APPENDIX A: OVERSIZE/OVERWEIGHT VEHICLE REGULATIONS IN TEXAS

This appendix covers the regulations of OS/OW vehicle operations in Texas. This includes the history of regulations in the state, current legal limits for permitted loads operating in Texas, the types of permits issued in Texas, and the movement restrictions on permitted loads.

BRIEF HISTORY OF OS/OW VEHICLE REGULATIONS IN TEXAS

Truck size and weight (TS&W) was first regulated at the federal level by the Federal-Aid Highway Act in 1956. The regulation set maximum Gross Vehicle Weight (GVW) at 73,280 pounds for trucks, 18,000 pounds for single-axle loads, and 32,000 pounds for tandem-axle loads. Prior to 1956, TS&W was regulated at the state level beginning in 1913 in Maine and Massachusetts (1).

The Federal-Aid Highway Act Amendments of 1974 increased the maximum GVW limits to 80,00 pounds and the axle load limits to 20,000 pounds and 34,000 pounds for single and tandem axles, respectively. The new limits provided in the 1974 legislation were not mandatory for the states until the enactment of the Surface Transportation Assistance Act of 1982, which required all states to adopt the 1974 GVW and axle load limits for the interstate system. A grandfather clause was added in both the 1974 and 1982 federal acts to allow states with previously established higher TS&W limits to retain the higher limits. The next grandfather clause occurred in the Intermodal Surface Transportation Efficiency Act of 1991, which set long combination-vehicle weight limits (2).

Texas's TS&W regulations were first enacted in 1929 but have been amended through a number of major regulations detailed in Table A1.

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1. Prozzi, J. A., P. Buddhavarapu, Kouchaki, J. Weissmann, A. Weissmann, N. Jiang, K. Savage, and C. M. Walton. *Infrastructure-Friendly Vehicles to Support Texas Economic Competitiveness*. Report 0-6817-1. Center for Transportation Research, 2017.
2. Texas Department of Transportation. Texas Administrative Code, Chapter 28, Oversize and Overweight Vehicles and Loads. http://txrules.elaws.us/rule/title43_chapter28. Accessed October 31, 2018.

Table A1. Major OS/OW Regulation Legislation in Texas (3)

Bill No.	Year	Major Components
House Bill (HB) 336	1931	Authorizes the Department of Highways to issue permits limited to periods of 90 days or less for transportation of OS/OW or overlength commodities that could not be reasonably dismantled, and transportation of super-heavy or OS equipment. Authorizes the department to designate county judges along with its designated agencies to be granted authority to issue such permits. Also authorizes commissioners courts through the county judges to issue permits for movement over the highways of their respective counties. Authorizes commissioners courts to require a bond in an amount sufficient to guarantee payment of any damages to the road/bridge.
HB 465	1949	Augments the applicant permit fee: $5 for a permit, $5 for a single trip, $10 for a permit not exceeding 30 days, $15 for a permit not exceeding 60 days, and $20 for a permit not exceeding 90 days. Fees are to be deposited to the State Highway Fund.
SB (Senate Bill) 57	1951	Sets the allowable GVW load limit to 58,420 pounds based on the 1946 American Association of State Highway Officials bridge formula. Increases the GVW load limit from 48,000 pounds to encourage truckers to add an additional axle, thus reducing the number of OW axles. It was anticipated that the users would, as a result, use combination vehicles of four or more axles, and add to the payload as a consequence, which would eliminate OW axles.
HB 182	1971	Authorizes short-term movement of seasonal agricultural products to markets/points of sale that are of larger tonnage for one year. Sets the permit fee as a percentage of the difference between regular annual registration and the annual fee for heavier tonnage based on the number of months requested.
SB 351	1971	Authorizes short-term movement of seasonal agricultural products to markets/points of sale that are of larger tonnage for one year. Sets the permit fee as a percentage of the difference between regular annual registration and the annual fee for heavier tonnage based on the number of months requested.
SB 142	1973	Gives the department authority to issue an annual permit with a $50 fee for movement of unladen lift equipment motor vehicles that exceed maximum weight and width limitations.
HB 81	1977	Sets registration and width requirements for vehicles used to transport/spread fertilizer, including agricultural limestone. Sets an annual license fee for a vehicle used exclusively for this purpose at $50. Width requirements do not apply to a registered vehicle that is 136 inches or less at its widest part.

3. This table is apadpted from Prozzi, J. M. Murphy, L. Loftus-Otway, A. Banerjee, M. Kim, H, Wu, J.P. Prozzi, R. Hutchinson, R. harrison, C.M. Walton, J. Weissman, A. Weissmann.. *Oversize/Overweighyt Vehicle Permit Study Fee*. Report 0-6736-2. Center for Transportation Research, 2012. https://ctr.utexas.edu/wp-content/uploads/pubs/0_6736_2.pdf. Accessed February 2020.

Bill No.	Year	Major Components
HB 1121	1977	Authorizes vehicles used exclusively to transport milk to use highways if the distance between the front wheel and the forward tandem axle and rear wheel of the rear tandem axle is at least 28 feet and the maximum load carried on any group of axles does not exceed 68,000 pounds.
HB 638	1979	Authorizes vehicles used to exclusively transport seed cotton modules to exceed the limitation for length but not to exceed 48 feet, and to exceed the limitations on weight provided the load on any one axle does not exceed 20,000 pounds and 44,000 pounds on a tandem axle. Requires the overall GVW to not exceed 64,000 pounds. Requires the owner of a vehicle with a tandem axle weight greater than 34,000 pounds to compensate the state for all damages to the highway caused by the weight of the tandem axle load.
HB 931	1981	Amends the width limit allowed on interstate highways.
HB 869	1981	Allows a vehicle that does not exceed 100,000 pounds and is transporting grain to cross the width of a highway from a private property to another private property. Requires an agreement with the department to indemnify for the cost of maintenance/repair for damage caused by vehicles crossing that portion of the highway.
HB 691	1983	Further prohibits commercial vehicles of excessive weight from using state-maintained highways inside of incorporated city limits of cities with more than 1.5 million in population.
HB 860	1983	Sets the height limit for vehicles transporting cottonseed at 14 feet 6 inches.
HB 1114	1983	Extends the standard weight limits to state highways located in incorporated cities. Adds enforcement by municipal police offices from cities with a population greater than 1.5 million. Sets a stricter fine. Exempts loading of agricultural or forestry commodities prior to the first processing of the commodity.
HB 1601	1983	Amends definitions for truck-tractors to conform to federal statutes, amends various statutes to eliminate prescribed limits for truck-tractor combinations, and establishes limits for the lengths of trailers and semi-trailers.
HB 1602	1983	Amends Articles 6701d-11 and 6701d-11a, VTCS, to raise width limits and set lower limits on specially designated highways. Amends related statutes to conform with federal laws.
SB 1438	1983	Amends Article 6701-1/2, VTCS, by adding new language that prohibits manufactured housing from being moved over roads except in accordance with permits issued by the department. Authorizes local subdivisions to designate routes to be used within their boundaries but not to require an additional fee or license.
HB 797	1985	Creates a system for OS/OW permits to be acquired by phone. Exempts oilfield equipment transportation vehicles from truck length limits. The Legislative Budget Board estimated revenue losses from the highway fund of $5,860,000 each year for the five years after bill passage.
HB 1344	1985	Amends the regulation to allow municipal police officers in cities with a population of 100,000 to enforce weight laws.

Bill No.	Year	Major Components
SB 1114	1985	Allows dealers moving OS implements for husbandry to secure annual permits for $90. Authorized the county judge to issue an annual permit.
HB 14	1986	Amends Article 6701a, VTCS, to allow telephone permits for OS/OW vehicles.
HB 9	1987	Repeals Article 6701d-15, VTCS, which set the length of oil well service units that could be operated over state highways at 40 feet so that these vehicles could now operate at limits of 45 feet.
HB 647	1987	Allows courts to set a lesser fine than previously stipulated for violations of axle load if the gross weight limit is not exceeded.
HB 647	1987	Allows courts to set a lesser fine than previously stipulated for violations of axle load if the gross weight limit is not exceeded.
HB 1646	1987	Amends Article 6701a, VTCS, by adding a new section on penalty provisions for offenses of provisions contained in the bill. Violations of the act are misdemeanors.
HB 361	1989	Amends Article 6701d-11, VTCS, to allow module haulers to transport cotton and equipment used in transport and processing of cotton. Deletes all axle load weight limits and requires the owner of a vehicle with a GVW over 59,400 pounds to compensate the political subdivision for damages to roads and bridges caused by the weight of the load.
HB 1892	1989	Amends Article 6701d-11, VTCS, to bring Texas length limits into compliance with the federal statute that established a length limit of 59 feet for semi-trailers.
HB 2060	1989	Amends Article 6675a-6-1/2, VTCS, to allow operation on public roads of certain vehicles and for deposits to the country road and bridge fund. Authorizes the department to issue permits to allow a commercial motor vehicle, truck-tractor, trailer, or semitrailer to operate at a weight that exceeds that allowable axle weight by a tolerance allowance of 10 percent and that exceeds the allowable gross weight by a tolerance of 5 percent. Permits are valid for one year and are $75; $50 of this permit fee is to be remitted to the counties in a ratio based on the total number of miles maintained by the county and the total number of miles of county roads. A bond is required to be filed with the department in the amount of $15,000.
HB 490	1991	Amends 6701d-11 and 6675a-1, VTCS, to change the width requirements for vehicles transporting cotton or cotton-related equipment. Provides for issuance of special license plates for these vehicles.
SB 944	1991	Amends 6701d-11, VCTS, for vehicles loaded with timber, pulp, wood chips, cotton, or agricultural product to have a defense to prosecution as long as they are not on a federal highway.
HB 1896	1993	Authorizes the Transportation Commission to enter into agreements with other states to issue permits (either for the state or on behalf of other states) authorizing transportation of vehicles that exceed legal size/weight limitations.

