22	44	59	11	29	93	122	135	166	163	195		
7/7/2015	__07064620	FR14	370	444	426	385	392	420	451	425	455	272			
7/8/2015	__07064620	TA01	88	126	140	161	152	182	226	1					
7/9/2015	__07064620	BA05	294	202	199	199	257	251	326	325	229	288	256	225	341
Total			5,974	7,229	7,489	4,957	4,959	5,414	6,566	6,340	6,780	7,108	5,399	2,948	1,578

Table III-5 Average Speed by Site and Time of Day

			Mean Hourly Speed MPH												
Date	**Unit**	**Site**	**06 & earlier**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18 & later**
5/12/2015	__06064615	CH11	31	30	30	28	30	30	29	29	28	28			
5/13/2015	__06064615	SM13	28	28	28	28	28	30	29	29	28	21	17		
5/14/2015	__06064615	AA14	34	33	33	33	33	33	32	33	33	32	32	31	
5/15/2015	__06064615	PG11	40	35	39	36	34	35	36	35	34	34	34		
5/18/2015	__06064615	BA25	28	28	28	27	28	27	27						
5/19/2015	__06064615	BA05	33	34	34	34	34	34	33	34	34	34	34	34	37
5/20/2015	__06064615	BA25						28	27	27	27	27	28	28	
5/20/2015	__06064615	QA05	21	20	19	20									
5/21/2015	__07064620	MO11	29	27	26	19									
5/22/2015	__07064620	BA20	32	31	31										
5/26/2015	__07064620	CE04	30	30	31	33									
5/27/2015	__07064620	MO10	33	31	31	31	33	32	32	33	32	32			
5/28/2015	__07064620	BA03	34	32	31	31	31	33	32	33	33	33	34	33	34
5/29/2015	__07064620	PG10	34	29	33	33	32	32	31	32	18	15	23		
6/1/2015	__06064615	AL12		26	25	25	25	25	25	25	25	26	25	25	29
6/2/2015	__07064620	AL13				18	18	20	20						
6/3/2015	__07064620	WA12	31	29	29	27	26	27	26	26	26				
6/4/2015	__07064620	FR14	29												
6/5/2015	__06064615	CR01							26	25	25	25	26	26	28
6/8/2015	__07064620	KE11	29	26	25	26	24	24	24	24	24	25	24		
6/11/2015	__06064615	TA01									32	35	35	37	38
6/11/2015	__07064620	TA01	39	38	36	35	36	36	36	36	36				
6/25/2015	__07064620	MO11	29	28	28	29	27	29	28	28	22	19			
6/26/2015	__06064615	BA05						38	40	38	39	40	40	40	38
6/26/2015	__07064620	PG11	42	39	39	38									
6/29/2015	__07064620	HO13	33	30	30	31	30	31	31	30	31	22	15	15	
6/30/2015	__07064620	AA13	30	30	29	30	30								
7/1/2015	__07064620	HA13	33	32	32	32	32	34	30	31	32	31	31		
7/2/2015	__07064620	CL13	29	28	29	29	29	30	30	30	31	31	31		
7/7/2015	__07064620	FR14	29	30	30	29	29	29	29	30	30	30			
7/8/2015	__07064620	TA01	40	38	40	37	37	36	36	44					
7/9/2015	__07064620	BA05	36	36	37	38	37	37	37	38	37	38	38	38	37

Table III-6 Average Acceleration by Site and Time of Day

			Mean Hourly Acceleration MPH/s												
Date	**Unit**	**Site**	**06 & earlier**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18 & later**
5/12/2015	__06064615	CH11	0.6	0.8	0.8	0.9	0.9	0.8	0.9	0.9	0.8	0.8			
5/13/2015	__06064615	SM13	1.2	1.2	1.0	1.1	1.1	1.1	1.1	1.0	1.1	1.3	1.5		
5/14/2015	__06064615	AA14	0.3	0.5	0.5	0.4	0.4	0.5	0.6	0.6	0.5	0.5	0.6	0.6	
5/15/2015	__06064615	PG11	0.0	0.3	0.1	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.4		
5/18/2015	__06064615	BA25	1.2	1.2	1.2	1.2	1.2	1.2	1.2						
5/19/2015	__06064615	BA05	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.8	0.9	0.8	0.8	0.9	0.3
5/20/2015	__06064615	BA25						1.3	1.4	1.3	1.3	1.3	1.2	1.2	
5/20/2015	__06064615	QA05	0.5	0.7	0.5	0.8									
5/21/2015	__07064620	MO11	0.2	0.4	0.4	1.5									
5/22/2015	__07064620	BA20	0.9	0.9	1.0										
5/26/2015	__07064620	CE04	1.0	1.1	1.1	0.7									
5/27/2015	__07064620	MO10	0.6	0.6	0.7	0.7	0.7	0.7	0.6	0.6	0.7	0.6			
5/28/2015	__07064620	BA03	1.0	1.1	1.0	1.0	1.1	1.0	1.0	1.1	1.0	1.0	1.0	1.1	1.1
5/29/2015	__07064620	PG10	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.1	1.2	1.0		
6/1/2015	__06064615	AL12		0.3	0.5	0.6	0.4	0.5	0.6	0.6	0.6	0.5	0.6	0.5	0.7
6/2/2015	__07064620	AL13				0.9	2.3	1.5	-0.3						
6/3/2015	__07064620	WA12	0.2	0.3	0.4	0.6	0.6	0.7	0.7	0.8	0.7				
6/4/2015	__07064620	FR14	1.2												
6/5/2015	__06064615	CR01							0.3	0.3	0.3	0.4	0.5	0.4	0.7
6/8/2015	__07064620	KE11	1.0	1.3	1.2	1.4	1.4	1.5	1.5	1.4	1.5	1.4	1.5		
6/11/2015	__06064615	TA01									1.0	1.0	0.9	0.9	0.9
6/11/2015	__07064620	TA01	0.8	0.8	0.9	1.0	0.9	0.9	0.9	1.0	0.8				
6/25/2015	__07064620	MO11	0.5	0.6	0.5	0.4	0.5	0.4	0.5	0.4	1.1	1.2			
6/26/2015	__06064615	BA05						0.6	0.6	0.6	0.6	0.5	0.6	0.5	0.6
6/26/2015	__07064620	PG11	-0.0	0.2	0.2	0.3									
6/29/2015	__07064620	HO13	0.9	1.0	1.1	1.0	1.0	1.0	1.1	1.1	1.0	1.2	1.4	1.4	
6/30/2015	__07064620	AA13	0.8	0.8	0.8	0.7	0.7								
7/1/2015	__07064620	HA13	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8		
7/2/2015	__07064620	CL13	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4		
7/7/2015	__07064620	FR14	1.1	1.2	1.2	1.2	1.3	1.2	1.3	1.3	1.3	1.2			
7/8/2015	__07064620	TA01	0.9	0.9	0.8	1.0	1.0	1.1	1.0	0.6					
7/9/2015	__07064620	BA05	0.7	0.8	0.7	0.7	0.8	0.9	0.7	0.7	0.7	0.7	0.6	0.7	0.8

Table III-7 Average CO% by Site and Time of Day

			Mean Hourly CO %												
Date	**Unit**	**Site**	**06 & earlier**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18 & later**
5/12/2015	__06064615	CH11	0.2	0.3	0.2	0.3	0.3	0.2	0.2	0.2	0.3	0.3			
5/13/2015	__06064615	SM13	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1		
5/14/2015	__06064615	AA14	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	
5/15/2015	__06064615	PG11	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1		
5/18/2015	__06064615	BA25	0.1	0.1	0.1	0.1	0.1	0.2	0.1						
5/19/2015	__06064615	BA05	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5/20/2015	__06064615	BA25						0.1	0.1	0.1	0.2	0.2	0.2	0.3	
5/20/2015	__06064615	QA05	0.1	0.1	0.1	0.1									
5/21/2015	__07064620	MO11	0.1	0.1	0.1	0.1									
5/22/2015	__07064620	BA20	0.1	0.1	0.2										
5/26/2015	__07064620	CE04	0.1	0.1	0.1	0.0									
5/27/2015	__07064620	MO10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1			
5/28/2015	__07064620	BA03	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.0	0.1	0.1
5/29/2015	__07064620	PG10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
6/1/2015	__06064615	AL12		0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1
6/2/2015	__07064620	AL13				0.0	0.1	0.2	0.0						
6/3/2015	__07064620	WA12	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2				
6/4/2015	__07064620	FR14	0.1												
6/5/2015	__06064615	CR01							0.2	0.1	0.1	0.2	0.2	0.2	0.1
6/8/2015	__07064620	KE11	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
6/11/2015	__06064615	TA01									0.1	0.1	0.1	0.1	0.2
6/11/2015	__07064620	TA01	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0				
6/25/2015	__07064620	MO11	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1			
6/26/2015	__06064615	BA05						0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1
6/26/2015	__07064620	PG11	0.1	0.1	0.1	0.1									
6/29/2015	__07064620	HO13	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	
6/30/2015	__07064620	AA13	0.1	0.1	0.1	0.1	0.1								
7/1/2015	__07064620	HA13	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
7/2/2015	__07064620	CL13	0.1	0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
7/7/2015	__07064620	FR14	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1			
7/8/2015	__07064620	TA01	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0					
7/9/2015	__07064620	BA05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table III-8 Average HC ppm hexane by Site and Time of Day

			Mean Hourly HC ppm hexane												
Date	**Unit**	**Site**	**06 & earlier**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18 & later**
5/12/2015	__06064615	CH11	27	19	19	33	38	61	36	47	80	55			
5/13/2015	__06064615	SM13	28	**111**	15	50	23	15	22	21	23	20	21		
5/14/2015	__06064615	AA14	11	22	14	11	20	24	15	33	44	21	12	24	
5/15/2015	__06064615	PG11	5	1	2	-0	22	7	10	27	8	23	5		
5/18/2015	__06064615	BA25	13	18	18	11	16	25	23						
5/19/2015	__06064615	BA05	-4	7	16	3	3	3	4	4	8	5	4	6	63
5/20/2015	__06064615	BA25						8	23	19	24	31	32	16	
5/20/2015	__06064615	QA05	17	16	17	13									
5/21/2015	__07064620	MO11	11	2	4	6									
5/22/2015	__07064620	BA20	21	11	11										
5/26/2015	__07064620	CE04	5	0	6	7									
5/27/2015	__07064620	MO10	3	15	35	4	2	20	6	5	5	2			
5/28/2015	__07064620	BA03	25	13	1	5	8	35	41	-2	11	1	-2	2	2
5/29/2015	__07064620	PG10	4	4	10	-1	1	1	-1	18	9	8	-8		
6/1/2015	__06064615	AL12		49	21	12	13	19	22	14	21	28	27	14	10
6/2/2015	__07064620	AL13				1	10	37	2						
6/3/2015	__07064620	WA12	10	3	-0	6	14	6	17	13	20				
6/4/2015	__07064620	FR14	20												
6/5/2015	__06064615	CR01							21	14	23	12	18	19	-3
6/8/2015	__07064620	KE11	13	12	12	14	20	17	37	13	24	15	48		
6/11/2015	__06064615	TA01									5	3	5	3	7
6/11/2015	__07064620	TA01	16	10	2	7	8	25	5	-2	-5				
6/25/2015	__07064620	MO11	10	9	10	6	13	6	12	7	10	8			
6/26/2015	__06064615	BA05						1	0	-1	0	11	4	4	3
6/26/2015	__07064620	PG11	4	1	-0	-0									
6/29/2015	__07064620	HO13	2	4	3	3	8	-2	-1	6	1	3	1	2	
6/30/2015	__07064620	AA13	5	36	2	5	2								
7/1/2015	__07064620	HA13	9	12	3	9	2	9	3	-0	1	1	3		
7/2/2015	__07064620	CL13	12	5	19	-4	-15	5	0	-1	1	10	2		
7/7/2015	__07064620	FR14	17	5	6	8	5	7	20	11	3	7			
7/8/2015	__07064620	TA01	83	-4	-1	-3	39	-0	3	4					
7/9/2015	__07064620	BA05	5	-1	6	4	8	1	5	-0	5	1	1	5	1

Table III-9 Average NO ppm by Site and Time of Day

			Mean Hourly NO ppm												
Date	**Unit**	**Site**	**06 & earlier**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18 & later**
5/12/2015	__06064615	CH11	56	106	86	111	168	118	100	147	157	122			
5/13/2015	__06064615	SM13	230	177	218	187	153	175	205	168	245	152	102		
5/14/2015	__06064615	AA14	127	101	101	150	128	185	183	147	134	149	161	137	
5/15/2015	__06064615	PG11	116	52	92	74	96	81	124	89	143	112	93		
5/18/2015	__06064615	BA25	94	73	82	77	128	140	94						
5/19/2015	__06064615	BA05	106	95	100	43	52	71	53	62	111	70	64	79	-3
5/20/2015	__06064615	BA25						135	133	103	104	189	184	194	
5/20/2015	__06064615	QA05	219	98	116	88									
5/21/2015	__07064620	MO11	93	70	72	17									
5/22/2015	__07064620	BA20	193	143	172										
5/26/2015	__07064620	CE04	99	79	80	48									
5/27/2015	__07064620	MO10	93	89	80	87	86	144	99	64	64	68			
5/28/2015	__07064620	BA03	147	99	62	93	151	52	89	78	76	92	66	41	64
5/29/2015	__07064620	PG10	90	42	73	71	79	71	58	70	53	35	10		
6/1/2015	__06064615	AL12		253	199	147	121	206	174	145	169	177	163	126	64
6/2/2015	__07064620	AL13				16	59	505	-17						
6/3/2015	__07064620	WA12	88	115	109	110	165	126	136	178	186				
6/4/2015	__07064620	FR14	138												
6/5/2015	__06064615	CR01							147	121	125	114	132	88	1
6/8/2015	__07064620	KE11	146	135	117	184	204	178	236	136	206	172	169		
6/11/2015	__06064615	TA01									58	79	100	61	96
6/11/2015	__07064620	TA01	129	91	127	86	106	109	113	46	0				
6/25/2015	__07064620	MO11	78	63	62	66	89	84	86	69	69	62			
6/26/2015	__06064615	BA05						76	66	55	85	85	48	50	47
6/26/2015	__07064620	PG11	134	59	83	135									
6/29/2015	__07064620	HO13	72	65	59	118	129	80	78	91	96	60	35	33	
6/30/2015	__07064620	AA13	66	50	20	48	67								
7/1/2015	__07064620	HA13	138	90	78	48	63	82	85	72	96	85	66		
7/2/2015	__07064620	CL13	79	79	83	29	38	126	82	100	87	100	87		
7/7/2015	__07064620	FR14	122	57	56	83	81	85	104	97	74	89			
7/8/2015	__07064620	TA01	77	38	61	69	78	96	94	86					
7/9/2015	__07064620	BA05	87	59	64	80	99	41	59	60	48	55	53	62	44