Bill No.	Year	Major Components
HB 1345	1997	Authorizes TxDOT to issue an annual permit for movement of certain OS/OW vehicles. Sets out a set of load characteristics for safe travel on the state highway system. Sets out how permits fees will be distributed to the general revenue fund and to Fund 6.
SB 1631	1997	Allows TxDOT to contract with a third party to act as its agency for processing permit application and distribution. Allows TxDOT to adopt rules prescribing a payment method, including use of electronic funds/credit cards. Requires that for a single trip, the permit must state highways to be used, but removes the requirement for distance. Requires the region/area over which the equipment is operated to be stated on the permit for multiple trips.
SB 1276	1997	Adds Subchapter K to Chapter 623, Transportation Code, for a new optional procedure for permit issuance by port authorities in counties contiguous to the Gulf of Mexico or a bay/inlet and bordering Mexico (e.g., the Port of Brownsville). Stipulates elements required to be stated in the permit.
HB 1147	1999	Changes lighting and flag requirements for vehicles with extended loads.
HB 1538	1999	Amends the Transportation Code to allow motor carriers to acquire an annual permit to operate a super-heavy or OS vehicle if it is properly registered. Eliminates the department's reporting requirement on the cumulative effects of permits issued on the state highway system.
SB 844	1999	Authorizes cities with a population of 50,000 or more to enforce weight standards in city limits.
SB 934	1999	Requires a statement on cargo being transported over SH 48 and SH 4 between Port of Brownsville and International Bridge.
HB 3467	1999	Amends the disposition of proceeds of fines if they occurred within 20 miles of an international border, providing that the entire amount shall be deposited for the purpose of road maintenance in a municipal treasury if the fine is imposed by a municipal court, and in the county treasury if by a justice court.
HB 1679	2001	Provides that tow truck operators are not required to obtain a permit to exceed vehicle weight limitations if the tow truck provides services necessary to remove a disabled, abandoned, or accident-damaged vehicle, and towing is to the nearest authorized place of repair, termini, or storage.
SB 545	2001	Requires that the holder of 2060 permits can operate a vehicle on the country road or bridge of a county designated in the permit application only with approval of a county judge or the judge's appointee. Increases the fees associated with this permit.
SB 886	2001	Makes major updates to various provisions of size and weight restrictions, which had some provisions dating back to the 1930s, to reflect current practices.

Bill No.	Year	Major Components
SB 889	2001	Amends some provisions concerning bonds for carriers who are exempt from the 2060/1547 permit requirement but are required to have a $15,000 bond (concrete, solid waste, and recyclable material haulers). Requires that a copy of the bond be carried in the vehicle when it is on a public highway and be presented to an officer authorized to enforce these provisions.
SB 20	2003	Provides for an operational procedure for permit issuance by the Victoria County Navigation District for movement of OS/OW loads on state highways located in the county using FM 1432 to and from the Victoria Barge Canal up to but not past the intersection with SH 185.
SB 1748	2003	Amends the date for continuation of the law authorizing issuance of OS/OW vehicle permits by certain port authorities to June 1, 2007.
HB 1044	2005	Provides an operational procedure for permit issuance by Chambers County for movement of OS/OW vehicles in the county. Permits issued under this chapter can only be used on FM 1405 and the frontage road of SH 99 located in a specific business park for movement of cargo weighing less than 100,000 pounds. The county can collect a fee that does not exceed $80.
SB 737	2005	Amends jurisdictional authority relating to the prosecution of offenses.
SB 1641	2005	Continues the law relating to issuance of permits by port authorities for two more years until 2009.
HB 2093	2007	Authorizes TxDOT to revoke motor carrier registration for violating certain provisions of the statute regarding OW or for not paying penalties imposed. Sets out a new hearing process and eliminates different hearing processes based on the type of violation. Provides for penalties and revocations for OW/OS permit violations. Authorizes TxDOT to investigate and impose sanctions on shippers that provide false information. Makes major changes to fees for 2060/1547 permits and for heavy-vehicle permits. Changes the weight for equipment transporting cotton seed—now 64,000 pounds. Increases the highway maintenance fee and fees for manufactured houses.
HB 4594	2009	Amends the Transportation Code to expand permit movement of OS/OW cargo in Chambers County. Adds FM 565 from the intersection with FM 1405 for approximately 6200 linear feet; adds FM 2354 from the intersection with FM 1405 for approximately 300 linear feet.
SB 1571	2009	Authorizes the Port of Corpus Christi to issue a permit for OS/OW vehicles on the roadway owned by the port.
SB 1373	2009	Amends the Transportation Code to provide for fees collected under the subsection. These fees, less administrative costs, can be used for maintenance and improvement of the state highways listed within the chapter. The port authority can retain the administrative costs, which cannot exceed 15 percent of fees collected.
SB 274	2013	Amends the Transportation Code to add more Chambers County OS/OW routes.

Bill No.	Year	Major Components
HB 474	2013	Establishes multiple routes where the Hidalgo Regional Mobility Authority is authorized to establish OS/OW permits for vehicles not exceeding 125,000 pounds. The fees cannot exceed $80, with a maximum of 15 percent of the revenue made available for administrative costs, and the rest for the maintenance of the designated roadways.
HB 3125	2013	Allows that, for a permit issued by a port authority in a county that borders the United Mexican States, the Transportation Commission, with the consent of the port authority, shall designate the most direct route along specified roadways.
SB 1059	2015	Amends the Transportation Code to provide an optional procedure for the issuance of permits for the movement of OS/OW vehicles carrying cargo on certain roads in San Patricio and Nueces Counties.
HB 2861	2015	Allows the City of Laredo in Webb County to issue OS/OW permits to trucks carrying cargo in the city not exceeding 125,000 pounds on specific roads. The city cannot charge more than $200 for a permit, and the permit fee can be adjusted each year using the consumer price index from the previous year. Administrative costs cannot exceed 15 percent of the collected fees.

The current legislation, established under Title 43 Texas Administrative Code Chapter 28, ensures the safety of the traveling public, and protects the integrity of the highways and the bridges by (2):

- Authorizing the issuance of permits for the movement of OS/OW vehicles and loads.
- Executing special contracts for the movement of OS/OW vehicles and loads to travel across the width a state highway.

Three agencies are directly involved with inspection and enforcement of size and weight rules and regulations in Texas: TxDMV, TxDPS, and TxDOT.

TxDMV processes approximately 800,000 OS/OW permits each year and is also responsible for reviewing permit violations. Motor carriers must obtain permits for loads that exceed the legal size and weight restrictions and cannot be reasonably dismantled for shipment (4). Furthermore, on January 1, 2012, the size and weight enforcement program was transferred from TxDOT to TxDMV. The OS/OW section of the TxDMV Enforcement Division is charged with enforcing the applicable statutes and related

4. Texas Department of Transportation. *Motor Carrier Handbook Oversize/Overweight Vehicles and Loads.* 2011.

administrative rules as set forth in the Transportation Code and the Texas Administrative Code. The Enforcement Division's OS/OW investigators review citations issued by law enforcement (TxDPS) and conduct audits of motor carriers where there appears to be a pattern of violations (5).

The TxDPS Commercial Vehicle Enforcement Service weighs and checks commercial vehicle traffic operations on the public highway system to ensure compliance with TS&W regulations (6). TxDPS inspections cover vehicle weight, safety, registration, and hazardous material movements. Statewide, TxDPS recorded approximately 153,000 violations each fiscal year from 2015 to 2018, with 2.6 percent being weight related (7).

TxDPS provides TxDOT with a report of all the size and weight violations and of all the bridge hits each month, which TxDOT uses to track which bridges are hit, the type of damage caused, and the associated repair costs (8). TxDOT provides information to TxDMV on structures with low vertical clearances (5), load-restricted bridges (9), load-zoned roads (10), hazardous material routing (11), and routes with permit restrictions as a result of vertical height clearance, roadway maintenance work, and weight restrictions, among others (12). TxDOT also publishes the list of approved routes for fluid milk transport and is responsible for conducting route inspections for permits issued for

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5. Texas Department of Motor Vehicles. Structures with Low Vertical Clearance. https://www.txdmv.gov/motorcarriers/low-clearance. Accessed October 31, 2018.
6. Texas Department of Motor Vehicles. *FY 2016 Annual Report Enforcement Division*. 2016.
7. Texas Department of Public Safety. Commercial Vehicle Enforcement. https://www.dps.texas.gov/cve/index.htm. Accessed October 31, 2018
8. Sassine, C., O. G. Arce, M. Murphy, H. Wu, L. Loftus-Otway, Z. Zhang, J. Prozzi, R. Harrison, C. M. Walton, J. Weissmann, and A. Weissman. *Process for Evaluating Overweight Truck Corridors Serving Coastal Port Regions and Border Ports of Entry.* Center for Transportation Research, 2015.
9. Texas Department of Transportation. Texas Load Restricted Bridge Map. http://apps.dot.state.tx.us/apps/gis/lrbm/. Accessed October 31, 2018.
10. Texas Department of Transportation. Texas Load Zone. https://www.txdot.gov/apps/gis/loadzone/. Accessed October 31, 2018
11. Texas Department of Transportation. *NRHM Routes in Texas*. 2007. https://ftp.dot.state.tx.us/pub/txdot-info/trf/nrhm/hazmat.pdf. Accessed February 10, 2020.
12. Texas Department of Motor Vehicles. Permit Restrictions. https://www.txdmv.gov/motorcarriers/permit-restrictions. Accessed October 31, 2018

vehicles or loads that exceed 20 feet in width, 18.9 feet in height, or 125 feet in length (13).

Current Vehicle Size and Weight Limits in Texas

TxDMV publishes the size and weight limits for vehicles and loads moving with or without an OS/OW permit on its website (14). In addition to these state limits, the federal bridge formula determines the acceptable weight limits on interstate highways by defining a range of permissible gross loads for vehicles in regular operation. The following definitions are used to determine if a vehicle needs an OS/OW permit for travelling on Texas roads:

- Width—The width of a vehicle is measured from the widest part of the vehicle/load, not including any safety devices.
- Height—The height of a vehicle is measured from the highest point of the vehicle or load (whichever is higher) to the roadbed.
- Length—The length of a vehicle is measured from the foremost point to the rearmost point of the vehicle or load, whichever extends further.
- Weight—The total weight includes both the weight of the vehicle and the weight of the load being transported.

Permitted Size and Weight Limits

Table A2 details the maximum dimensions for commercial vehicles to operate on Texas's highways without a permit.

13. Texas Department of Motor Vehicles. Route Inspections for Oversize/Overweight Permits. https://www.txdmv.gov/oversize-weight-permits/route-inspections. Accessed October 31, 2018.

14. Texas Department of Motor Vehicles. Texas Size and Weight Limits. https://www.txdmv.gov/motor-carriers/oversize-overweight-permits/texas-size-weight-limits. Accessed October 31, 2018.

Table A2. Legal Size and Weight Limits in the State of Texas (14)

Measure	Legal Limit
Vehicle width	8 feet 6 inches
Vehicle height	14 feet
Vehicle length	
Single motor vehicle	45 feet
Truck-tractor	Unlimited
Semitrailer, of two-vehicle combination	59 feet
Two-vehicle combination, other than truck-tractor	65 feet
Three-vehicle combination, other than truck-tractor	65 feet
Each trailer or semitrailer of twin-trailer combination	28.5 feet
Stinger-steered auto/boat or traditional auto/boat transporter (truck-tractor)	Unlimited
Truck towing trailer transportation boats	65 feet
Front overhang	3 feet
Rear overhang	4 feet
Weight	
Gross	80,000 pounds
Single axle	20,000 pounds
Tandem-axle group	34,000 pounds*
Triple-axle group	42,000 pounds*
Quad-axle group	50,000 pounds*

* A minimum spacing of 40 inches between axles is required.

Size Limits for Movement with Texas Permit

Table A3 includes the maximum dimensions of vehicles that may be operated on Texas highways with a permit.

Table A3. Maximum Vehicle Dimensions in Texas for Operating with a Permit

Measure	Legal Limit
Width Limits	
Maximum width permitted on holidays	14 feet, except for manufactured housing
Maximum width permitted on controlled-access highways (Interstate Highway System)	16 feet, except for manufactured housing
Maximum width permitted without a route inspection certification by applicant on file	20 feet
Height Limits	
Maximum height permitted on holidays	18 feet
Maximum height permitted without a route inspection certification by applicant on file	18 feet 11 inches
Length Limits	
Maximum length permitted on holidays	110 feet
Truck or single vehicle	75 feet
Front overhang	25 feet
Rear overhang	30 feet
Maximum length permitted without a route inspection certification by applicant on file	125 feet

Weight Limits for Movement with a Texas Permit

The maximum permit weight for a vehicle operating in Texas is 650 pounds per inch (15) of tire width, or based on the axle group weights, shown in Table A4, whichever is lower. If a vehicle/load combination exceeds the limits listed in Table A4, it might be eligible for a super-heavy permit.

Table A4. Maximum Vehicle Weight Limits

Axle Group	Maximum
Single	25,000 pounds
Tandem (two axle)	46,000 pounds
Tridem (three axle)	60,000 pounds
Quadrem (four axle)	70,000 pounds
Quint (five axle)	81,400 pounds
Six or more axles	Determined by the Motor Carrier Division based on an engineering study of the equipment and measurements

15. Some permit types, typically crane and oil well service related, may allow weight in excess of 650 pounds per inch on the steer axle(s).

In addition to the limits in Table A4:

- There must be a minimum spacing of 40 inches between axles within the group.
- The total weight may not exceed the tire's carrying capacity based on the manufacturer's rating.
- If the spacing between two or more consecutive axle groups is less than 12 feet, then the weight will be reduced by 2.5 percent for every foot less than 12 feet in the spacing.
- The load should be spaced so that there is no more than a 10 percent difference between any two axles in an axle group.
- Trunnion axles may have up to 30,000 pounds per axle if all of the following apply:
    - The trunnion configuration has two axles with eight tires per axle.
    - The axles are at least 10 feet wide.
    - There is at least 5 feet, but not more than 6 feet, of spacing between the axles.
- If traveling on load-restricted roads, the axle and axle group weights must be load zoned. Load-zoned weight is 10 percent less than the maximum permitted.

Federal Permissible Gross Loads for Vehicles Based on Bridge Formula

Texas's current truck size and weight regulation is defined in the Texas Transportation Code, Chapter 621: "General provisions relating to vehicle size and weight." The maximum legal GVW is based on the federal bridge formula. According to the formula, the maximum legal GVW is a function of the number of axles and the distance between the extremes of any group of two or more consecutive axles. The formula used to obtain the maximum legal weights shown in Table A5 is:

$$W = 500 \times \left[\frac{LN}{N-1} + 12N + 36 \right] \qquad \text{(Equation A1) (16)}$$

16. Federal Highway Administration. Bridge Formula Weights. https://ops.fhwa.dot.gov/Freight/publications/brdg_frm_wghts/index.htm. Accessed October 31, 2018.

Where:

- W = the overall gross weight on any group of two or more consecutive axles to the nearest 500 pounds.
- L = the distance in feet between the outer axles of any group of two or more consecutive axles.
- N = the number of axles in the group under consideration.

Table A5. Federal Permissible Gross Loads for Vehicles: Bridge Formula (17)

Distance in feet between the extremes of any group of 2 or more consecutive axles	Maximum load in pounds carried on any group of 2 or more consecutive axles* 2 axles	3 axles	4 axles	5 axles	6 axles	7 axles	8 axles	9 axles
4	†34,000							
5	†34,000							
6	†34,000							
7	†34,000							
8 and less	†34,000	34,000						
more than 8	38,000	42,000						
9	39,000	42,500						
10	40,000	43,500						
11		44,000						
12		45,000	50,000					
13		45,000	50,500					
14		46,500	51,500					
15		47,000	52,000					
16		48,000	52,500	58,000				
17		48,500	53,500	58,500				
18		49,500	54,000	59,000				
19		50,500	54,500	60,000				
20		51,000	55,500	60,500	66,000			
21		51,500	56,000	61,000	66,500			
22		52,500	56,500	61,500	67,000			
23		53,000	57,500	62,500	68,000			
24		54,000	58,000	63,000	68,500	74,000		
25		54,500	58,500	63,500	69,000	74,500		
26		55,500	59,500	64,000	69,500	75,000		
27		56,000	60,000	65,000	70,000	75,500		
28		57,000	60,500	65,500	71,000	76,500	82,000	
29		57,500	61,500	66,000	71,500	77,000	82,500	
30		58,500	62,000	66,500	72,000	77,500	83,000	
31		59,000	62,500	67,500	72,500	78,000	83,500	
32		60,000	63,500	68,000	73,000	78,500	84,500	90,000
33			64,000	68,500	74,000	79,000	85,000	90,500
34			64,500	69,000	74,500	80,000	85,500	91,000
35			65,500	70,000	75,000	80,500	86,000	91,500
36			‡ 66,000	70,500	75,500	81,000	86,500	92,000
37			‡ 66,500	71,000	76,000	81,500	87,000	93,000
38			‡ 67,500	71,500	77,000	82,000	87,500	93,500
39			68,000	72,500	77,500	82,500	88,500	94,000
40			68,500	73,000	78,000	83,500	89,000	94,500
41			69,500	73,500	78,500	84,000	89,500	95,000
42			70,000	74,000	79,000	84,500	90,000	95,500
43			70,500	75,000	80,000	85,000	90,500	96,000
44			71,500	75,500	80,500	85,500	91,000	96,500
45			72,000	76,000	81,000	86,000	91,500	97,500
46			72,500	76,500	81,500	87,000	92,500	98,000
47			73,500	77,500	82,000	87,500	93,000	98,500
48			74,000	78,000	83,000	88,000	93,500	99,000
49			74,500	78,500	83,500	88,500	94,000	99,500
50			75,500	79,000	84,000	89,000	94,500	100,000

VEHICLE PERMIT TYPES IN TEXAS

Table A6 provides information for each of the 29 permit types that are issued in Texas. The permit types, descriptions, and images in this table are from the TxDMV website (18).

17. The table is adapted from Federal Highway Administration. Bridge Formula Weights. https://ops.fhwa.dot.gov/Freight/publications/brdg_frm_wghts/index.htm. Accessed October 31, 2018.
18. Texas Department of Motor Vehicles. Oversize/Overweight Permits. https://www.txdmv.gov/motor-carriers/oversize-overweight-permits. Accessed October 31, 2018.

Table A6. Texas Vehicle Permit Types

Permit	Description

General OS/OW	• Non-divisible load.
	• Single, continuous movement from point A to point B.
	• Weight limits up to 254,300 pounds.
	• Vehicles and loads exceeding the following dimensions must have a Route Inspection Certification on file prior to permit issuance:
	  o Width—20 feet.
	  o Height—18 feet 11 inches.
	  o Length—125 feet.