Table III-10 Average % of New Models with HC Greater than 150ppm Hexane

Hourly percent of MY 2010 and newer with HC GT 150 ppm hexane															
Date	**Unit**	**site**	**06 & earlier**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18 & later**
5/12/2015	__06064615	CH11	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	**6.8%**	**8.2%**	**8.6%**	4.7%			
5/13/2015	__06064615	SM13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
5/14/2015	__06064615	AA14	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	
5/15/2015	__06064615	PG11	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
5/18/2015	__06064615	BA25	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
5/19/2015	__06064615	BA05	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
5/20/2015	__06064615	BA25							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
5/20/2015	__06064615	QA05	0.0%	0.0%	1.0%	0.0%									
5/21/2015	__07064620	MO11	0.0%	0.0%	0.0%										
5/22/2015	__07064620	BA20	2.2%	1.8%	0.0%										
5/26/2015	__07064620	CE04	0.5%	0.0%	0.0%										
5/27/2015	__07064620	MO10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
5/28/2015	__07064620	BA03		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	0.0%
5/29/2015	__07064620	PG10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.0%	0.0%			
6/1/2015	__06064615	AL12		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	1.0%	
6/2/2015	__07064620	AL13					**6.7%**								
6/3/2015	__07064620	WA12	0.0%	0.0%	0.0%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%				
6/4/2015	__07064620	FR14	0.0%												
6/5/2015	__06064615	CR01							0.0%	0.0%	1.1%	0.0%	0.0%	0.0%	
6/8/2015	__07064620	KE11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
6/11/2015	__06064615	TA01									0.0%	1.0%	0.0%	0.0%	0.0%
6/11/2015	__07064620	TA01	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
6/25/2015	__07064620	MO11	0.0%	0.0%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
6/26/2015	__06064615	BA05						0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
6/26/2015	__07064620	PG11	0.0%	0.0%	0.0%	0.0%									
6/29/2015	__07064620	HO13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
6/30/2015	__07064620	AA13	0.0%	0.0%	0.0%	0.0%	0.0%								
7/1/2015	__07064620	HA13	**9.0%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
7/2/2015	__07064620	CL13		0.0%	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
7/7/2015	__07064620	FR14	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%			
7/8/2015	__07064620	TA01	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
7/9/2015	__07064620	BA05	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table III-11 Average Hourly Temperature

Mean Hourly Temperature Degrees Celsius															
Date	**Unit**	**Site**	**06 & earlier**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18 & later**
5/12/2015	__06064615	CH11	24	25	26	28	32	33	34	34	34	34			
5/13/2015	__06064615	SM13	22	24	26	27	28	29	30	30	28	28	28		
5/14/2015	__06064615	AA14	18	20	23	24	25	26	26	28	29	31	31	31	
5/15/2015	__06064615	PG11	17	18	20	23	25	28	30	30	30	31	31		
5/18/2015	__06064615	BA25	27	28	32	35	37	37	36						
5/19/2015	__06064615	BA05	26	26	27	29	31	32	33	33	34	35	36	36	36
5/20/2015	__06064615	BA25						24	25	26	27	27	26	26	
5/20/2015	__06064615	QA05	22	25	25	25									
5/21/2015	__07064620	MO11	20	21	23	22									
5/22/2015	__07064620	BA20	15	22	23										
5/26/2015	__07064620	CE04	22	22	25	26									
5/27/2015	__07064620	MO10	27	28	28	29	30	32	33	34	34	35			
5/28/2015	__07064620	BA03	25	26	28	31	33	35	38	42	41	42	41	41	40
5/29/2015	__07064620	PG10	27	26	26	29	27	27	31	30	33	33	33		
6/1/2015	__06064615	AL12		27	27	29	31	32	33	34	35	34	32	30	30
6/2/2015	__07064620	AL13				23	21	20	20						
6/3/2015	__07064620	WA12	21	22	23	23	25	23	22	24	24				
6/4/2015	__07064620	FR14	20												
6/5/2015	__06064615	CR01							20	23	25	26	27	29	29
6/8/2015	__07064620	KE11	20	22	24	25	26	27	29	30	30	30	31		
6/11/2015	__06064615	TA01									35	35	36	36	37
6/11/2015	__07064620	TA01	24	25	26	27	28	29	30	33	33				
6/25/2015	__07064620	MO11	24	25	27	29	30	32	33	34	34	33			
6/26/2015	__06064615	BA05						28	29	30	30	31	31	31	29
6/26/2015	__07064620	PG11	24	23	24	25									
6/29/2015	__07064620	HO13	19	21	23	24	26	27	29	31	32	35	36	35	
6/30/2015	__07064620	AA13	25	25	26	27	26								
7/1/2015	__07064620	HA13	23	23	24	26	27	29	31	32	33	34	34		
7/2/2015	__07064620	CL13	25	25	25	25	25	27	28	28	28	28	27		
7/7/2015	__07064620	FR14	28	28	28	29	30	32	33	34	35	37			
7/8/2015	__07064620	TA01	28	29	29	29	29	30	31	32					
7/9/2015	__07064620	BA05	29	28	31	32	32	33	34	35	35	35	35	35	34

2. Identification and Treatment of Outliers

Measurements outside expected measurement ranges were flagged invalid as indicated below:

- HC less than minus 150 ppm hexane or greater than 50,000 ppm hexane: 0 records
- CO less than minus 0.25% or greater than 20%: 2 records
- NO less than minus 250 ppm or greater than 20,000 ppm: 6 records

Daily mean values of HC, CO and NO were calculated for 2010 and newer vehicles after removal of the outlying measurements. The results are plotted in Figures III-1 through III-3. Daily average emissions for new models were between -11 and +10 ppm HC, between 0.02 and 0.13 % CO and between 4 and 28 ppm NO.

To further investigate individual vehicle measurement outliers, frequency distributions of HC, CO and NO were determined and plotted in Figures III-4 through III-6. There are small tails of negative values representing measurement noise and large tails of positive values representing high emitters.