	
Manufactured Housing—Single Trip	• Transport manufactured housing and industrialized buildings and housing. • Single, continuous movement from point A to point B. • Valid for five days. • Transported on any returnable undercarriage or temporary chassis system. • Each section of a multi-section manufactured home requires its own permit. • Must obtain a general single-trip permit to haul a stack of manufactured housing frames.
	

Permit	Description
Manufactured Housing—Annual	• Transport new homes from a manufacturing facility to a temporary storage location (20-mile radius). • May be used by multiple vehicles. • Valid for one year. • Must obtain a general single-trip permit to haul a stack of manufactured housing frames. • Manufactured housing exceeding legal gross, axle or axle group weights must obtain a general single-trip permit. • A permit may not be transferred between permittees.
	
Portable Building	• Transport portable buildings and compatible cargo. • Single, continuous movement from point A to point B. • Multiple portable buildings may be loaded end to end, provided they are loaded at the narrowest width and the overall length does not exceed 80 feet including the rear overhang, which cannot exceed legal (4 feet).
	
Super Heavy	• Non-divisible load. • Gross weight may exceed 254,300 pounds or 200,000 pounds with less than 95 feet of axle spacing. • May exceed maximum permit weights on axle or axle group. • May require coordination with TxDOT district offices to determine route suitability or to facilitate movement of the load.
	

Permit	Description

House Move	• Transport houses that exceed 20 feet wide.
	• Single, continuous movement from point A to point B.
	• TxDMV proposes route based on:
	  ○ The amount of inconvenience and hazard imposed on the traveling public.
	  ○ Highway geometrics and time of movement.
	  ○ The overall width, measured to the nearest inch, of the house, including the eaves or porches.

	
Intermodal Shipping Container Port Permit	• Intermodal shipping containers. • Travel within 30 miles of port authorities or ports of entry located in a county contiguous to the Gulf of Mexico or a bay or inlet opening into the gulf. • Valid for one year. • Ports currently available: Freeport, Houston—Barbours Cut, and Houston IH 610. • A truck-tractor and semitrailer combination must have six axles or seven axles. • Appendix C provides more information on axle distances.
	

Permit	Description
Crane and Well Service Unit Mileage	• Unladen lift equipment. • Fixed-load machinery used to drill, service, or clean oil wells. • Single, continuous movement. • Valid for a maximum of seven consecutive days, from a specific point of origin to a specific ending point. • A single-trip mileage permit allows the unit to return to the point of origin or other location on the same permit, provided the miles for the entire route are charged. • The maximum permit weight for any single axle may not exceed 30,000 pounds or 850 pounds per inch of tire width, whichever is less. • Units may not exceed 850 pounds per inch of tire width for non-steerable units and 950 pounds per inch of tire width for steerable units. • An oil-well-related vehicle or crane exceeding 175,000 pounds gross weight must have front and rear escorts when crossing bridges to prevent traffic from traveling beside the unit. • Self-propelled well-servicing units, moving with this permit, that are 9 feet wide or less, 14 feet high or less, and 65 feet long or less are allowed 24-hour movement. • Self-propelled cranes moving with this permit that are 10 feet 6 inches wide or less, 14 feet high or less, and 95 feet long or less are allowed night movement with front and rear escorts.
	

Permit	Description
Mobile Crane (Annual)	• Unladen lift equipment. • Valid for one year. • Night movement is allowed with front and rear escorts. • Cranes operating under this permit may not exceed: ○ Dimensions: – Width—10 feet. – Height—legal. – Length—legal. ○ Weight: – 650 pounds per inch of tire width. – 120,000 pounds gross weight. – 25,000 pounds single axle. – 46,000 pounds tandem-axle group. – 60,000 pounds three-axle group. – 70,000 pounds four-axle group. – 81,400 pounds five-axle group.
	
Well-Servicing Unit (Annual)	• Legal size and weight units. • Must have Texas "P" (permit) plate. • Valid for one year. • Units operating under this permit may not exceed 650 pounds per inch of tire width on the front axle. • Night movement is allowed. • Permit may not be amended.
	

Permit	Description

Rig-Up Truck	• Truck equipped with a winch and gin poles.
	• Valid for one year.
	• The unit may not haul a load.
	• Units operating under this permit may not exceed:
	   ○ Height—legal.
	   ○ Length—legal.
	   ○ Weight—25,000 pounds or 850 pounds per inch of tire width on the steer axle(s), whichever is less. All other axles must be legal weight.
	• Night movement is allowed provided the width does not exceed 9 feet.
	• Permit may not be amended.

	

Self-Propelled Off-Road Equipment	• Drive off-road equipment on state roadways.
	• Single, continuous movement from point A to point B.
	• Self-propelled off-road equipment operating under this permit must meet the following requirements:
	   ○ Weight per inch of tire width does not exceed 650 pounds.
	   ○ Weight per axle does not exceed 45,000 pounds.
	   ○ All wheels have a minimum rim diameter of 25 inches.
	   ○ Minimum spacing between axles, measured from the center of the axle to the center of the axle, is not less than 12 feet.
	   ○ Equipment must be empty.
	
	Note: Equipment moving under this permit may not travel on controlled-access highways.

	

Permit	Description

Temporary Vehicle Registration	• Temporary movement of vehicles under the following circumstances:
	  ○ The vehicle is not registered.
	  ○ The vehicle is registered in a state that does not have a reciprocity agreement with Texas.
	  ○ The vehicle is registered in a state that has a prorate agreement with Texas, but the vehicle does not have a prorate sticker or registration cab card for Texas.
	  ○ To increase weight if the vehicle is not registered for its maximum allowable weight.
	• Four types of temporary registration permits are available to motor carriers: 72 hour, 144 hour, one trip, and 30 day.
	
	Appendix C provides more information on this permit type.

	

30/60/90-Day Width or Length	• Non-divisible loads.
	• Use width and length permits in conjunction with one another.
	• Select a 30-, 60-, or 90-day effective period.
	• To qualify, vehicles and loads must be any of the following:
	  ○ No greater than 13 feet wide, 14 feet high, and legal length for an overwidth permit.
	  ○ No greater than 8 feet 6 inches wide, 14 feet high, and 110 feet long for vehicles and loads on a trailer for an overlength permit.
	  ○ No greater than 75 feet long for single vehicles moving empty or hauling a load.
	• A 30/60/90-day overwidth permit may be used in conjunction with a 30/60/90-day overlength permit.
	• For overlength permits, the front overhang cannot be more than 25 feet, and the rear overhang may not exceed 30 feet.
	
	Note: Overwidth and overlength permits are not valid for manufactured homes or portable buildings.

	

Permit	Description

Company-Specific Envelope	• Non-divisible loads.
	• Can be used to operate any truck owned or leased by the company.
	• Valid for one year.
	• No more than one vehicle can be operated at one time with a specific permit, but a company may purchase more than one permit.
	• OS and/or OW equipment operating under this permit may not exceed:
	  o Width—12 feet.
	  o Height—14 feet.
	  o Length—110 feet.
	  o Weight—120,000 pounds gross weight.
	• A single-trip permit may be purchased to be used in conjunction with an annual envelope permit to increase height or width limits. Length and weight limitations cannot be increased.
	• Permit may not be amended or transferred between permittees.

	

Permit	Description

Vehicle-Specific Envelope	• Non-divisible loads.
	• Valid for one year.
	• OS and/or OW equipment operating under this permit may not exceed:
	  o Width—12 feet.
	  o Height—14 feet.
	  o Length—110 feet.
	  o Weight—120,000 pounds gross weight.
	• A single-trip permit may be purchased to be used in conjunction with an annual envelope permit to increase height or width limits. Length and weight limitations cannot be increased.
	• Permit is non-transferrable between permittees.
	• Permit is non-transferable between companies or vehicles, unless one of the following occurs:
	  o The permitted vehicle is destroyed or otherwise becomes permanently inoperable to an extent that it will no longer be used, and the permittee provides proof that the negotiable certificate of title or other qualifying documentation has been surrendered.
	  o The permittee provides proof that the certificate of title (or other qualifying documentation) to the permitted vehicle is transferred to someone other than the permittee.

	

Permit	Description

Fracking Trailer	• Semitrailer containing a tank and pump unit specifically designed for transporting liquid fracking products, liquid oil well waste products, and unrefined liquid petroleum products to or from oil wells not connected to a pipeline.
	• Valid for one year.
	• This permit allows movement when the vehicle or semitrailer does one of the following:
	    o Carries liquid oil well waste products or unrefined petroleum products from wells not connected to a pipeline and return empty.
	    o Hauls liquid products related to oil well production to an oil well and returns empty.
	    o Hauls liquid products related to oil well production to an oil well and returns with liquid waste products or unrefined liquid petroleum products from an oil well not connected to a pipeline.
	• The permit lists only one semitrailer, but the permittee may transfer the permit from an existing trailer taken from service to a new trailer added to the permittee's fleet.

	
Hay	• Transport cylindrical (round) bales of hay. • Side-by-side loading. • Valid for one year. • Permit allows round bales of hay to be loaded side by side up to 12 feet wide to travel on all state-maintained highways in Texas. All other dimensions and weight must be legal.
	

<table>
<tr><th>Permit</th><th>Description</th></tr>
<tr><td rowspan="2">Quarterly Hubometer</td><td>

Drive or transport hubometer-equipped fixed-load machinery and cranes.
Mileage-based fees.
Valid for 91 days.
A hubometer is required on the drive axle of the permitted unit with the exception of units that are overlength only. Hubometers may be purchased at oil field supply stores.
TxDMV issues quarterly hubometer permits for the following vehicle types:

Self-propelled oil-well-servicing units.
Self-propelled mobile cranes.
Self-propelled concrete pumps.
Trailer-mounted oil-well-servicing units.
Coiled tubing units.
Swabbing units.
Self-propelled bundle extractors.