Figure III-1 Daily Mean HC for 2010 and Newer Vehicles

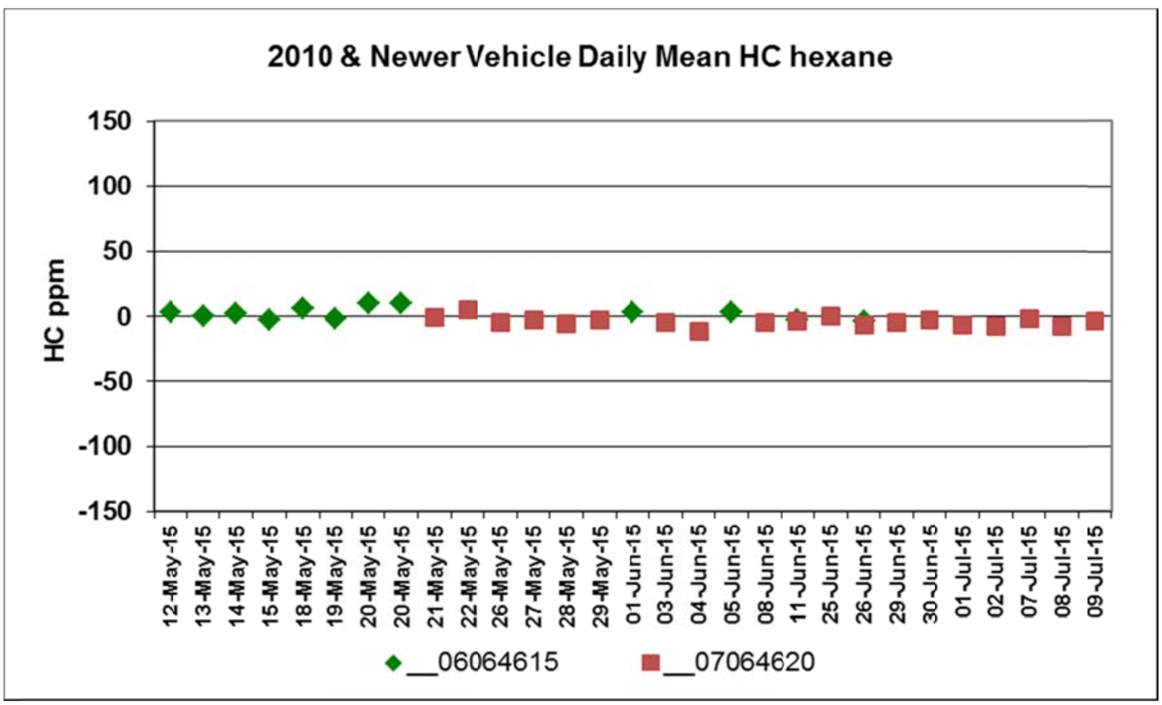


Figure III-2 Daily Mean CO for 2010 and Newer Vehicles

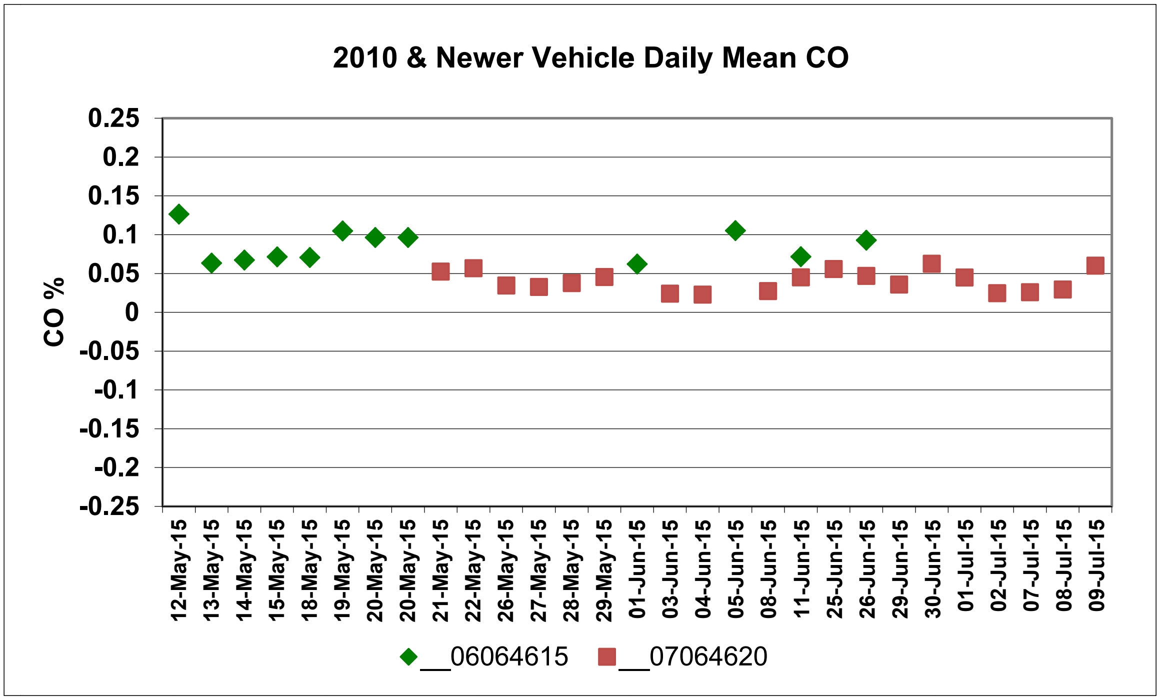


Figure III-3 Daily Mean NO for 2010 and Newer Vehicles

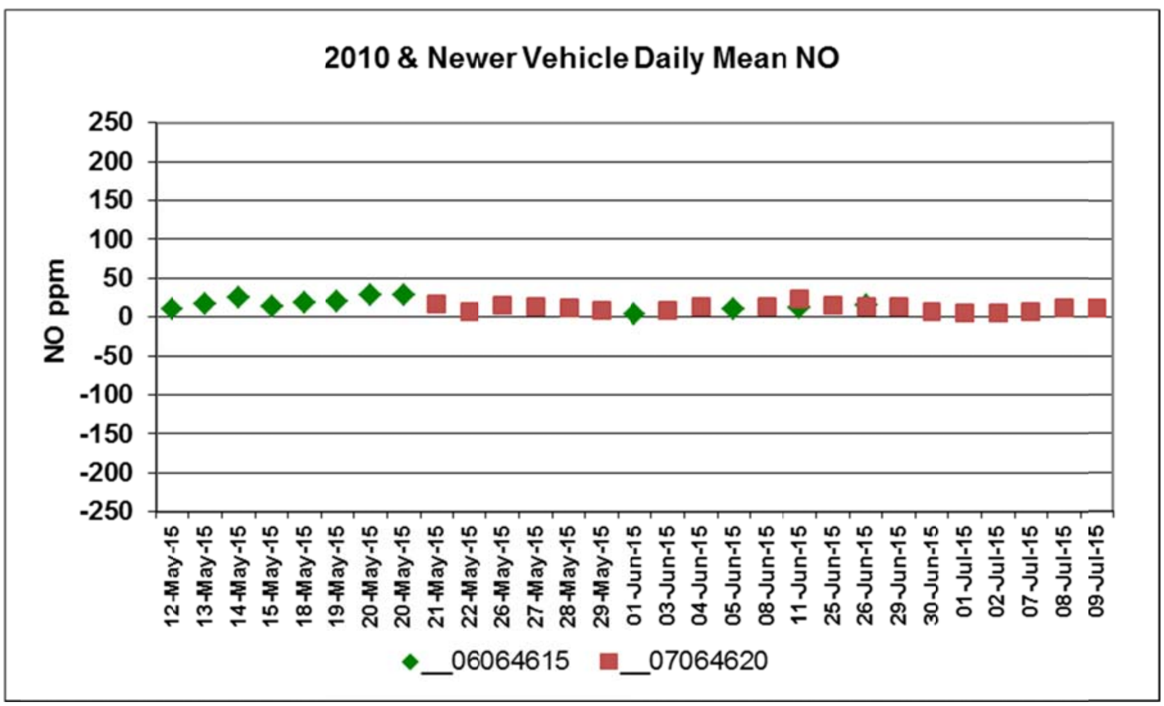


Figure III-4 HC Frequency Distribution

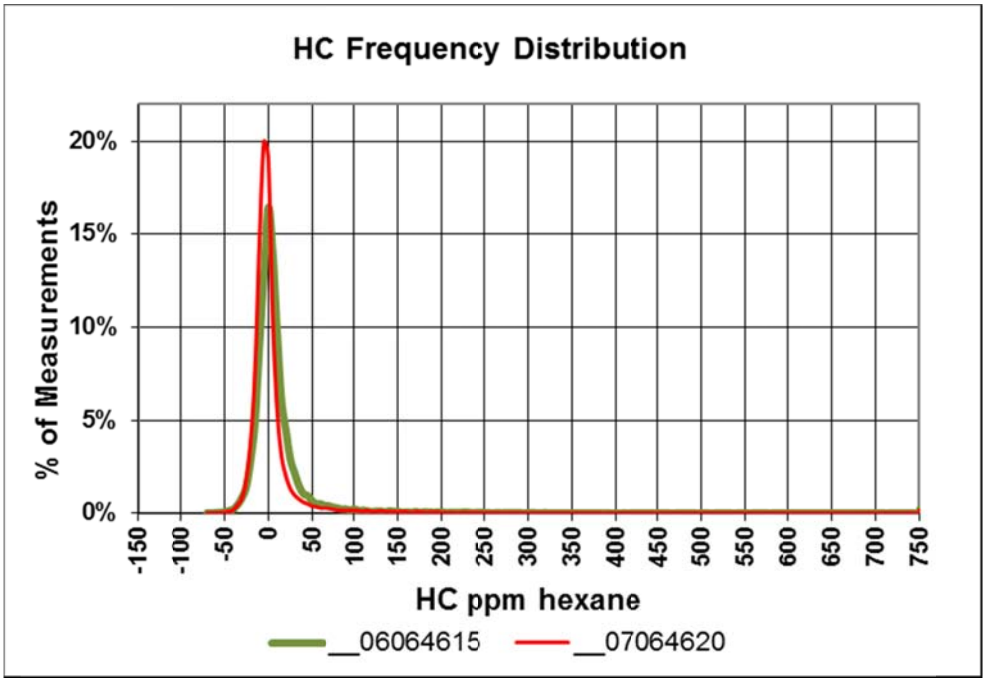


Figure III-5 CO Frequency Distribution

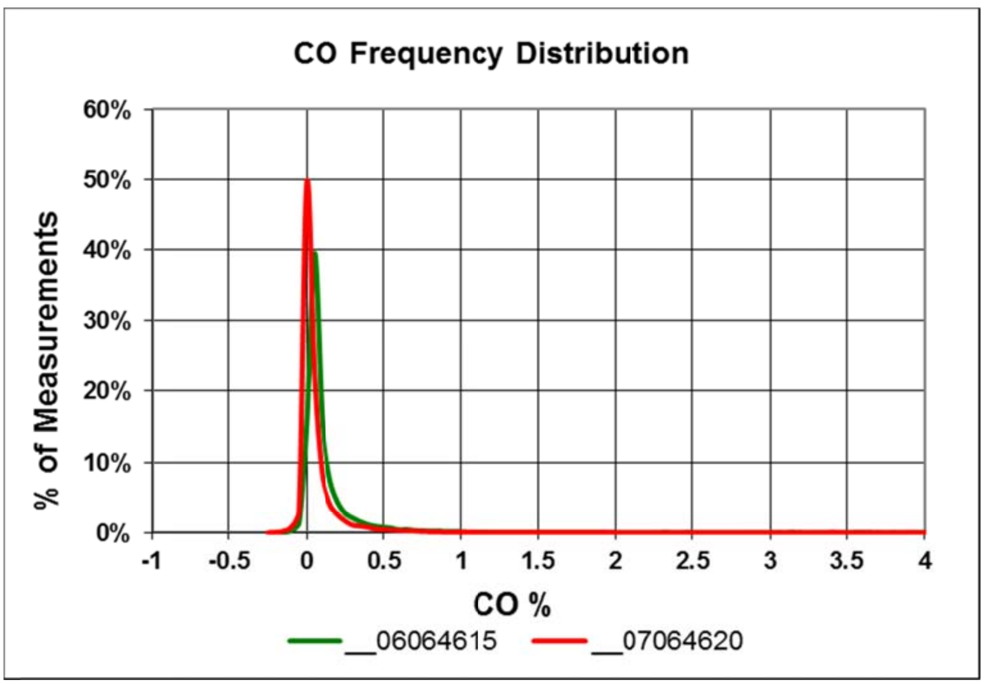
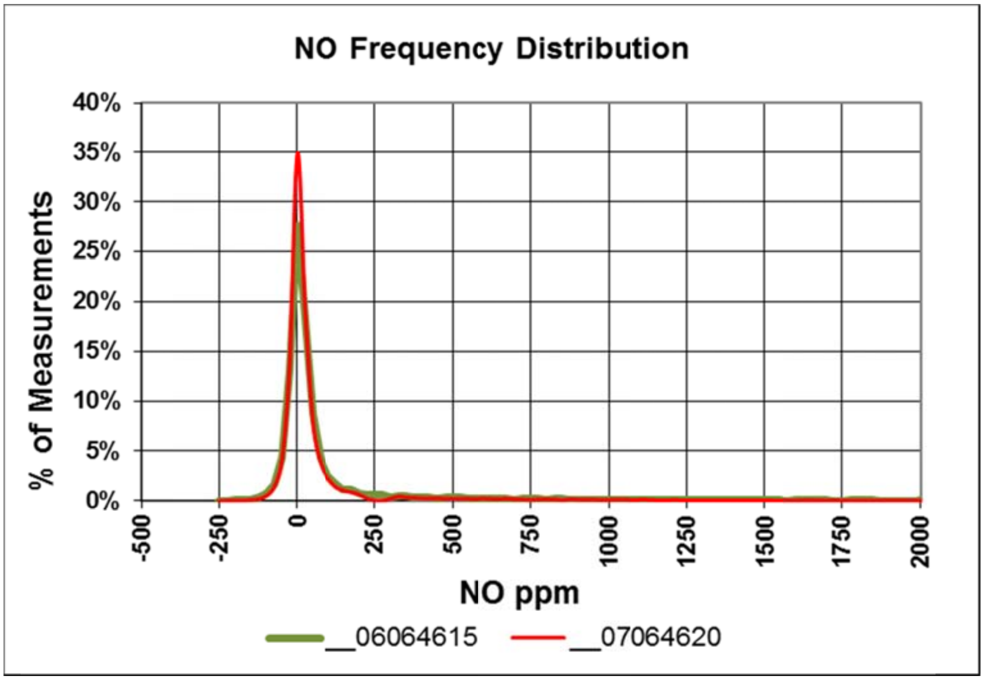


Figure III-6 NO Frequency Distribution



1. *Vehicle Mix at Each Site*

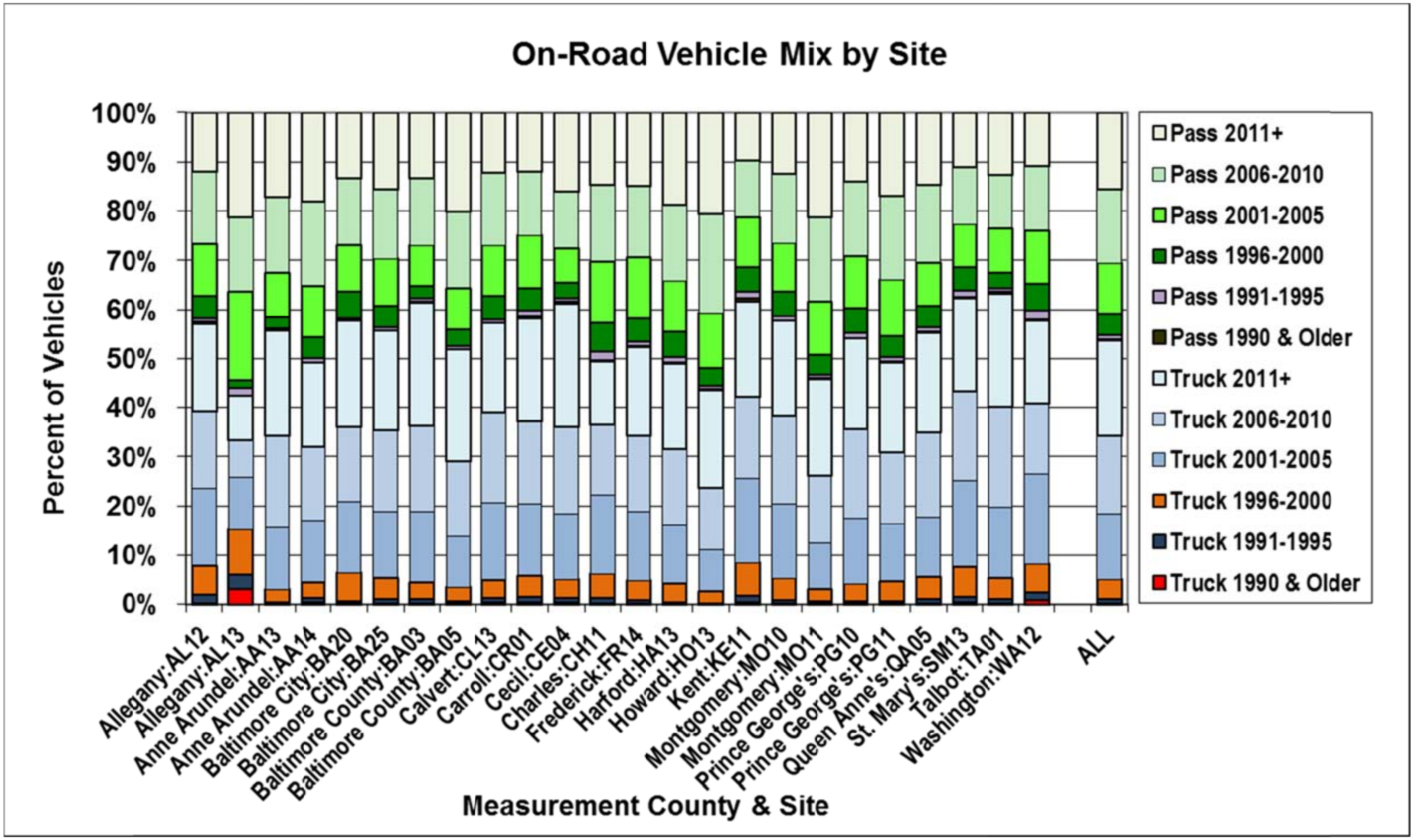
For vehicles matched to registration records, the vehicle type was decoded from the VIN into three groups: T- trucks less than 10,000 lbs GVWR, P – light passenger vehicle, and O – other, which includes heavier vehicles.

Table III-12 and Figure III-7 Vehicle Mix by Site show the percentage of each type/model year range measured at the sites in each county. The fleet is divided between 46% light passenger vehicles (green and purple) and 54% trucks less than 10,000 lbs GVWR (blue and red). Sites in Baltimore, Cecil, Kent, Saint Mary's and Talbot counties measured more than 60% light trucks.

Table III-12 Vehicle Mix by Site

Site	Pass 1990 & Older	Pass 1991-1995	Pass 1996-2000	Pass 2001-2005	Pass 2006-2010	Pass 2011+	**Total Passenger**	Truck 1990 & Older	Truck 1991-1995	Truck 1996-2000	Truck 2001-2005	Truck 2006-2010	Truck 2011+	**Total Truck**
Allegany:AL12	0%	1%	5%	11%	15%	12%	**43%**	0%	2%	6%	16%	16%	18%	**57%**
Allegany:AL13	0%	2%	2%	18%	15%	21%	**58%**	3%	3%	9%	11%	8%	9%	**42%**
Anne Arundel:AA13	0%	0%	2%	9%	15%	17%	**44%**	0%	0%	3%	12%	19%	21%	**56%**
Anne Arundel:AA14	0%	1%	4%	10%	17%	18%	**51%**	0%	1%	3%	12%	15%	17%	**49%**
Baltimore City:BA20	0%	1%	6%	9%	13%	13%	**42%**	0%	0%	6%	14%	15%	22%	**58%**
Baltimore City:BA25	0%	0%	4%	10%	14%	16%	**44%**	0%	1%	4%	13%	16%	20%	**56%**
Baltimore County:BA03	0%	1%	3%	8%	14%	13%	**39%**	0%	1%	3%	14%	18%	25%	**61%**
Baltimore County:BA05	0%	1%	3%	8%	15%	20%	**48%**	0%	0%	3%	10%	15%	23%	**52%**
Calvert:CL13	0%	1%	5%	10%	15%	12%	**43%**	0%	1%	4%	16%	18%	18%	**57%**
Carroll:CR01	0%	1%	4%	11%	13%	12%	**42%**	0%	1%	4%	14%	17%	21%	**58%**
Cecil:CE04	0%	1%	3%	7%	12%	16%	**39%**	0%	1%	4%	13%	18%	25%	**61%**
Charles:CH11	0%	2%	6%	12%	16%	15%	**51%**	0%	1%	5%	16%	14%	13%	**49%**
Frederick:FR14	0%	1%	5%	13%	15%	15%	**48%**	0%	1%	4%	14%	15%	18%	**52%**
Harford:HA13	0%	1%	5%	10%	15%	19%	**51%**	0%	0%	4%	12%	15%	17%	**49%**
Howard:HO13	0%	1%	4%	11%	20%	21%	**57%**	0%	0%	2%	8%	13%	20%	**43%**
Kent:KE11	1%	2%	5%	10%	12%	10%	**38%**	0%	1%	7%	17%	17%	19%	**62%**
Montgomery:MO10	0%	1%	5%	10%	14%	12%	**42%**	0%	1%	4%	15%	18%	19%	**58%**
Montgomery:MO11	0%	1%	4%	11%	17%	21%	**54%**	0%	0%	3%	9%	14%	20%	**46%**
Prince George's:PG10	0%	1%	5%	11%	15%	14%	**46%**	0%	1%	3%	13%	18%	18%	**54%**
Prince George's:PG11	0%	1%	4%	11%	17%	17%	**51%**	0%	1%	4%	12%	15%	18%	**49%**
Queen Anne's:QA05	0%	1%	4%	9%	16%	15%	**45%**	0%	1%	5%	12%	17%	20%	**55%**
St. Mary's:SM13	0%	1%	5%	9%	12%	11%	**38%**	0%	1%	6%	17%	18%	19%	**62%**
Talbot:TA01	0%	1%	3%	9%	11%	13%	**37%**	0%	1%	4%	14%	20%	23%	**63%**
Washington:WA12	0%	2%	5%	11%	13%	11%	**42%**	1%	2%	6%	18%	14%	17%	**58%**
ALL	**0%**	**1%**	**4%**	**10%**	**15%**	**16%**	**46%**	**0%**	**1%**	**4%**	**13%**	**16%**	**19%**	**54%**

Figure III-7 Vehicle Mix by Site



2. *Screening by VSP for Emissions Analysis*

Range Vehicle Specific Power

Research[1] has shown that vehicle specific power (VSP) has an important effect on tailpipe emissions. VSP is the power needed to overcome forces acting on the vehicle. In order to compare RSD measurements taken at different sites and at different times, it is necessary to ensure the sets of measurements have similar distributions of vehicle engine load. RSD measurements have been screened to identify those collected when vehicles were operating within a moderate load range of from 3 kilowatts per ton (kW/t) to 22 kilowatts per ton (kW/t). This is a range within the scope of the IM240 and Federal Test Procedure (FTP) tests and over which tailpipe emission concentrations are more stable. Results from vehicles measured outside this range are excluded from the charts and tables of emission values as their results are not comparable to I/M test results.

Vehicle Specific Power (VSP) is the vehicle engine power per unit mass required to overcome gravitational force, inertia, aerodynamic drag and rolling resistance[2]. Expressed in kilowatts per ton it is the sum of:

- Gravitational force: 4.39 x sin(Road grade degrees/57.3) x Speed mph
- Inertial force: 0.22 x Speed mph x Acceleration mph/s
- Aerodynamic drag: 0.0000272 x $Speed^3$ mph
- Rolling resistance: 0.0954 x Speed mph

The rate of fuel consumption is approximately proportional to VSP. At negative values of VSP, the inertia of the vehicle is greater than the opposing forces and power is either dissipated through the vehicle driving the engine or through braking and very little fuel is being used. This situation typically occurs on downhill grades or during deceleration. When a vehicle engine transitions from producing power to absorbing power, the tailpipe emissions concentrations can vary widely.