Units operating under this permit may not exceed:

Maximum width—12 feet.
Maximum height—14 feet 6 inches.
Maximum length—95 feet.
Maximum weight:

30,000 pounds per axle based on results of weight analysis.
850 pounds per inch of tire width for non-steerable units.
950 pounds per inch of tire width for steerable units.

Permit may only be amended to indicate a new hubometer serial number or a new license plate number.
Permit may not be transferred between vehicles or permittees.
Self-propelled well-servicing units, moving with this permit, that are 9 feet wide or less, 14 feet high or less, and 65 feet long or less are allowed 24-hour movement.
Self-propelled cranes moving with this permit that are 10 feet 6 inches wide or less, 14 feet high or less, and 95 feet long or less are allowed night movement with front and rear escorts.

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<table>
<tr><th>Permit</th><th>Description</th></tr>
<tr><td>Implements of Husbandry</td><td>

Transport farm implements used to till soil.
Valid for one year.
Transport and spread fertilizer.
Deliver feed to livestock.
OS or OW implements of husbandry operating under this permit may not exceed:

Maximum width—16 feet.
Maximum height—16 feet.
Maximum length—110 feet.
Maximum weight—maximum allowable permit weights.

Implements of husbandry include farm implements, machinery, and tools as used in tilling the soil; towed vehicles that transport to the field and spread fertilizer or agricultural chemicals; and motor vehicles designed and adapted to deliver feed to livestock. Examples are cultivators, farm tractors, reapers, binders, combines, cotton module builders, planters, discs, etc.
Implements of husbandry do not include automobiles, trucks, or items used on the farm such as irrigation systems, silos, barns, etc.

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Permit	Description
Over Axle/Over Gross Weight Tolerance	• Haul divisible commodities. • Vehicles, alone or in combination, may exceed the allowable axle weight by a tolerance of 10 percent and may exceed the gross weight by a tolerance of 5 percent. Tolerances are above the maximum allowed for the particular vehicle or combination and are enforced based on the "outer bridge" distance, not the vehicle's registered weight. • Travel on state-maintained and county roads in select counties. • Valid for one year. • Permit does not exempt any owner, motor carrier, operator, or driver from complying with any statute, regulation, rule, order, or other legal requirement not specifically referenced in Transportation Code, Section 623.011, or 43 Texas Administrative Code, Section 219.30. • Vehicles and/or vehicle combinations may not exceed Texas legal size limits. • Vehicles may not operate on a load-posted bridge if the gross weight of the vehicle and load, or the axles and wheel loads, are greater than the established and posted limits, unless the bridge provides the only public vehicular access to or from origin or destination. Note: Vehicles moving under this permit may travel on county roads and state-maintained roadways, excluding the Interstate Highway System, in those counties selected on the permit application.
	
Utility Pole	• Transport poles required for electrical power transmission and line distribution. • Night movement allowed for emergencies. • Valid for one year. • Maximum vehicle dimensions may be up to 75 feet long and may not exceed other Texas legal size and weight limits. • Night movement will be allowed for emergency movement by utility companies only to restore power. A rear escort is required for emergency night movement by utility companies.
	

Permit	Description

Water-Well-Drilling Machinery and Equipment	• Self-propelled or mounted machinery used exclusively for drilling water wells.
	• Valid for one year.
	• OS or OW water-well-drilling machinery and equipment operating under this permit may not exceed:
	  o Maximum width—16 feet.
	  o Maximum height—14 feet 6 inches.
	  o Maximum length—110 feet.
	  o Maximum weight—maximum allowable permit weights.
	• A permit may not be transferred between vehicles or permittees.
	
	Note: Machinery and equipment moving under this permit may only travel on the state highway system.

	
Annual Timber Permit	• Transport unrefined timber, wood chips, or woody biomass. • Vehicles may have up to 44,000 pounds on a tandem axle; the gross weight of the vehicle may not exceed 84,000 pounds. • Valid for one year. • Trucks may not exceed Texas legal size limits. Note: Vehicles moving under this permit may travel on county roads and state-maintained roadways, excluding the Interstate Highway System, in timber harvest counties selected on the permit application. The applicant may only select from counties named in the most recent Texas A&M Forest Service's *Harvest Trend Report*.
	

Permit	Description
Ready-Mixed Concrete Trucks	• Trucks operating on three axles. • Travel on state-maintained and county roads in select counties. • Valid for one year.
	

Annual Length Permit	• Non-divisible overlength loads.
	• Valid for one year.
	• To qualify for this permit, vehicles and loads must be one of the following:
	    ○ No greater than 8 feet 6 inches wide, 14 feet high, and 110 feet long for vehicles and loads on a trailer.
	    ○ No longer than 75 feet long for single vehicles moving empty or hauling a load.
	
	Note: This permit adds an annual option to the existing 30-, 60-, and 90-day length permit.

	

Permit	Description

Emergency Relief Permit	• To deliver relief supplies (entire load must be relief supplies).
	• To assist in expediting debris removal.
	• Expires 120 days from the date of the U.S. president's disaster declaration.
	• Vehicles moving under this permit may travel to and within the geographical area covered by the emergency declaration to do one of the following:
	    ○ Assist in expediting debris removal from roadways, staging areas, or temporary structure locations.
	    ○ Deliver relief supplies (the entire load must consist of relief supplies).
	
	Note: This permit is only valid for travel in Texas. If the geographical location listed in the emergency declaration is in another state, carriers must contact each state they will travel through for individual state permits.
	
	• Size—The vehicle and load may not exceed legal size limits.
	• Weight:
	    ○ 21,500 pounds per axle.
	    ○ 43,000 pounds per two-axle group.
	    ○ 53,000 pounds per three-axle group (a wheelbase more than 8 feet and less than 13 feet).
	    ○ 160,000 pounds gross weight.

	

Permit	Description

North Texas Intermodal Permits	• Intermodal shipping containers.
	• Travel within 5 miles of the Texas/Arkansas border.
	• Valid for one year.
	• TxDMV issues an annual permit for the transport of intermodal shipping containers, transported in Bowie County on US 71/US 59 from the Arkansas state border to the eastbound entrance ramp for IH 49, which do not exceed legal size limits. This permit is an annual permit that expires one year from the "movement to begin" date.
	• The truck-tractor and semitrailer combination must have six axles and must have all of the following:
	  ○ Approximately 647 inches between the front axle of the truck-tractor and the last axle of the semitrailer.
	  ○ 51 to 52 inches between the axles in the truck-tractor two-axle group.
	  ○ 60 inches between the axles in the semi-trailer three-axle group.
	• The gross weight may not exceed 93,000 pounds. Axle weight limits are:
	  ○ Truck-tractor single axle—13,000 pounds.
	  ○ Truck-tractor two-axle group—18,500 pounds per axle.
	  ○ Semitrailer three-axle group—16,400 pounds per axle.
	• This permit does not authorize the transport of a material designated as of January 1, 2017, as a hazardous material by the U.S. secretary of transportation under 49 United States Code, Section 5103(a).

	

Permit	Description

Fluid Milk Transport Permit	• Transport fluid milk.
	• Travel on dairy routes approved by TxDOT.
	• Valid for one year.
	• This is the only permit issued by TxDMV that may be used to transport fluid milk.
	• The vehicle combination may not exceed Texas legal size limits. The permit is an annual permit that expires one year from the effective date.
	• The truck-tractor and semitrailer combination must have six axles and must have the following axle distances:
	  ○ 15 feet or more between the first (steer) axle of the truck-tractor and the first axle of the first axle group (drive axles).
	  ○ 36 feet or more between the first drive axle and last trailer axle.
	  ○ 48 to 54 inches between the axles within each axle group.
	• The gross weight may not exceed 90,000 pounds. Axle and axle group weight limits are:
	  ○ Truck-tractor single axle—legal weight.
	  ○ Two-axle group—36,500 pounds total.
	  ○ Three-axle group—42,500 pounds total.
	
	Note: A vehicle moving with this permit may operate on a federal interstate highway or a state, county, or municipal road if the vehicle displays the permit windshield sticker, has the required number of axles and axle distances, and does not exceed the maximum gross weight or axle/axle group weight limits. Permit is valid for travel on specific routes that have been approved by TxDOT. The permit applicant must select routes to be traveled at the time of application.
	
	A list of TxDOT-approved milk permit routes is available at https://www.txdmv.gov/reports-and-data/doc_download/8423-fluid-milk-permit-routes.

	

Movement Restrictions and Escort Vehicle Requirements

According to the TxDOT *Motor Vehicle Handbook* (19), OS/OW loads have the following movement restrictions.

Daylight Movement

A permitted load may be moved only during daylight hours (defined as 30 minutes prior to sunrise to 30 minutes after sunset) unless it meets required criteria for night movement.

Night Movement

A permitted vehicle may be granted night movement when it is one of the following:

- Only OW on any state-maintained road.
- Traveling on an interstate highway and does not exceed 10 feet wide and 100 feet long, with legal front and rear overhangs.
- OW and meets the criteria in the second bulleted item.
- A mobile crane not exceeding 10 feet 6 inches wide, 14 feet high, or 95 feet long on any state-maintained road.
- A self-propelled oil-well-servicing unit not exceeding 9 feet wide on any state-maintained road.

TxDOT may grant an exception to these restrictions in certain emergency situations. These may include the movement of utility poles to prevent or restore power in the case of a disruption, or equipment needed to clear railroad track access in the event of a derailment. However, if the exception is granted, the loads are required to have both front and rear escorts.