To avoid using measurements that are not representative of vehicle emissions performance within the power range contained in the federal certification test, measurements made below a vehicle specific power (VSP) of 3 kW/t or above 22 kW/t have been screened. These measurements are excluded from the emissions analyses presented in following sections.

IV. On-Road Emissions

A. Emissions by Model Year

Figures IV-1 through IV-3 show emissions by model year for I/M area vehicles. Trucks are treated as a single class and 99.6% of trucks measured were less than 10,000 lbs GVWR. There were 68 measurements of trucks between 10-14,000 lbs GVWR and 24 measurements of trucks greater than 14,000 lbs.

Figure IV-4 shows the number of RSD measurements by model year. Lower numbers of 2009 and 2010 models remain evident. The percentage of trucks among light vehicle models, which had averaged 56% for 2004-2006 models and dipped to an average of 50% for 2007-2011 models, rose to 58% in 2014 and 2015.

Early model years were combined to ensure each bin contained at least 75 measurements. The exceptions were 24 measurements of 1980 and older models, which were kept separate because their vehicle type was unknown.

The emissions follow the typical patterns for HC, CO and NO_x[iv]. Newer vehicles had lower tailpipe concentrations than older vehicles. Model years 2000 and newer vehicles emitted on average 0.2% CO or less, model years 2003 and newer vehicles emitted on average less than 15 ppm HC, and model years 2007 and newer vehicles emitted on average 50 ppm NO_x or less.

Truck models over five years old had higher HC emissions than passenger vehicles. Truck models over three years old had higher NO_x emissions than passenger vehicles.

[iv] The I/M humidity correction factor has been applied to NOx values reported in this and subsequent sections.

Figure IV-1 Average RSD CO Emissions by Model Year

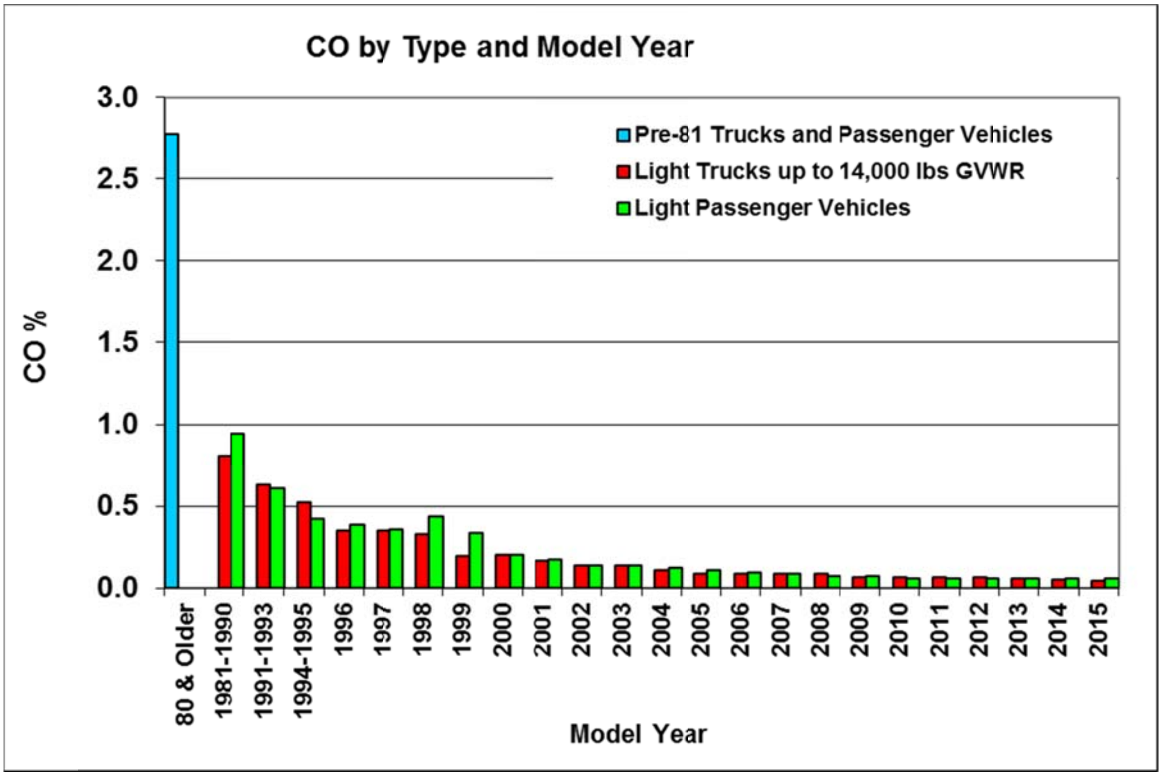


Figure IV-2 Average RSD HC Emissions by Model Year

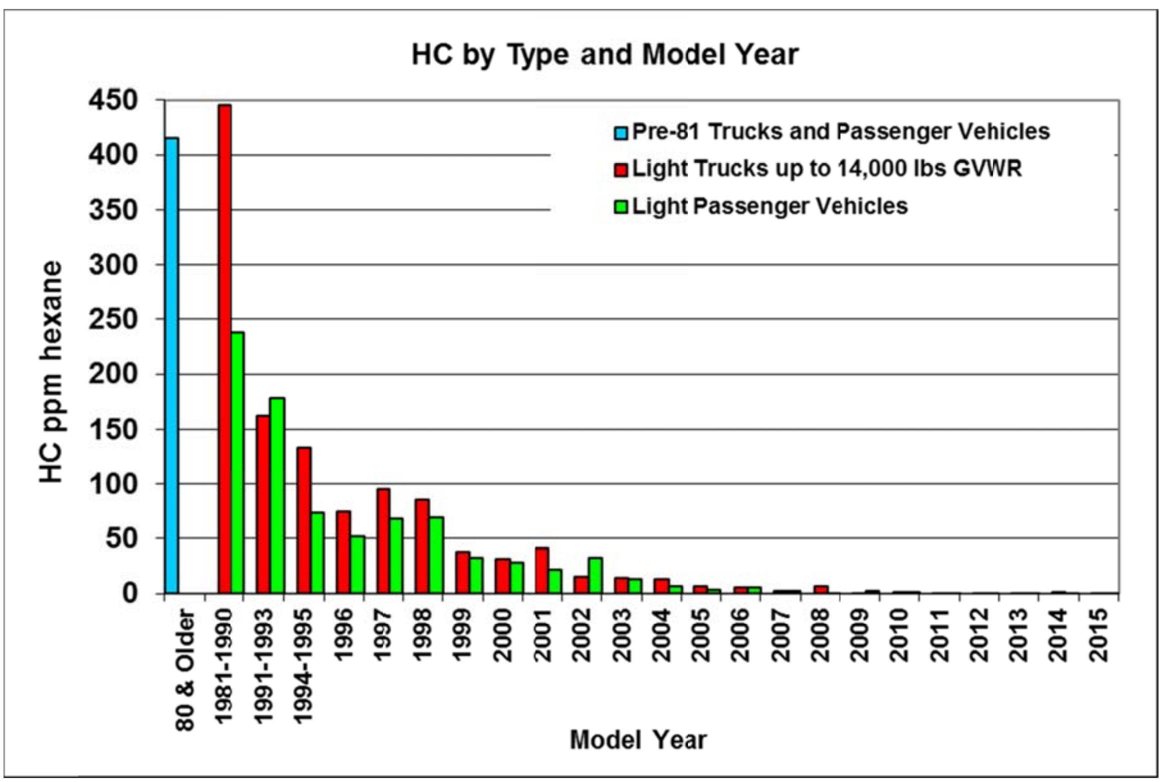


Figure IV-3 Average RSD NO_x Emissions by Model Year

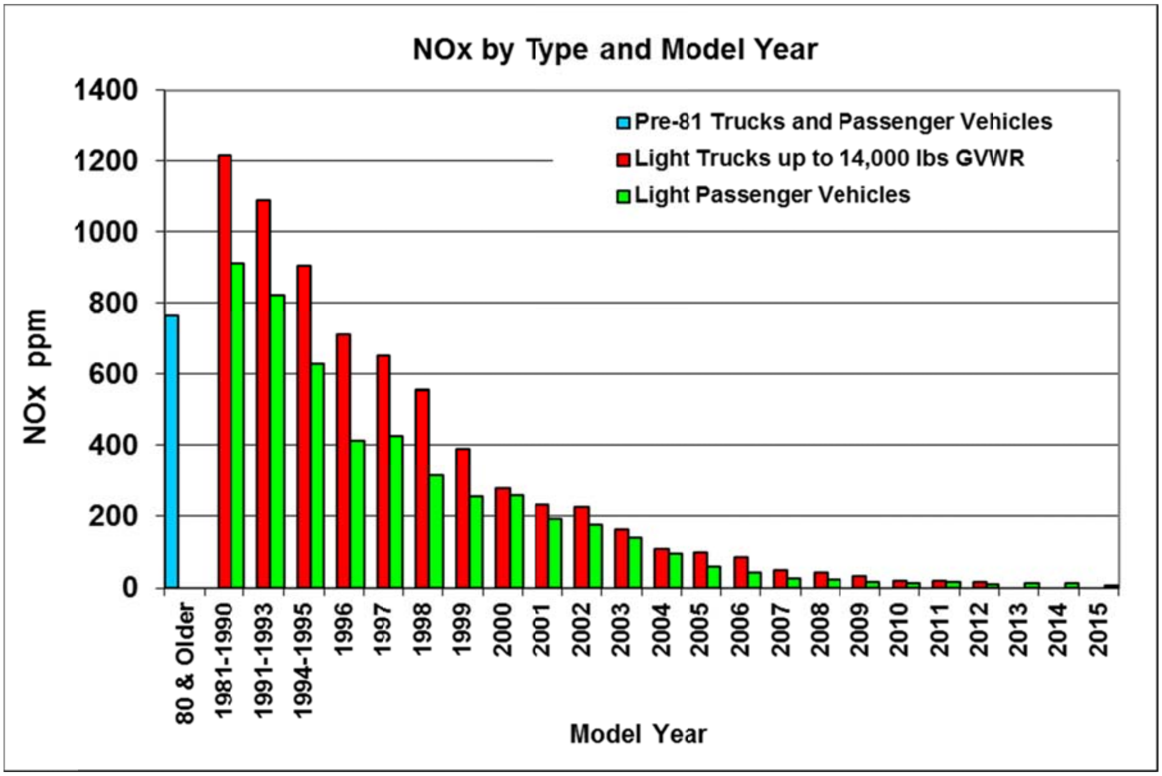
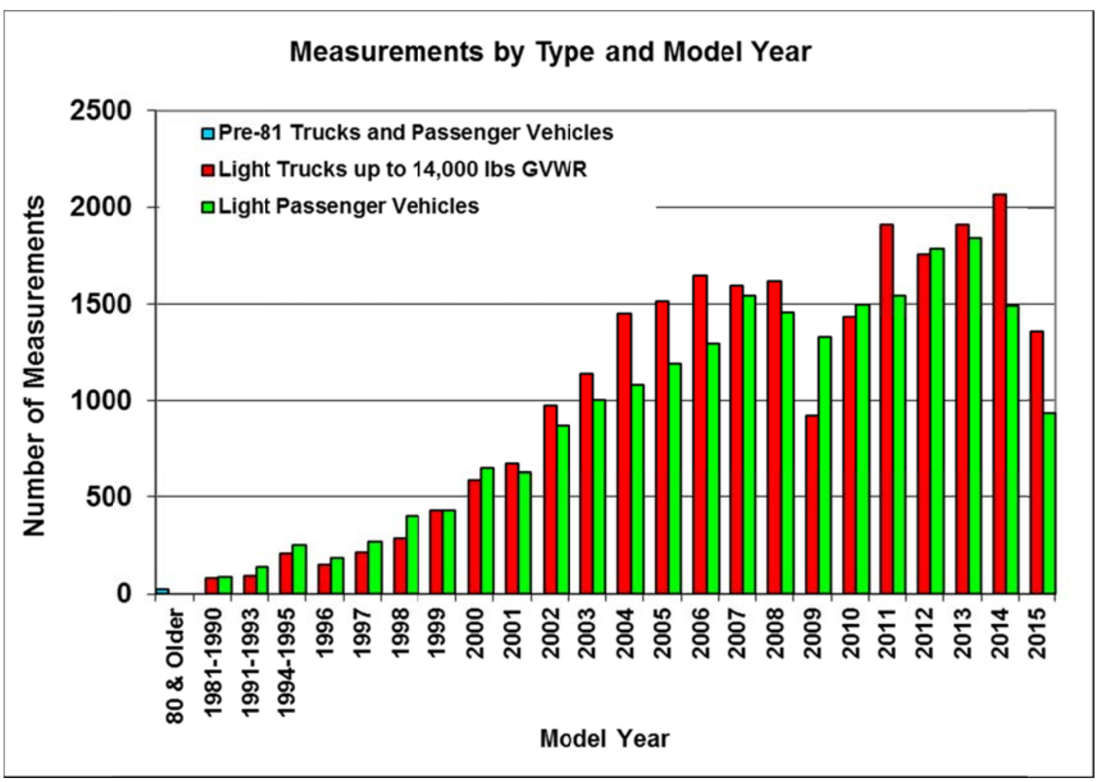


Figure IV-4 Measurements by Model Year



B. Emission Deciles by Model Year

The emission deciles for vehicles are shown in the following charts. These charts illustrate that high HC and CO emissions are more likely to occur among the oldest vehicles and are extremely high across a small portion of the fleet.

NO_x emissions, although also highly skewed, are somewhat less skewed than HC and CO among pre-OBD models.

Figure IV-5 CO Deciles by Model Year

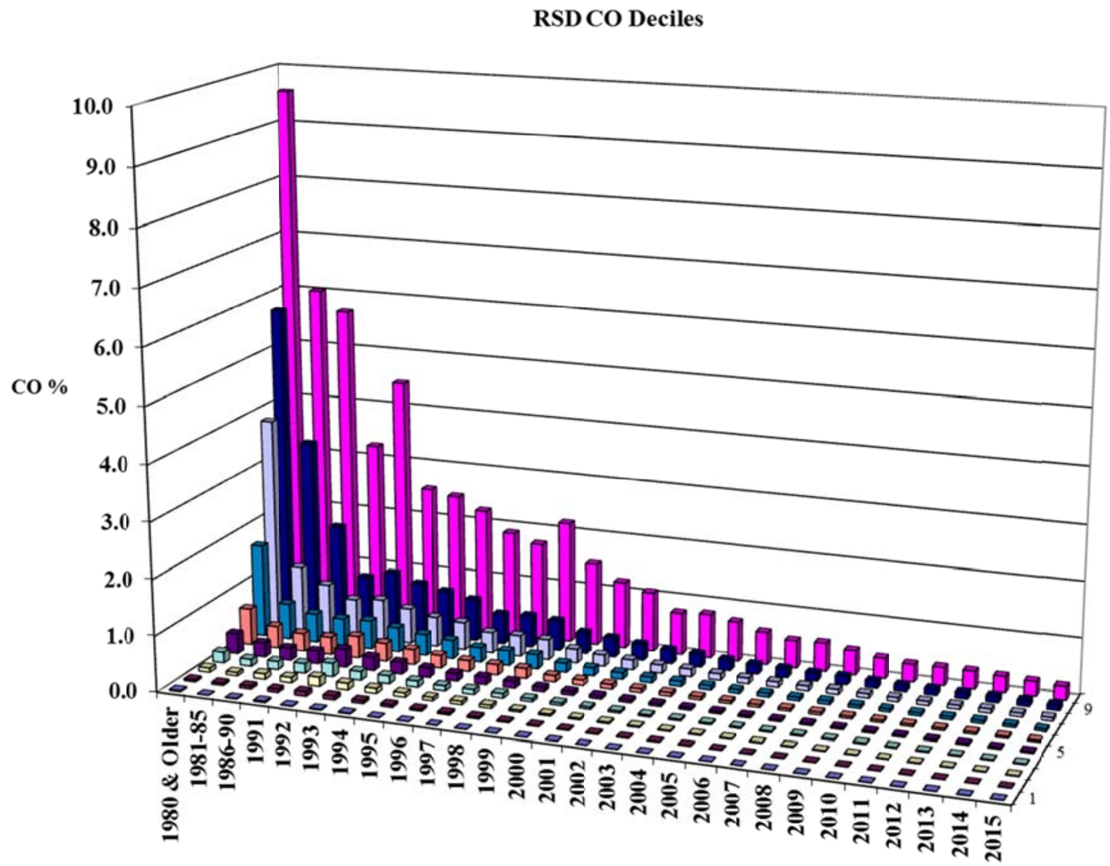


Figure IV-6 HC Deciles by Model Year

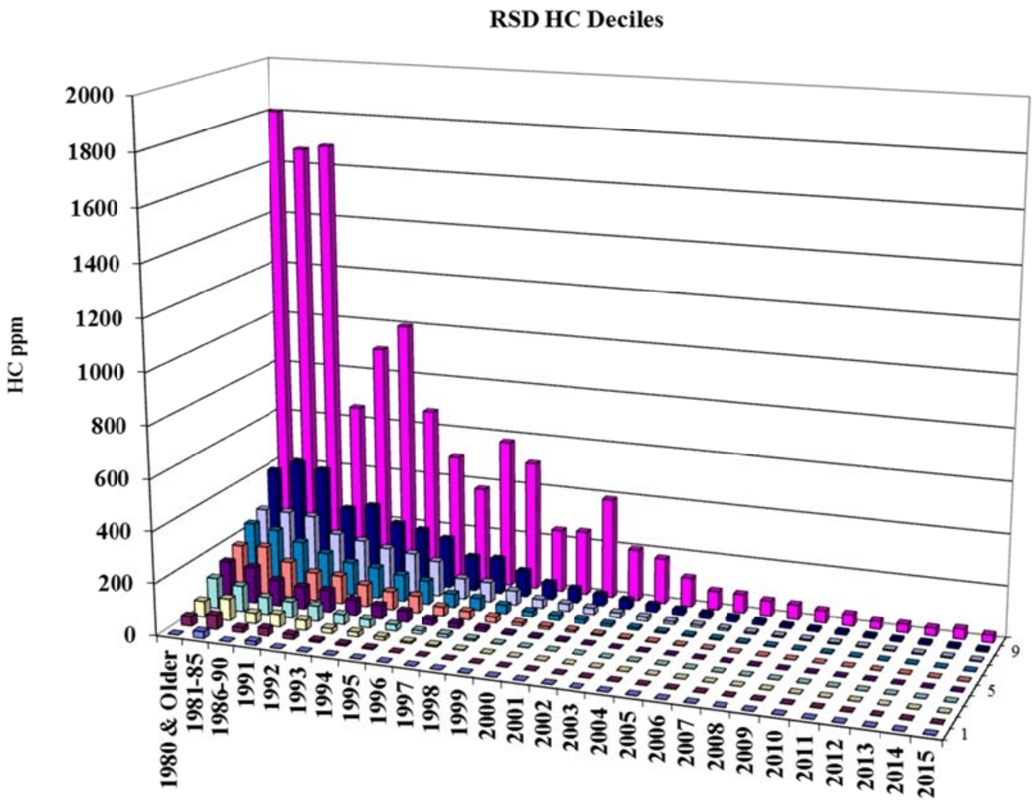
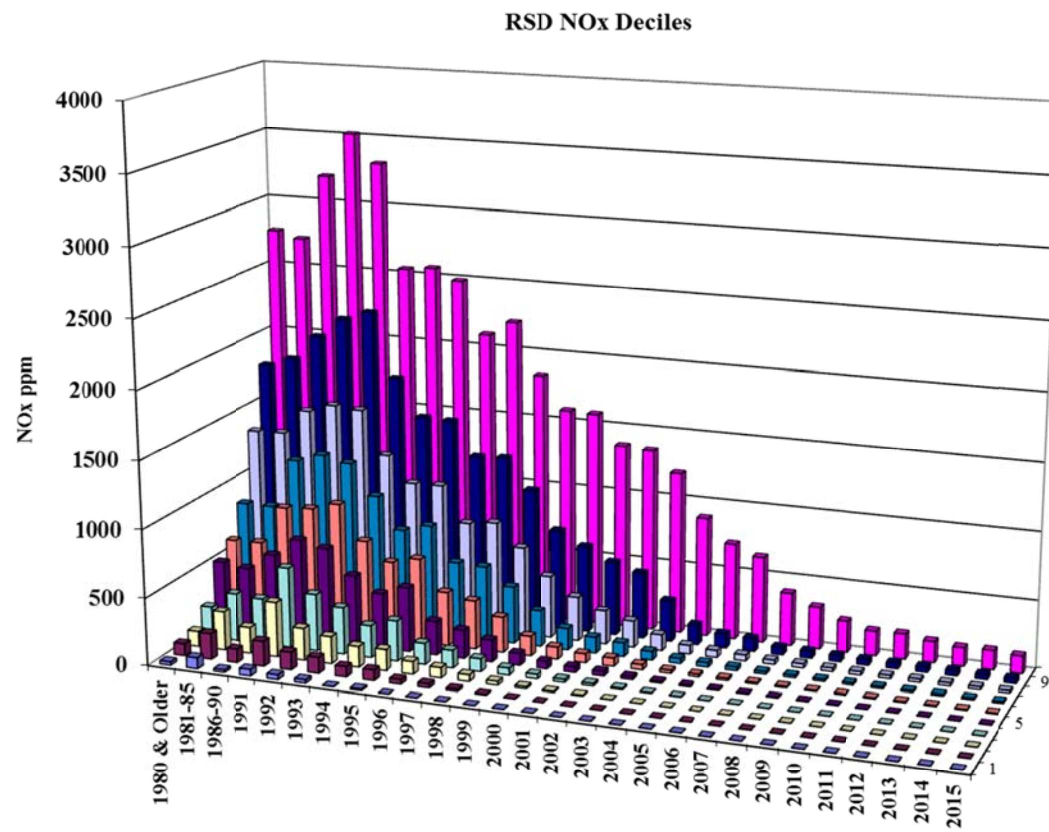


Figure IV-7 NO_x Deciles by Model Year



V. Tested and Untested Vehicles

A. Percent of Vehicles Tested

The on-road vehicles with plates matching Maryland Motor Vehicle Administration registrations were compared against the database of I/M inspection results to determine the percentage of on-road vehicles that have been inspected. Tests from January 2013 through June 2015 were examined. This covers the period from two years five months before the start of the on-road survey in May through almost the end of the survey on July 2015.

Matching Vehicle Emissions Inspection Program (VEIP) inspection records were identified for 90% of the 1981 to 2012 gasoline fueled model vehicles less than 10,000 lbs GVWR that were seen on the road and registered in counties subject to the VEIP program and 89% of gasoline fueled vehicles 10,000 lbs GVWR and over. The trends are shown by vehicle type and model year in Figure V-1. The first two model years are exempt from I/M inspection and 2013 models were part way through the inspection year when the matching tests were queried in July 2015.

Not all vehicles were subject to the program; diesel, solely electric, historic or antique vehicles and some other classes, e.g. farm, fire and ambulance were exempt. Diesel and electric vehicles identified by VIN were excluded but historic, antique and other exempt classes remain. Delayed recording of license plate transfers or address changes, remote sensing tag editing errors, VIN transcription errors, extensions, and late vehicles can all affect the number of vehicles matched to VEIP results.

The results presented in Figures V-1 and V-2 show the percentage of 1981-2012 model gasoline vehicles less than 10,000 lbs matched to VEIP tests was 90% and the percentage of gasoline fueled vehicles 10,000 lbs and over matched to tests was 89%. However, just because matching VEIP tests were not found does not necessarily mean vehicles were not tested.

The percentages of vehicles identified as being tested were similar to the equivalent percentages in the 2013 survey.

Figure V-2 shows there is a small variation in the percentage of on-road 1981 to 2012 model vehicles matched to VEIP tests by county of registration. VEIP tests were matched to 4% of vehicles registered in counties outside the I/M inspection program.

Figure V-1 % of Vehicles with I/M Tests

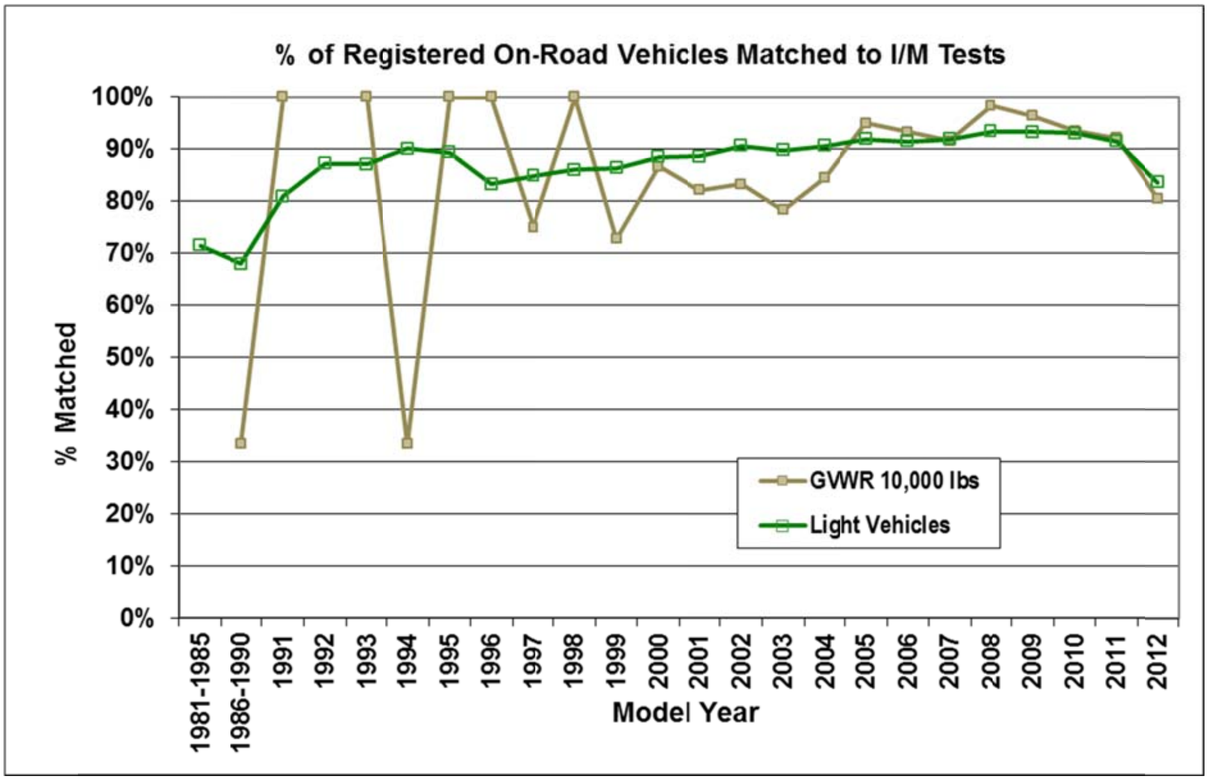
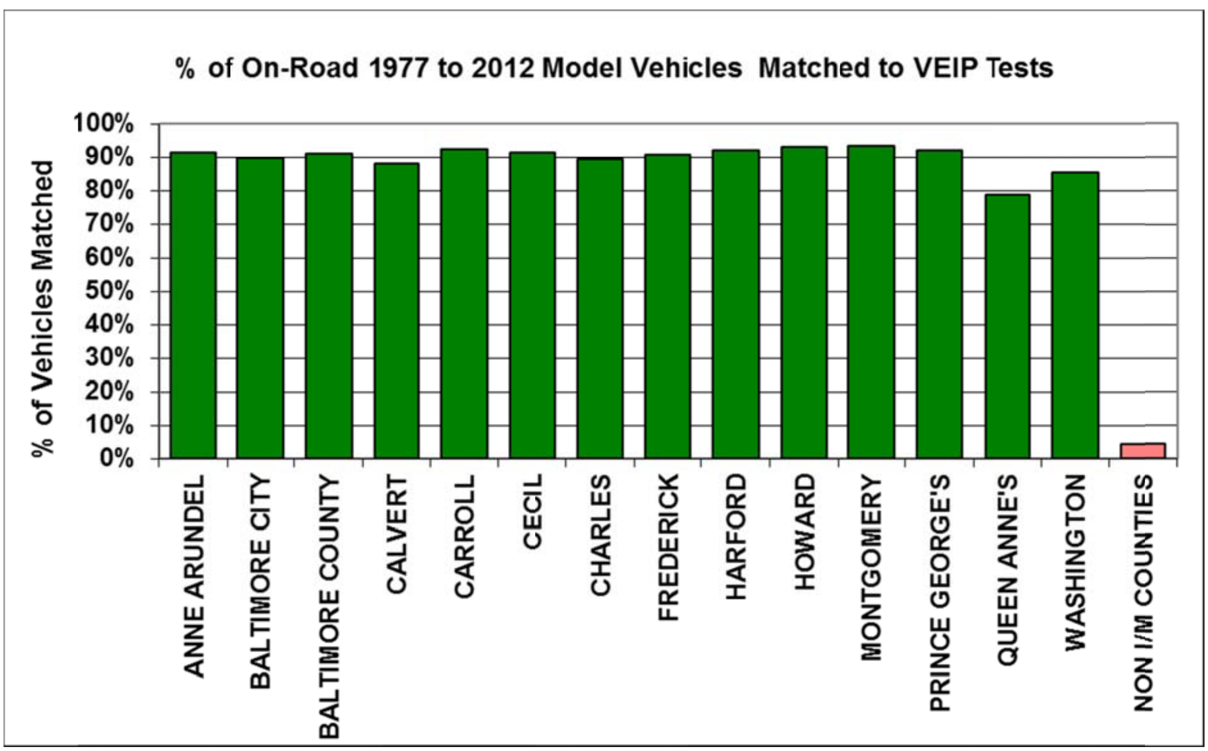


Figure V-2 On-Road Vehicles Matched to VEIP Tests by County of Registration



B. Vehicle Emissions by VEIP Status

The vehicles measured on-road and registered in VEIP counties were separated into three groups:

- Tested WF – vehicles registered to I/M counties for which the last matching VEIP test found was a waiver or a fail
- Unmatched – vehicles registered to I/M counties for which no matching VEIP inspection record was found
- Tested P – vehicles registered to I/M counties for which the last matching I/M test found was a pass

As noted earlier, only part of model year 2013 vehicles had been I/M inspected and model years 2014 and 2015 were exempt at the time of the remote sensing survey. Therefore, only model years 1977 through 2012 were included in this comparison. Diesel and electric vehicles were excluded.