Reduced Visibility

Movement of permitted loads is prohibited when visibility is reduced (less than 0.2 miles) or the road surface is hazardous due to weather conditions or highway maintenance and/or construction.

Heavy Traffic Conditions

TxDOT may limit certain routes due to heavy traffic.

19. Texas Department of Transportation, Motor Carrier Division. *Motor Carrier Handbook: Oversize/Overweight Vehicles and Loads*. May 2011.

Holiday Restrictions

Loads exceeding one of the following criteria may not be moved on holidays:

- 14 feet long.
- 16 feet high.
- 100 feet long.

The following holidays are included in this restricted access:

- New Year's Day.
- Memorial Day.
- Independence Day.
- Labor Day.
- Thanksgiving Day.
- Christmas Day.

Escort Flag Vehicle Requirements (20)

Escort vehicles are required depending on vehicle size to ensure the safety of the traveling public and the safe movement of the permitted vehicle. In addition to private escorts, TxDMV may require law enforcement escorts for some permitted vehicle movements. Table A7 lists escort requirements for most loads and permit types. Any load that exceeds the escort requirements in two dimensions requires both front and rear escorts, unless those two dimensions are length and overhang.

Over-length vehicles share escorts by convoying if the following conditions are met:

- 110 feet to 150 feet long—convoy up to four loads with one front and one rear escort.
- 150 feet 1 inch to 180 feet long—convoy two loads with one front and one rear escort.

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20. Texas Department of Motor Vehicles. Escort and Equipment Requirements. https://www.txdmv.gov/oversize-weight-permits/escort-and-equipment-requirements. Accessed October 31, 2018.

Table A7. Escort Vehicle Requirement Based on Vehicle Dimensions

Dimension	Measurement	Number and Placement of Escort(s)
Width	Exceeding 14 feet to 16 feet	1 front—two-lane highway
		1 rear—divided highway
	Exceeding 16 feet	1 front and 1 rear—all roads
Height	Exceeding 17 feet	1 front—equipped with height pole
	Exceeding 18 feet	1 front and 1 rear—all roads
		1 front—equipped with height pole
Length	Exceeding 110 feet to 125 feet	1 front—two-lane highway
		1 rear—divided highway
	Exceeding 125 feet	1 front and 1 rear—all roads
	Front overhang exceeds 20 feet	1 front—two-lane highway
		1 rear—four or more lane highway
	Rear overhang exceeds 20 feet	1 rear—all roads

Escort vehicles are required to be a single unit between 1,000 and 10,000 pounds GVW; and to be equipped with flashing lights, display signs, warning flags, a two-way communication radio, and a nonconductive metal height pole for permitted vehicles that exceed 17 feet in height.

Additional information on OS/OW movements is available at the following webpages:

- Permit restrictions by county—https://www.txdmv.gov/motorcarriers/permit-restrictions.
- Structures with low vertical clearance—https://www.txdmv.gov/motorcarriers/low-clearance.
- Load-zoned roads—https://www.txdot.gov/apps/gis/loadzone/.
- Load-restricted bridges—http://apps.dot.state.tx.us/apps/gis/lrbm/.
- Hazardous materials routing—https://www.txdot.gov/inside-txdot/forms-publications/publications/nrhm.html.

APPENDIX B: OVERSIZE/OVERWEIGHT VEHICLE OPERATIONS

This appendix covers operations of OS/OW vehicles. The data in this appendix come from past studies covering these operations. The studies conducted in Texas have mainly focused on operational characteristics related to transportation infrastructure (i.e., pavements and bridges).

A number of studies conducted on OS/OW vehicle operations in Texas have focused mainly on the pavement and bridge impacts of these vehicles. The studies cover issues relating to regulations, the impact of the energy industry, permitting fees, and truck configuration. TxPROS was found to be the preferred data source for OS/OW routing information, with WIM and other data sources being very site specific. The majority of the studies also focused on OS/OW movement across the entire state with few specifically looking at regions such as the DFW area.

One study (21), analyzed route permit data from 2007 to 2009 and found that of the approximately 1.5 million statewide issued routing permits, 4,750 started and 5,494 ended in the Barnett Shale area. These permits were specifically associated with the natural gas industry (e.g., rig equipment, drilling equipment, and salt water storage tanks). Figure B1 presents a density distribution map of natural-gas-related trips that originated in the Barnett Shale area. The map indicates that most of the trips began in Denton, Johnson, Wise, and Tarrant Counties. Overall, traffic related to well construction and saltwater disposal moved an average distance of around 10 miles based on a sample size of 50 permits, implying that the majority of the traffic was confined to the Barnett Shale region. Based on the limited sample size, it was found that vehicles involved in well construction (site preparation, rigging up, drilling, hydraulic fracturing, and rigging down) mainly used interstate highways (19 percent of total VMT), U.S. highways (23 percent of total VMT), state highways (28 percent of total VMT), and Farm to Market roads (27 percent of total VMT). The information in Table B8 summarizes the findings of recent studies of OS/OW vehicles in Texas.

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21. Prozzi, J., S. Grebenschikov, A. Banerjee, and J. Prozzi. *Impacts of Energy Developments on the Texas Transportation System Infrastructure*. Report 0-6513-1A. Center for Transportation Research, 2011.

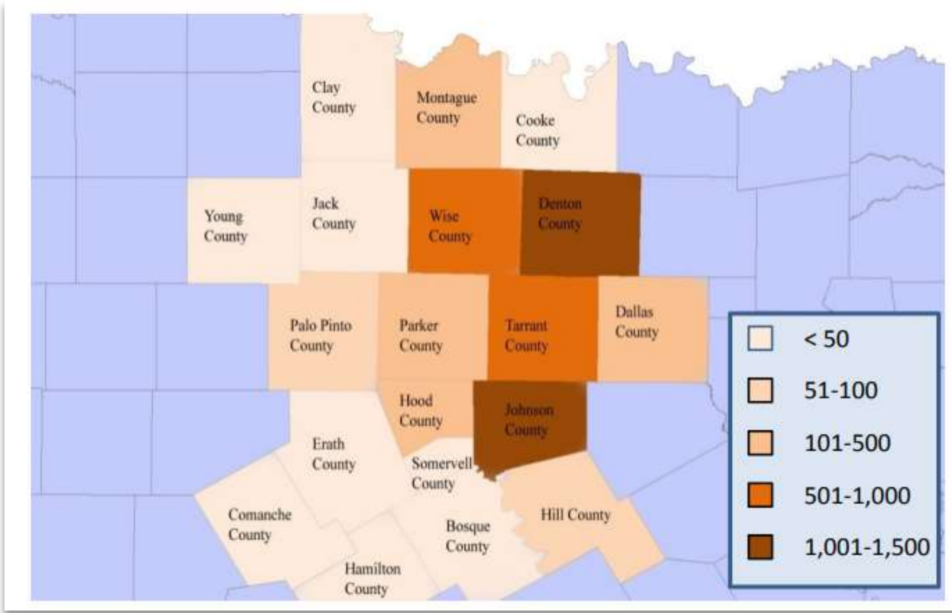

Figure B1. Permit Route Starts in the Barnett Shale Region (2007–2009)

Table B8. Summary of Studies Relating to OS/OW Vehicle Operations in Texas

Reference	Data Used	Geographic Resolution	OS/OW Routing	Study Objectives
Walton et al., 2010 (22)	• Federal Motor Carrier Safety Administration database (accidents and operator contacts) • Flexible pavement database • MOANSTR bridge route data • Traffic data (TxDOT Roadway-Highway Inventory) • Fuel consumption data	National	Yes	Evaluated the potential effects of longer combination vehicles on pavements, bridges, operational characteristics, and safety in Texas.
Prozzi et al., 2011 (21)	• Average daily traffic (TxDOT) • Employment data • Well count (Texas Railroad Commission) • Trip and permit data (TxPROS)	Barnett Shale region	Yes	Developed an understanding of the current and future impacts of the energy sector on Texas's transportation system.

22. Walton, C.M., R. Harrison, B. Bienkowski, K. Kockelman, A. Weissmann, J. Weissmann, A.T. Papagiannakis, M. Yang, and J.L. Kunsietty. *Potential Use of Longer Combination Vehicles in Texas: First Year Report*. Center for Transportation Research, 2010.

Reference	Data Used	Geographic Resolution	OS/OW Routing	Study Objectives
Prozzi et al., 2012 (23)	• Permit and trip data (TxPROS) • VMT • Bridge Inventory, Inspection, and Appraisal Program (BRINSAP)	Texas	Yes	Evaluated damage that OS/OW vehicles cause to the transportation infrastructure along with direct costs imposed by OS/OW vehicles on highway appurtenances.
Middleton et al., 2012 (24)	Permit data, and route and destination data (TxPROS)	Texas	Yes	Processed and mapped a dataset of OS/OW permit routes into a geographic information system format. This report presents the methodology and findings of the research, investigating the implications of improving current practice to more efficiently accommodate the movement of OS/OW loads.

23. Prozzi, J. M. Murpy, L. Loftus-Otway, A. Banerjee, M. Kim, H. Wu, J.P. Prozzi, R. Hutchinson, C.M. Walton, J. Weissmann, and A. Weissmann. *Oversize/Overweight Vehicle Permit Fee Study*. Center for Transportation Research, 2012

24. Middleton, D., Y. Li, J. Le, and N. Koncz. *Accommodating Oversize and Overweight Loads: Technical Report*. Report 0-6404-1. Texas A&M Transportation Institute, 2012.