Table V-1 shows the measurements and Figures V-3 through V-8 compare the emissions for these three groups of vehicles. This comparison should be treated with some caution as site-to-site differences have an effect on the emissions levels observed. In addition, the 'Unmatched' and 'Tested WF' bin for '1990 & older' vehicles contained fewer than ten measurements.

Model 1991-2005 vehicles whose last test resulted in a waiver or a fail typically had emissions 1 to 5 times those of vehicles passing their last test. HC emissions of 2006 to 2012 models passing inspection were less than 1 ppm while emissions of those in the waiver or fail group were 13 ppm and 11 ppm for passenger vehicles and light trucks respectively.

Unmatched models typically had higher emissions than those with passing test records.

Table V-1 Light Vehicles Matched to I/M Test Result

Model Years	Unmatched to Test	Tested Waiver or Fail	Tested Pass	Total
Passenger Vehicles				
1990 & older	8	1	21	30
1991-1995	38	11	249	298
1996-2000	274	173	1,466	1,913
2001-2005	472	275	3,925	4,672
2006-2012	1,005	97	8,998	10,100
Light Trucks				
1990 & older	14	2	22	38
1991-1995	23	13	201	237
1996-2000	203	170	1,222	1,595
2001-2005	524	338	4,654	5,516
2006-2012	859	156	9,358	10,373
Total	**3,420**	**1,236**	**30,116**	**34,772**

Figure V-3 Passenger Vehicle CO by VEIP Status

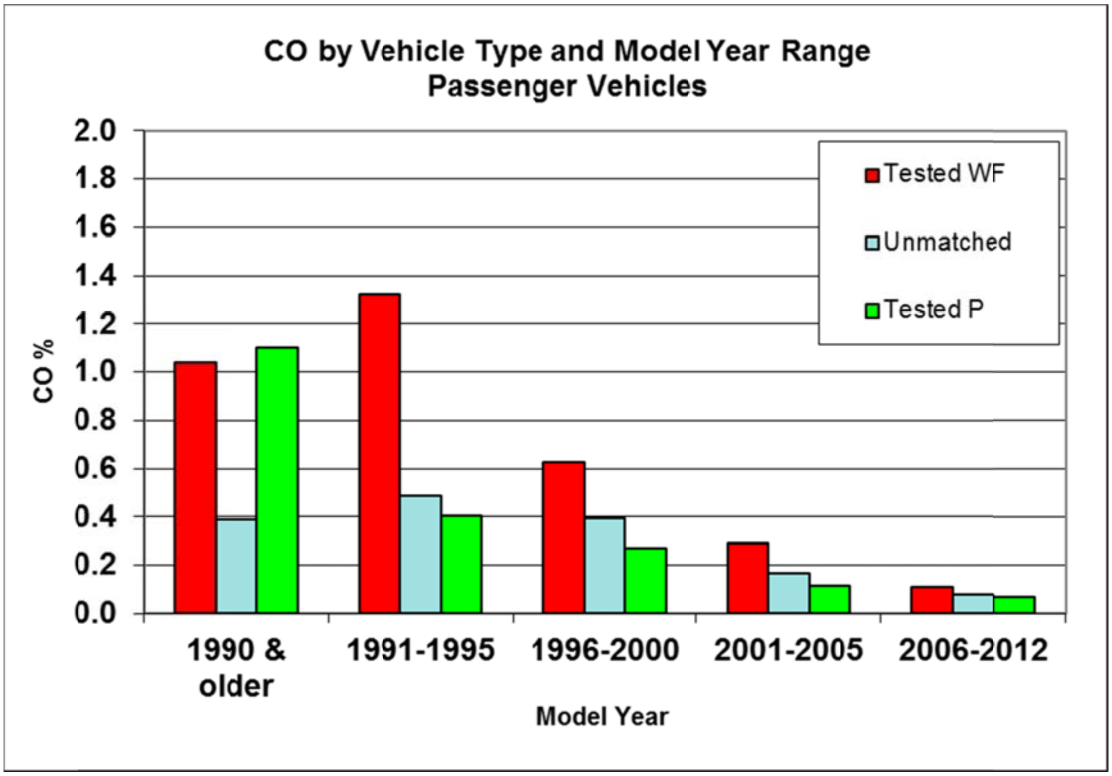


Figure V-4 Light Truck CO by VEIP Status

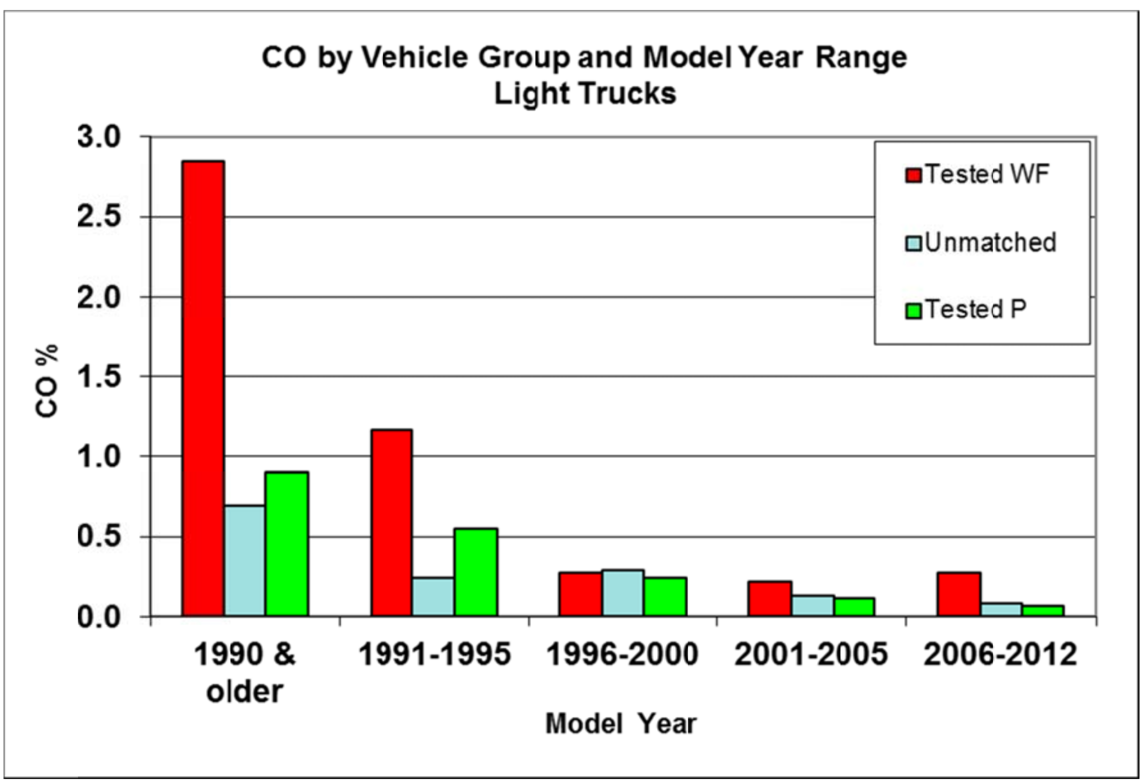


Figure V-5 Passenger Vehicle HC by VEIP Status

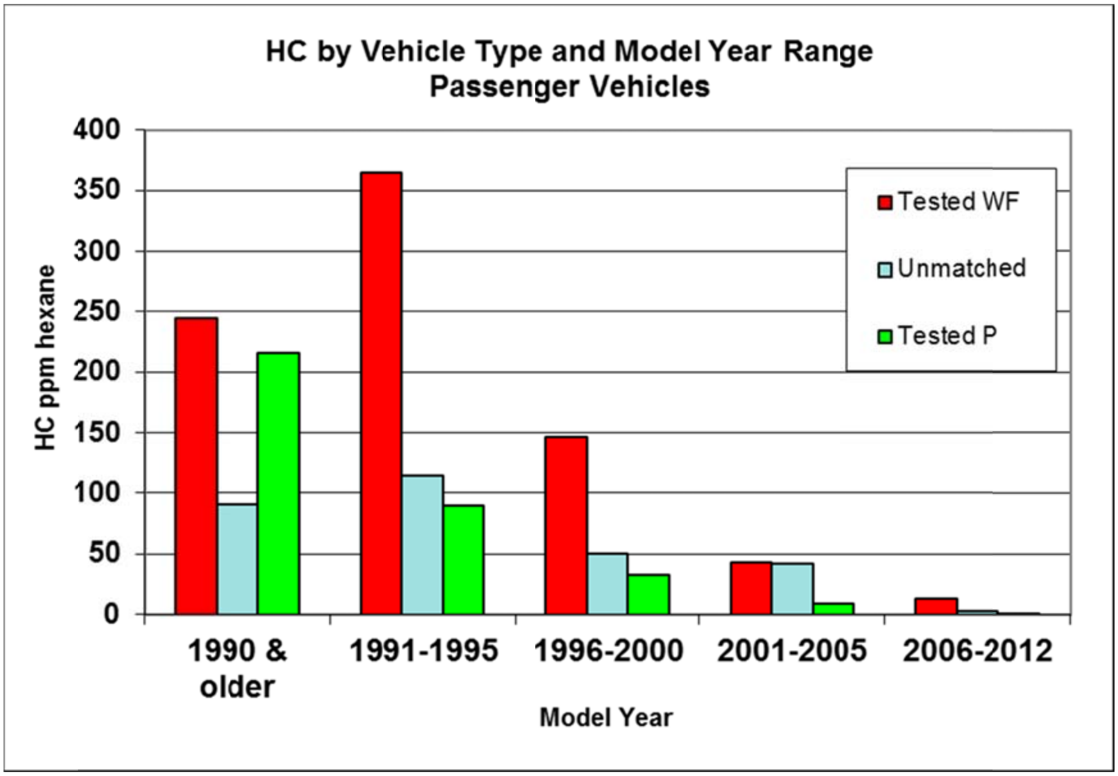


Figure V-6 Light Truck HC by VEIP Status

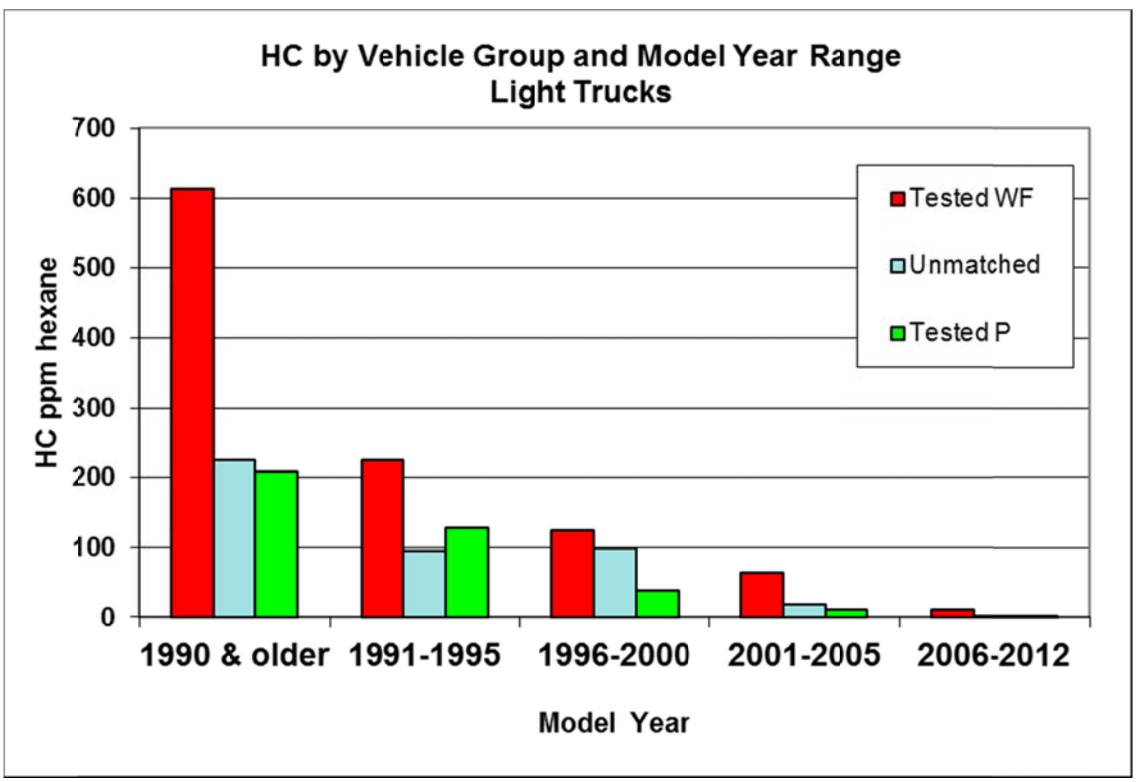


Figure V-7 Passenger Vehicle NO_x by VEIP Status

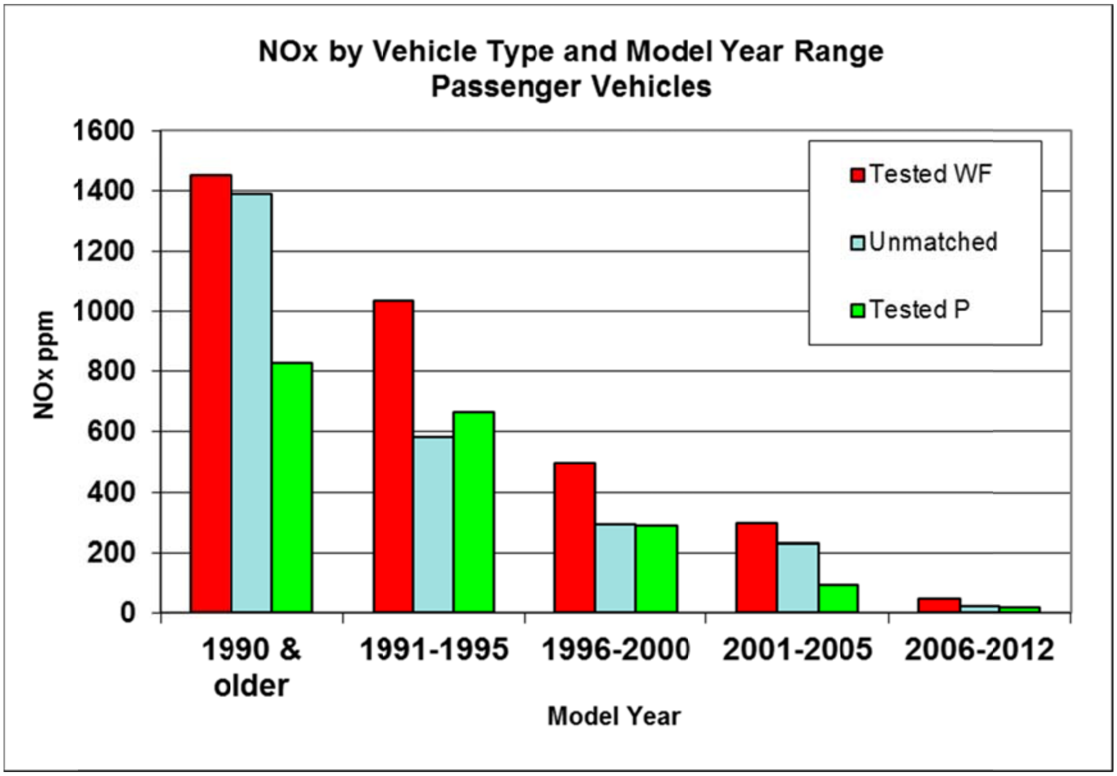
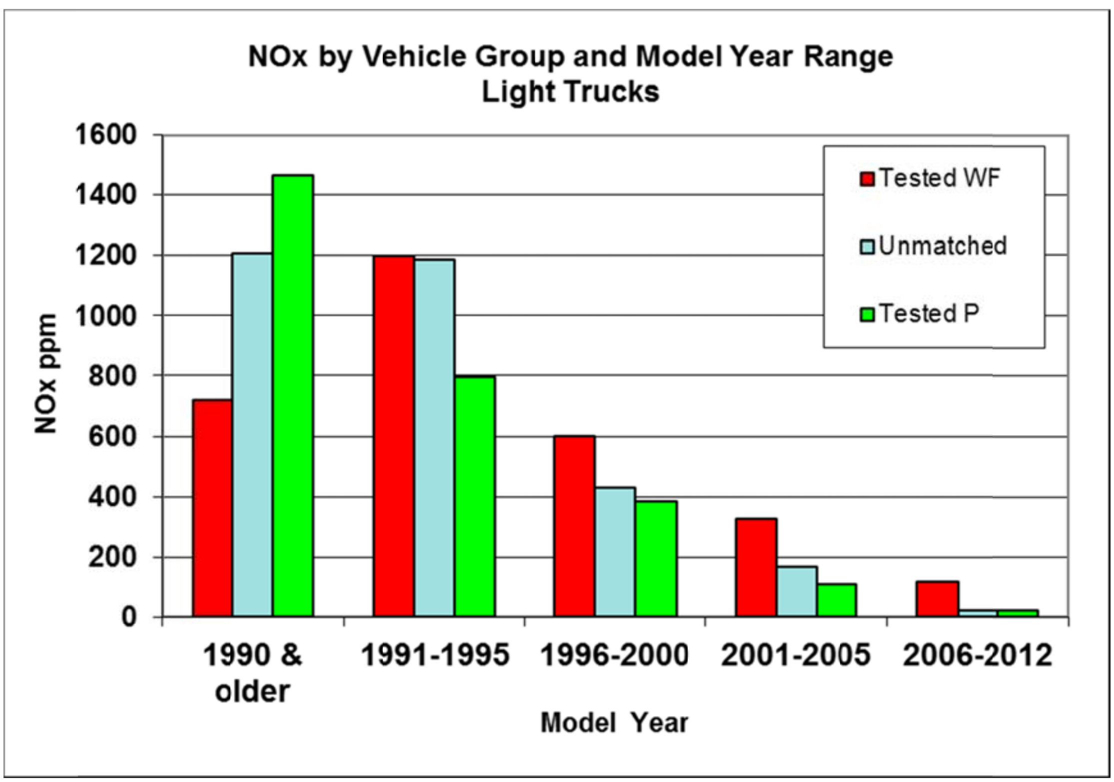


Figure V-8 Light Truck NO_x by VEIP Status



C. I/M and Non I/M Emissions

The vehicles measured on-road were separated into two groups based on their registration county:

- Non-VEIP– vehicles registered to counties outside the VEIP testing area;
- VEIP counties & Baltimore City

The results are plotted in Figures V-9 through V-11. The combined sample of passenger vehicles and light trucks registered in non-I/M counties contains 7,970 measurements. For both passenger vehicles and trucks, the average emissions of I/M registered vehicles are lower than those of non-I/M registered vehicles for HC, CO and NO_x.

Figure V-9 I/M and Non-I/M -CO

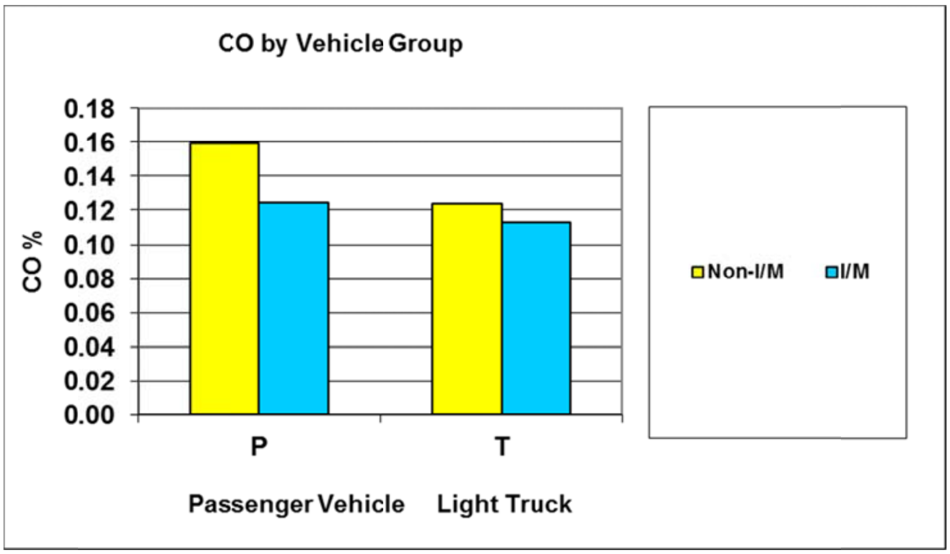


Figure V-10 I/M and Non-I/M - HC

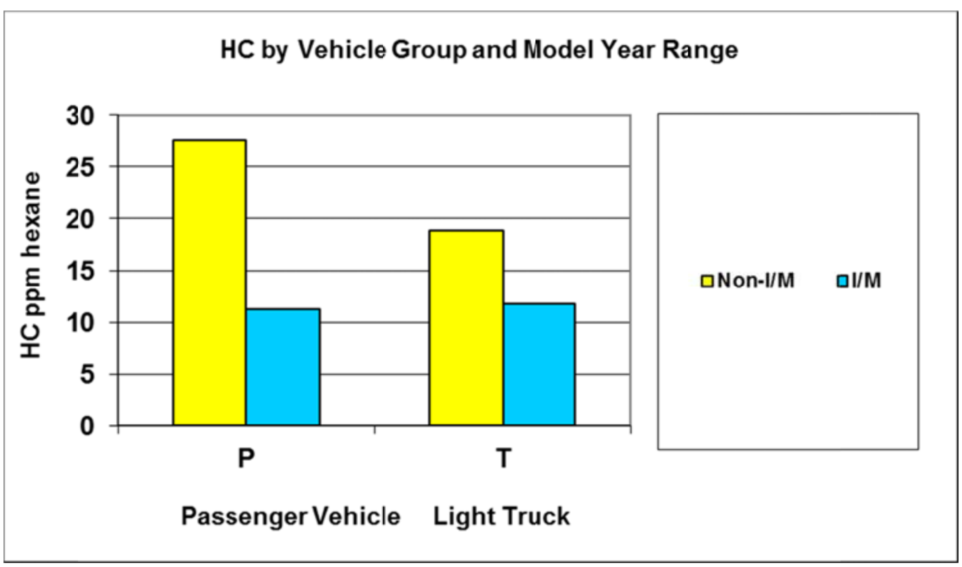
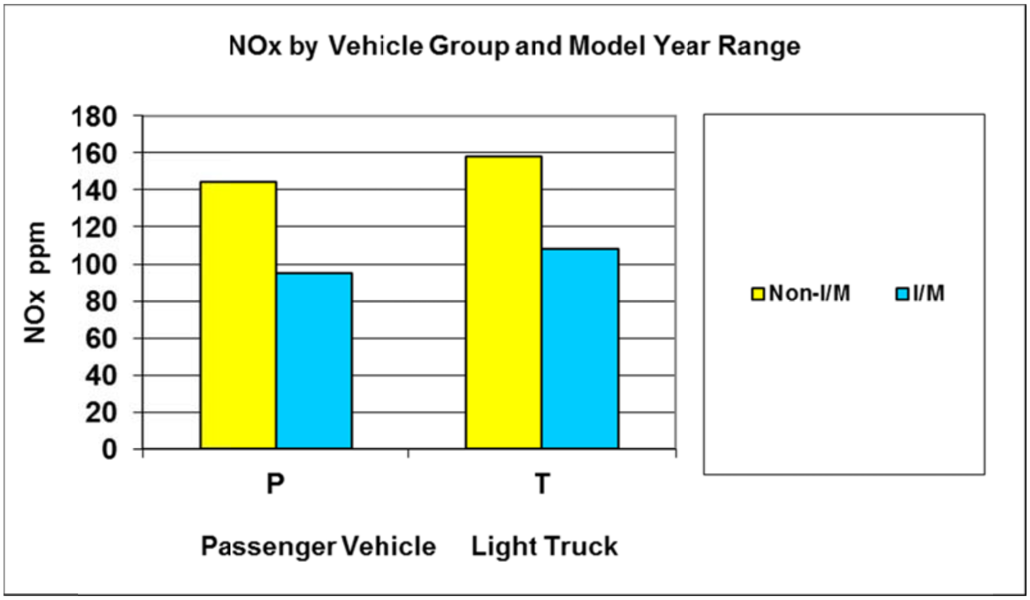


Figure V-11 I/M and Non-I/M - NO_x



D. Non-VEIP Traffic in VEIP Counties

Table V-2 lists the number and percentage of non-VEIP County vehicles observed at VEIP County sites. Approximately 1.8% of light duty vehicle traffic in VEIP counties were registered in non-VEIP counties. Half of these were measured in Calvert and Queen Anne's counties.

Table V-2 Non-I/M County Registered Vehicles at I/M County Sites

County	Site	City	Non-VEIP Vehicles	Non-VEIP % of Traffic
Anne Arundel	AA13	Annapolis	19	2.0%
Anne Arundel	AA14	Glen Burnie	47	1.2%
Baltimore City	BA20	Baltimore	1	0.2%
Baltimore City	BA25	Baltimore	10	0.4%
Baltimore County	BA03	Essex	3	0.2%
Baltimore County	BA05	Halethorpe	40	0.8%
Calvert	CL13	Lusby	121	12.8%
Carroll	CR01	Westminster	6	0.3%
Cecil	CE04	Port Deposit	3	0.2%
Charles	CH11	Waldorf	85	4.7%
Frederick	FR14	Frederick	29	0.8%
Harford	HA13	Belcamp	11	0.4%
Howard	HO13	Jessup	26	0.9%
Montgomery	MO10	Burtonville	6	0.3%
Montgomery	MO11	Chevy Chase	46	0.9%
Prince George's	PG10	Bowie	35	1.1%
Prince George's	PG11	Laurel	36	1.0%
Queen Anne's	QA05	Centreville	284	32.6%
Washington	WA12	Hagerstown	8	0.4%
Total I/M Counties			816	1.8%

VI. High Emitters

For this survey, high emitters were identified using cutpoints listed in Table VI-1. Vehicles have been divided into three classes: 1) 0 to 6,000 lbs, 2) 6,001 to 10,000 lbs, and 3) over 10,000 lbs. The cutpoints for HC in this table are specified in ppm hexane, i.e. concentrations of C_6 molecules, which is consistent with most I/M inspection equipment used to measure tailpipe concentrations. Remote sensing NO_x emissions were corrected for humidity as described in Section III before being compared to the high emitter standards.

In 2015 the cutpoints were modified from the cutpoints previously used and shown in Table VI-2. The main changes were the inclusion of lower, stricter cutpoints for 2007 and newer models and adjustment of NOx cutpoints.

Table VI-1 On-Road High Emitter Cutpoints for 2015

Year		GVWR <= 6,000 lbs			GVWR 6,001-10,000 lbs			GVWR 10,001+ lbs		
From	To	HC (ppm)	CO (%)	NOx (ppm)	HC (ppm)	CO (%)	NOx (ppm)	HC (ppm)	CO (%)	NOx (ppm)
1977		500	6.0	3000	580	7.0	3500	650	7.0	4500
1978		430	5.5	3000	550	6.7	3500	650	7.0	4500
1979		400	4.0	2750	470	5.0	2750	650	6.5	4500
1980		220	2.6	2750	350	5.0	2750	500	6.0	4500
1981		220	2.0	2750	250	3.0	2750	500	6.0	4500
1982		220	2.0	2750	220	2.5	2750	500	6.0	4500
1983		220	2.0	2750	220	1.5	2750	500	3.5	4500
1984		220	1.5	2250	220	1.5	2250	440	3.0	4500
1985		220	1.5	2250	220	1.5	2250	440	3.0	4500
1986		220	1.5	2250	220	1.5	2250	280	2.5	4500
1987		220	1.5	2250	220	1.5	2250	250	1.8	4500
1988		220	1.5	1650	220	1.5	1650	250	1.8	4500
1989		220	1.5	1650	220	1.5	1650	250	1.8	4500
1990		220	1.5	1650	220	1.5	1650	250	1.8	4500
1991		220	1.5	1650	220	1.5	1650	250	1.8	3300
1992		220	1.5	1650	175	1.5	1650	250	1.8	3300
1993		220	1.5	1650	175	1.5	1650	250	1.8	2750
1994		220	1.5	1650	175	1.5	1650	250	1.8	2750
1995		220	1.5	1650	175	1.5	1650	250	1.8	2750
1996	2000	100	1.0	1650	150	1.0	1650	200	1.5	2750
2001	2006	100	1.0	1650	150	1.0	1650	175	1.5	2200
2007		80	1.0	1450	130	1.0	1450	175	1.5	2200
2008	2015	80	1.0	1450	130	1.0	1450	175	1.5	1650

Table VI-2 On-Road High Emitter Cutpoints for MD RSD Studies 2003-2013

	GVWR <= 6,000 lbs			GVWR 6,001-10,000 lbs			GVWR 10,001+ lbs		
Year	HC (ppm)	CO (%)	NOx (ppm)	HC (ppm)	CO (%)	NOx (ppm)	HC (ppm)	CO (%)	NOx (ppm)
1977	700	7	2,718	700	7	2,557	700	7	5,000
1978	645	7	2,718	700	7	2,557	700	7	5,000
1979	600	6	2,718	700	7	2,045	700	7	5,000
1980	330	2.6	2,718	525	7	2,045	700	7	5,000
1981	330	1.8	2,718	375	4.5	2,045	700	7	5,000
1982	330	1.8	2,718	330	3.8	2,045	700	7	5,000
1983	330	1.8	2,718	330	2.3	2,045	700	5.3	5,000
1984	264	1.8	2,252	311	1.8	1,969	660	4.5	4,500
1985	264	1.8	2,252	292	1.8	1,969	660	4.5	4,500
1986	264	1.8	2,252	292	1.8	1,969	420	3.8	4,500
1987	264	1.8	2,252	187	1.8	1,969	330	1.8	4,500
1988	264	1.8	1,243	180	1.8	1,917	330	1.8	4,500
1989	264	1.8	1,243	180	1.8	1,917	330	1.8	4,500
1990	264	1.8	1,243	180	1.8	1,917	330	1.8	4,500
1991	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1992	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1993	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1994	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1995	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1996+	100	1.0	893	168	1.0	1,457	330	1.8	3,600

In order to be considered a high emitter in Maryland, a vehicle must have 2 or more readings that exceed the standards for the same pollutant on different days. If the standard is exceeded by less than the tolerance of the RSD unit, a third measurement is required for confirmation. Vehicles with out-of-State registrations were not considered in the high emitter analysis because their type and model year was unknown. Correct high emitter cutpoints cannot be selected without this information.