Reference	Data Used	Geographic Resolution	OS/OW Routing	Study Objectives
Quiroga et al., 2015 (25)	• Digital map data • Drilling permit data • Imaged records • Oil and gas field data • Oil and gas production data • Oil and gas regulatory data • Oil gas well data • Pipeline data	Eagle Ford Shale, Permian Basin, and Barnett Shale regions	Yes	Analyzed OS/OW permit and load trends, and estimated axle weight associated with the oil and gas industry.
Walton et al., 2016 (26)	• BRINSAP/National Bridge Inventory • Truck configuration data • Interviews • Workshops with trucking industry stakeholders	Texas	No	• Identified truck size and weight laws that would benefit the industry. • Developed a list of truck operations and configuration types for pavement and consumption analysis.

25. Quiroga, C., E. Kraus, and I. Tsapakis. *Truck Traffic and Truck Loads Associated with Unconventional Oil and Gas Developments in Texas*. Prepared for the Texas Department of Transportation Maintenance Division. Texas A&M Transportation Institute, 2015.

26. Walton, C.M., M. Murphy, J. Prozzi, J. Weissmann, H. Wu, N. Jiang, R. Harrison, L. Loftus-Otway, A. Weissmann, H. Xu, M. Hasan, and S. Agarwal. *SLA Truck Configuration Library Final Report*. Center for Transportation Research, 2016.

Reference	Data Used	Geographic Resolution	OS/OW Routing	Study Objectives
Prozzi et al., 2017 (27)	• Weight of shipments by mode • SAFERSYS.ORG database • WIM data • BRINSAP database • Crash Records Information System database • Climate station • AASHTOWare • Pavement Mechanistic-Empirical Design™ software	Texas	No. Used Rider 36 study routing information for bridge consumption costs	• Evaluated the effects of single, tandem, and tridem vehicle configurations on bridges and pavements. • Developed guidelines for more infrastructure-friendly configurations. • Developed a cost recovery structure that adequately funds repairs to roads used by OW trucks.
Sassine et al., 2017 (28)		Texas coast and border	Developed a prototype analysis tool for evaluating OW truck corridors based on pavement and bridge consumption, safety and pavement rehabilitation costs, truck distribution, and cost parameters	Developed a two-stage process for analyzing OS/OW corridors:

27. Prozzi, J. A., P. Buddhavarapu, S. Kouchaki, J. Weissmann, A. Weissmann, N. Jiang, K. Savage, and C. M. Walton. *Infrastructure-Friendly Vehicles to Support Texas Economic Competitiveness.* Report 0-6817-1, University of Texas at Austin, 2016

28. Sassine, C., O. Galvis-Arce, M. Murphy, H. Wu, L. Loftus-Otway, Z. Zhang, J. Prozzi, R. Harrison, C.M. Walton, J. Weissmann, and A. Weissmann, *Process for Evaluating Overweight Truck Corridors Serving Coastal Port Regions and Border Ports of Entry*. Report 0-6820-1, Center for Transportation Research, 2017.

Reference	Data Used	Geographic Resolution	OS/OW Routing	Study Objectives
				• Stage 1 provides network-level expedient analysis results that can be used to determine the fiscal impacts of a proposed new corridor or changes to an existing corridor. • Stage 2 uses more detailed information about each corridor route segment to help identify existing conditions and propose treatment plans to maintain safe operating conditions and preserve infrastructure conditions.
Texas A&M Transportation Institute's Transportation Policy Research Center, 2015 (29)	A literature review of technologies	Texas	No	Evaluated potential applications of new technologies to advance the development of an intelligent traffic and freight monitoring system.

29. Texas A&M Transportation Institute's Policy Research Center. *Intelligent Freight Monitoring: A Review of Potential Technologies.* https://policy.tti.tamu.edu/freight/prc-report-intelligent-freight-monitoring-a-review-of-potential-technologies/. Accessed March 2020.

APPENDIX C: WEIGH-IN-MOTION DATA ANALYSIS

The information in this appendix covers the detailed analysis of the data from the TxDOT WIM stations located in the NCTCOG region. Figure C2 shows the location of the WIM sites that were part of this analysis. The analysis focuses on the data broken down by vehicle classification. All vehicle images used in this document are from the Federal Highway Administration vehicle classification chart.

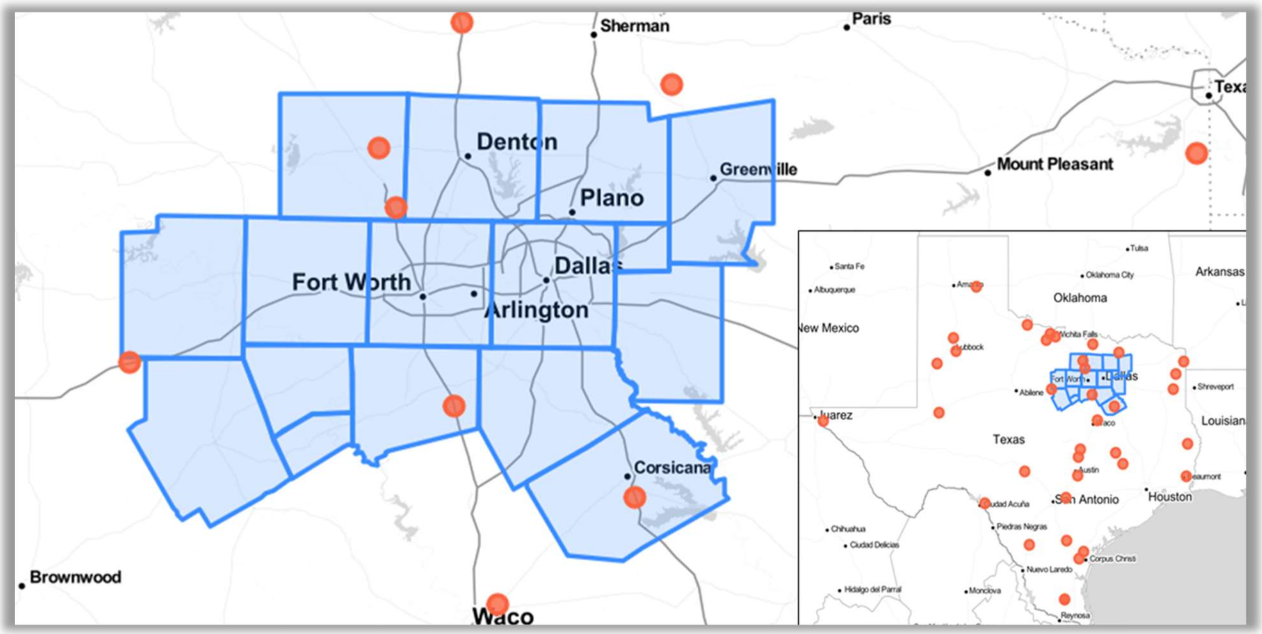

Figure C2. TxDOT WIM Sites within the NCTCOG Region

CLASS 13 TRUCKS

Class 13 vehicles are defined as multi-trailer configurations with seven or more axles. Figure C3 shows an example of a Class 13 truck and trailer combination. The analysis included 145,989 Class 13 vehicles.

Figure C3. Example Class 13 Vehicle

The average Class 13 vehicle weighs 82,000 pounds, with 10 percent of these vehicles weighing 130,500 pounds or more. Approximately 51.7 percent of the Class 13 vehicles exceeded 80,000 pounds. Figure C4 shows the data from the Class 13 vehicles. As the figure shows, the weights of the Class 13 trucks is evenly distributed between the different weight categories.

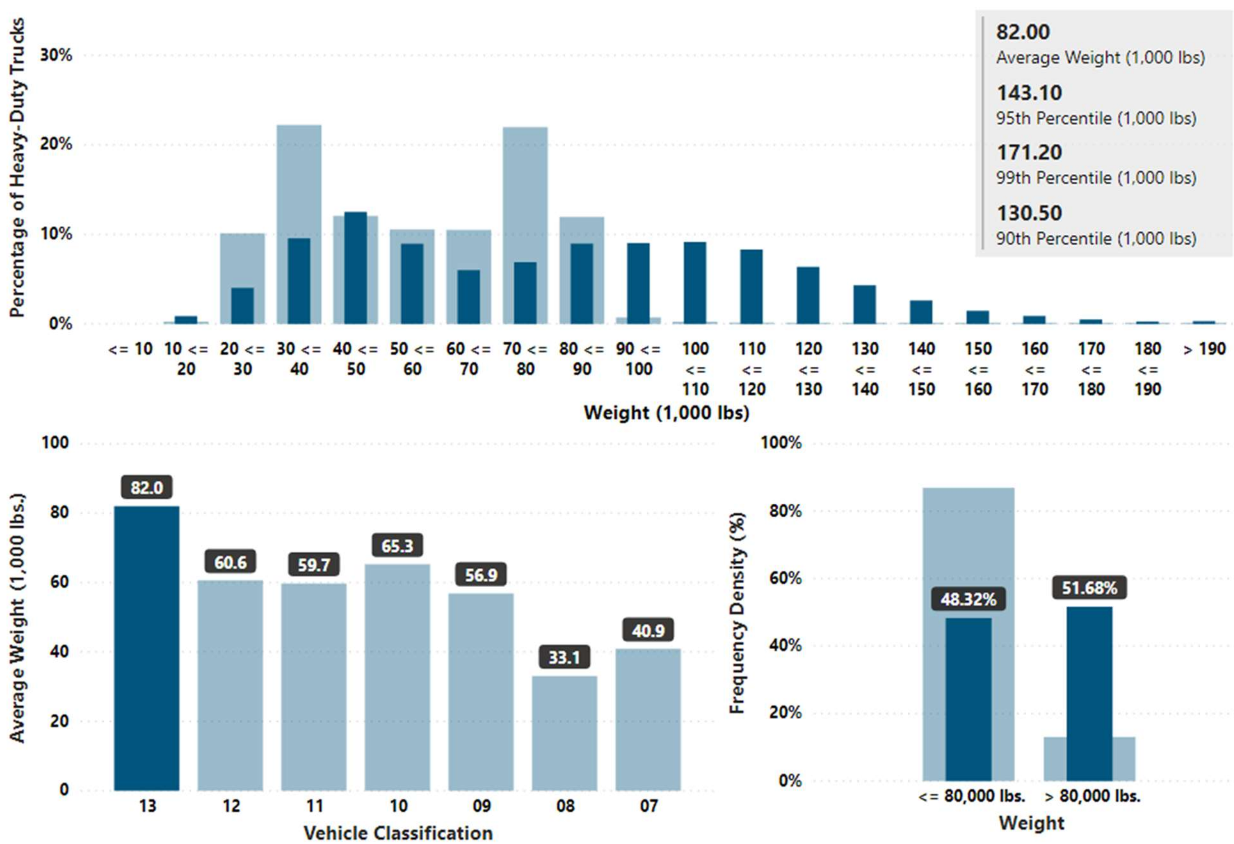

Figure C4. WIM Data for Class 13 Trucks

Class 12 Trucks

Class 12 trucks are multi-trailer configurations with six axles. Figure C5 shows an example of a Class 12 truck. The WIM data included 159,877 Class 12 trucks, with an average weight of 60,640 pounds.