Some 1,483 vehicles had two or more valid remote sensing measurements on different days within the normal VSP operating range of 3 to 22 kW/t and 80% were 2004 and newer models. Twenty-two (22) of the 1,483 vehicles exceeded the cutpoints on both of their last two measurements for the same pollutant.

Fourteen (14) vehicles exceeded the standard by more than the tolerance of the RSD unit on their last two measurements and qualify as high emitters.

Eight (8) suspected high emitting vehicles required additional confirmation by a third measurement. One of these vehicles, a 2012 Dodge van, had an earlier third measurement that did not confirm high HC. A second vehicle, a 2000 Ford, had three measurements all with high HC but two of the measurements were on the same day at the same site.

The high emitters and suspected high emitters by pollutant are summarized in Table VI-3.

Table VI-3 High Emitters by Pollutant

Pollutant Exceeded	High Emitter	Suspected	Total
HC only	2	5	7
CO only	1	1	2
NO only	4	2	6
HC & CO	3	0	3
HC & NOx	4	0	4
CO & NOx	0	0	0
All	0	0	0
Total	14	8	22

The high emitters that exceeded the standard by more than the tolerance of the RSD unit on their last two measurements are listed in Table VI- 4. Those requiring a third measurement are listed in Table VI-5.

Table VI-6 shows the emissions of one suspect vehicle with a third measurement that was not confirmed to be a high emitter.

Table VI-4 High Emitters

			Registration	Date		HC Values			CO Values			NOx Values		
Year	Make	Body Style	County	Last	Prev	Std	Last	Prev	Std	Last	Prev	Std	Last	Prev
High Emitters (Last two measurements both exceed the emissions standards for at least one pollutant by more than the RSD tolerance).														
1985	DODG	TK	T	08-Jul-15	11-Jun-15	220	296	402	1.5	3.6	4.5	2,250	202	321
1994	FORD	TK	F	07-Jul-15	04-Jun-15	200	100	58	1.5	0.0	0.0	1,650	3,113	2,372
1995	MERZ	4S	PG	29-May-15	15-May-15	200	678	636	1.5	0.0	0.0	1,650	287	2
1995	CHEV	TK	PG	26-Jun-15	15-May-15	175	168	122	1.5	0.1	0.1	1,650	4,164	3,228
1997	TOYT	4S	PG	29-May-15	21-May-15	100	634	1,792	1.0	0.6	0.5	1,650	367	301
1998	HOND	4S	BC	26-Jun-15	19-May-15	100	60	59	1.0	1.3	1.3	1,650	491	320
1998	HOND	4S	PG	29-May-15	15-May-15	100	284	126	1.0	1.7	1.6	1,650	1,055	778
2002	HOND	2S	PG	25-Jun-15	21-May-15	100	119	49	1.0	0.1	0.0	1,650	3,661	3,243
2002	NISS	4S	AA	09-Jul-15	19-May-15	100	167	105	1.0	0.8	0.7	1,650	2,273	2,264
2003	INFI	4S	QA	26-Jun-15	19-May-15	100	3	21	1.0	0.1	0.1	1,650	2,873	2,519
2003	NISS	4S	PG	25-Jun-15	21-May-15	100	285	257	1.0	0.6	0.4	1,650	2,292	2,278
2003	VOLK	4S	QA	08-Jun-15	20-May-15	100	293	286	1.0	0.4	0.6	1,650	3,086	2,642
2004	VOLK	4S	K	11-Jun-15	20-May-15	100	144	208	1.0	0.6	0.6	1,650	2,085	2,279
2005	PONT	4S	HA	20-May-15	19-May-15	100	155	123	1.0	1.6	1.5	1,650	1,813	1,417

Table VI-5 Suspected High Emitters Requiring a Third Measurement

Year	Make	Body Style	Registration County	Date Last	Date Prev	HC Values Std	HC Last	HC Prev	CO Values Std	CO Last	CO Prev	NOx Values Std	NOx Last	NOx Prev
A third reading is needed to verify high emitter status (The last two measurements exceed standard by less than the RSD tolerance).														
1997	FORD	VN	BC	20-May-15	18-May-15	100	33	134	1.0	0.3	(0.0)	1,650	1,817	2,715
2000	FORD	SW	HA	01-Jul-15	26-May-15	100	862	117	1.0	0.2	0.3	1,650	1,555	947
2001	BMW	2H	BC	20-May-15	18-May-15	100	3	(1)	1.0	2.2	1.1	1,650	73	162
2001	DODG	VN	F	07-Jul-15	04-Jun-15	100	143	346	1.0	0.5	0.1	1,650	60	35
2007	TOYT	4S	BC	25-Jun-15	21-May-15	80	178	143	1.0	0.3	0.4	1,450	597	687
2009	FORD	HY	M	25-Jun-15	21-May-15	80	0	(3)	1.0	0.1	0.0	1,450	2,231	1,452
2012	DODG	VN	0	09-Jul-15	26-Jun-15	130	880	146	1.0	0.5	0.7	1,450	131	78
2014	FORD	2S	BA	20-May-15	18-May-15	80	148	212	1.0	1.0	0.8	1,450	1,017	1,215

Table VI-6 Third Measurements of High Emitters

Year	Make	Body Style	Registration County	Date Last	Date Prev	Date 2nd Prev	HC Values Std	HC Last	HC Prev	HC 2nd Prev	CO Values Std	CO Last	CO Prev	CO 2nd Prev	NOx Values Std	NOx Last	NOx Prev	NOx 2nd Prev
2012	DODG	VN		09-Jul-15	26-Jun-15	19-May-15	130	880	146	55	1.00	0.51	0.65	0.32	1450	131	78	173

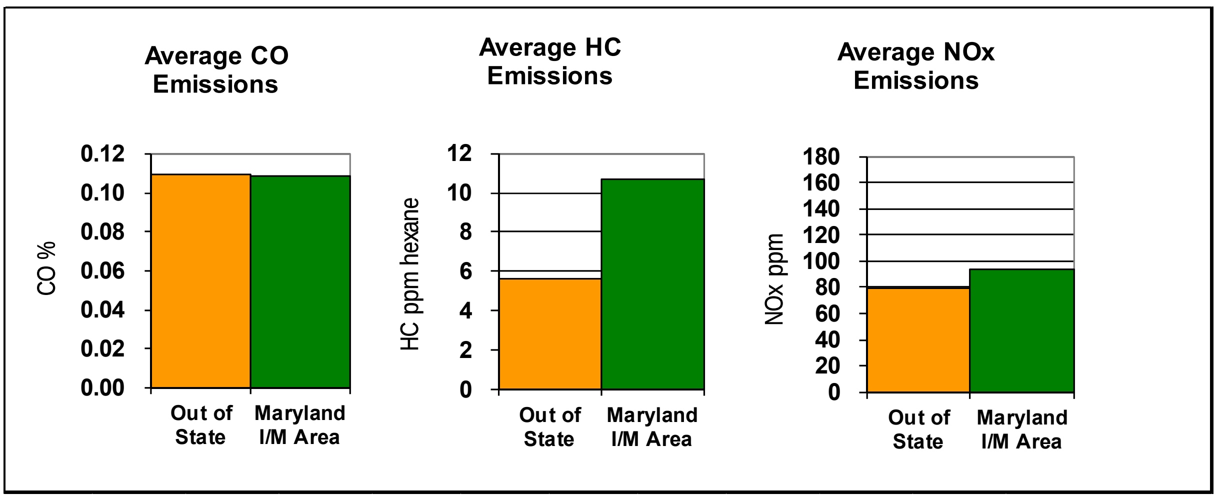
VII. Out of State Vehicles

Valid measurements were obtained on 13,326 vehicles with out of state plates. This is 19% of the surveyed vehicles with valid measurements and a visible plate. Because these vehicles are registered to other states, specific information about the type and age of these vehicles is not available as part of this survey. Compared to the surveyed vehicles registered in the Maryland I/M counties the vehicles from out-of-state had similar CO, 48% lower HC and 15% lower NO_x. In the 2013 survey, out-of-state vehicles had higher HC and NO_x. Lower out-of-state vehicle HC was evident at twenty out of twenty-three sites. Differences could reflect different Maryland and Out-of-State vehicle age profiles at the sites. More than half the out-of-state plate measurements were obtained at three sites; BA05, MO11 and AL12. Ninety percent of measurements at AL12 were out-of-state plates.

The Maryland vehicles on average were measured at 8% lower vehicle specific power than the out-of-state vehicles.

No conclusions can be drawn as to whether the out-of-state fleet is cleaner or dirtier for equivalent aged vehicles because the age of the out-of-state fleet is unknown. The comparative emissions are shown in Figure VII-1.

Figure VII-1 Maryland I/M and Out-of-state Vehicle Emissions

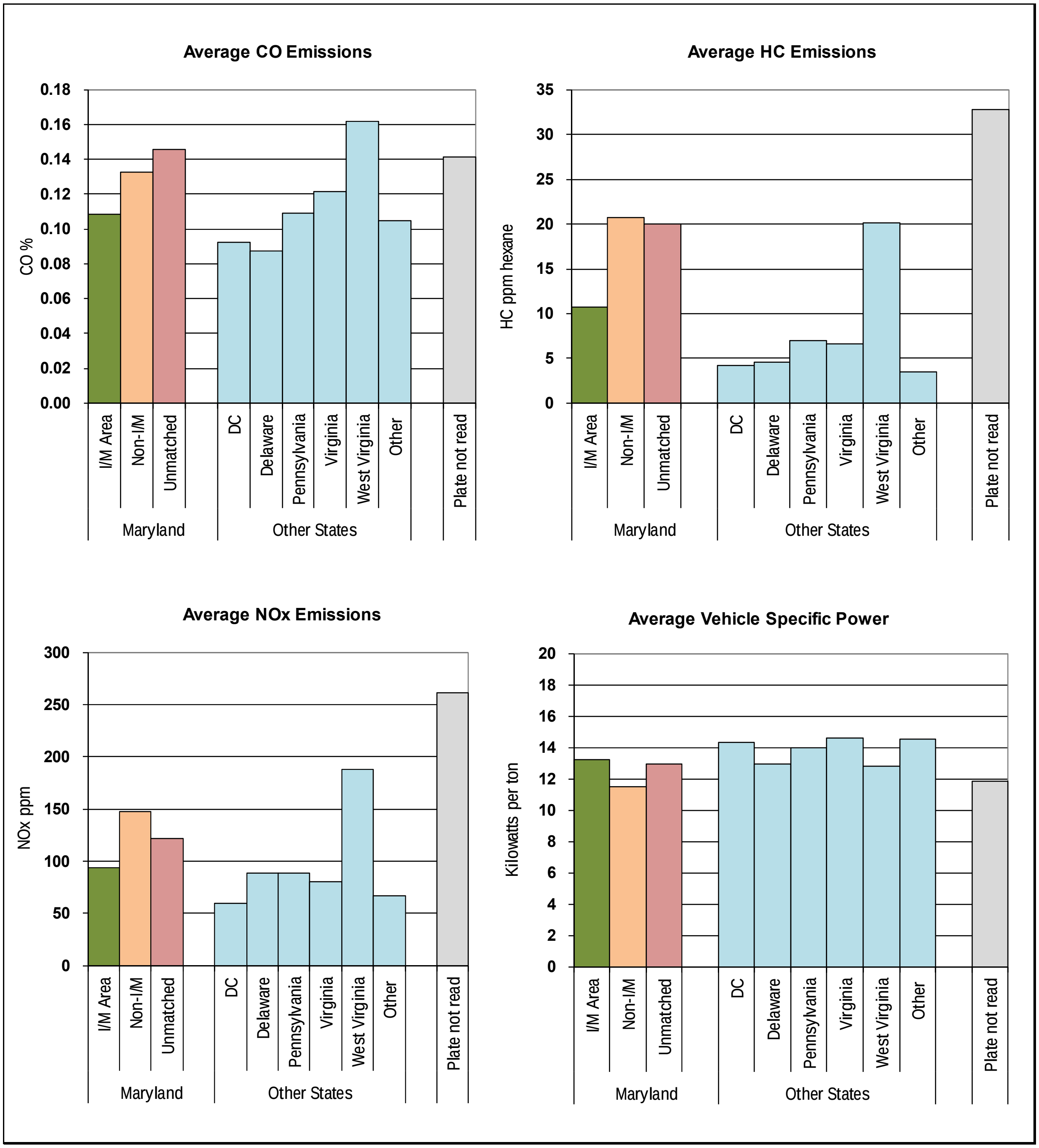


Average emissions and the average measured vehicle specific power are shown by jurisdiction in Figure VII-2. As noted in Section V, vehicles registered in Maryland counties subject to I/M had lower emissions than those registered in counties not subject to I/M. Vehicles registered in Maryland counties subject to I/M also had lower emissions than vehicles with Maryland plates that were not matched to a registration.

Vehicles from West Virginia, which has no I/M program, had higher average emissions of HC, CO and NO_x than both Maryland vehicles registered in I/M counties and vehicles from other states with I/M programs.

Vehicles whose plates were not captured or could not be read may be larger vehicles such as medium-duty trucks, vehicles with tow hitches or pulling trailers and vehicles with dirty or obscured plates. These vehicles had the highest average emissions of all pollutants.

Figure VII-2 Emissions by Plate Jurisdiction



References

1 McClintock, P. "The Colorado Enhanced I/M Program 0.5% Sample Annual Report" Prepared for the Colorado Department of Public Health and Environment, 1998.

2 Lindner, J. "Draft Guidance on Use of In-Program Data for Evaluation of I/M Program Performance" EPA, August 2001