Figure C5. Example Class 12 Truck

Figure C6 shows the data from the Class 12 trucks. The data show that 5.1 percent of the Class 12 trucks measured were over the non-permitted weight limit of 80,000 pounds, with most (31 percent) being between 60,000 and 70,000 pounds.

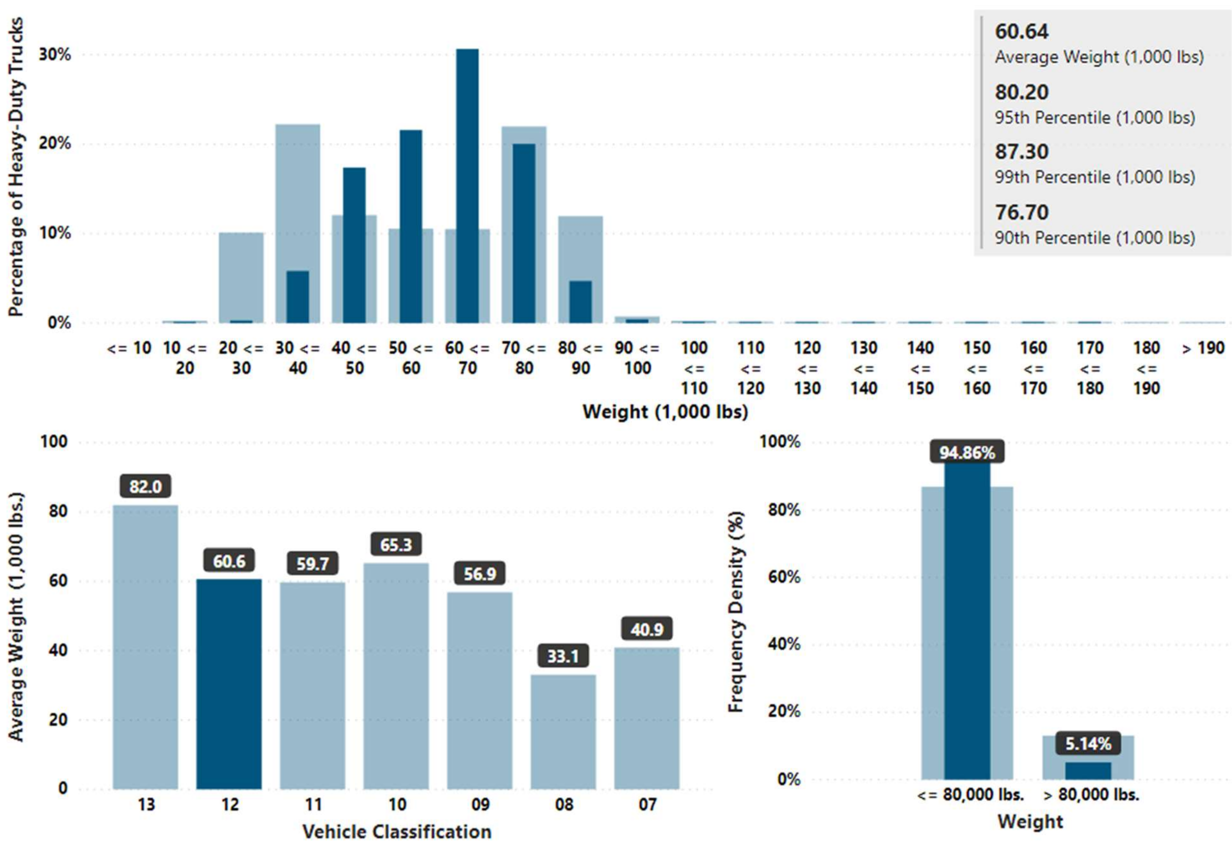

Figure C6. WIM Date for Class 12 Trucks

Class 11 Trucks

Class 11 trucks are multi-trailer configurations with five or fewer axles, shown in Figure C7. The data from the Class 11 trucks consisted of 256,031 records.

Figure C7. Example Class 11 Truck

The average weight of the Class 11 trucks was 59,720 pounds, which was very similar to the Class 12 average weight. A similar number of Class 11 trucks (4.3 percent) was over the 80,000 non-permitted weight limit. The weight distribution between the Class 11 and 12 trucks was also very similar, with the highest percentage of trucks weighing between 60,000 and 70,000 pounds. Figure C8 shows the breakdown of the WIM data for the Class 11 trucks.

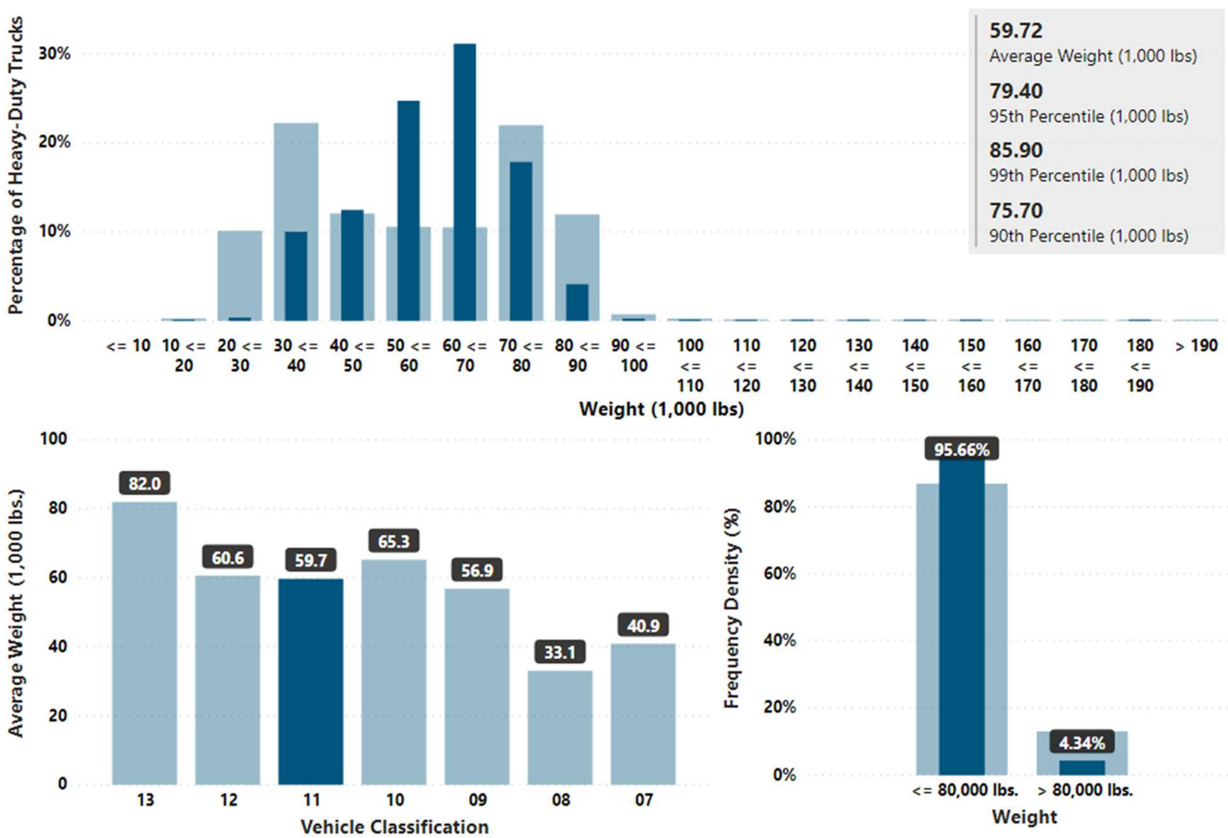

Figure C8. WIM Data for Class 11 Trucks

CLASS 10 TRUCKS

Class 10 trucks are single-trailer configurations with six or more axles. Figure C9 shows two examples of a Class 10 configuration.

Figure C9. Example Class 10 Truck

The WIM data included 110,648 Class 10 trucks, with an average weight of 65,270 pounds. The Class 10 trucks had a much higher percentage of OW vehicles at 28.2 percent compared to the Class 11 and 12 trucks. The weight distribution of this class was also more spread out, with the highest weight group (70,000–80,000 pounds) having just 17 percent of the total Class 10 trucks. Figure C10 shows the data from the Class 10 measurements.

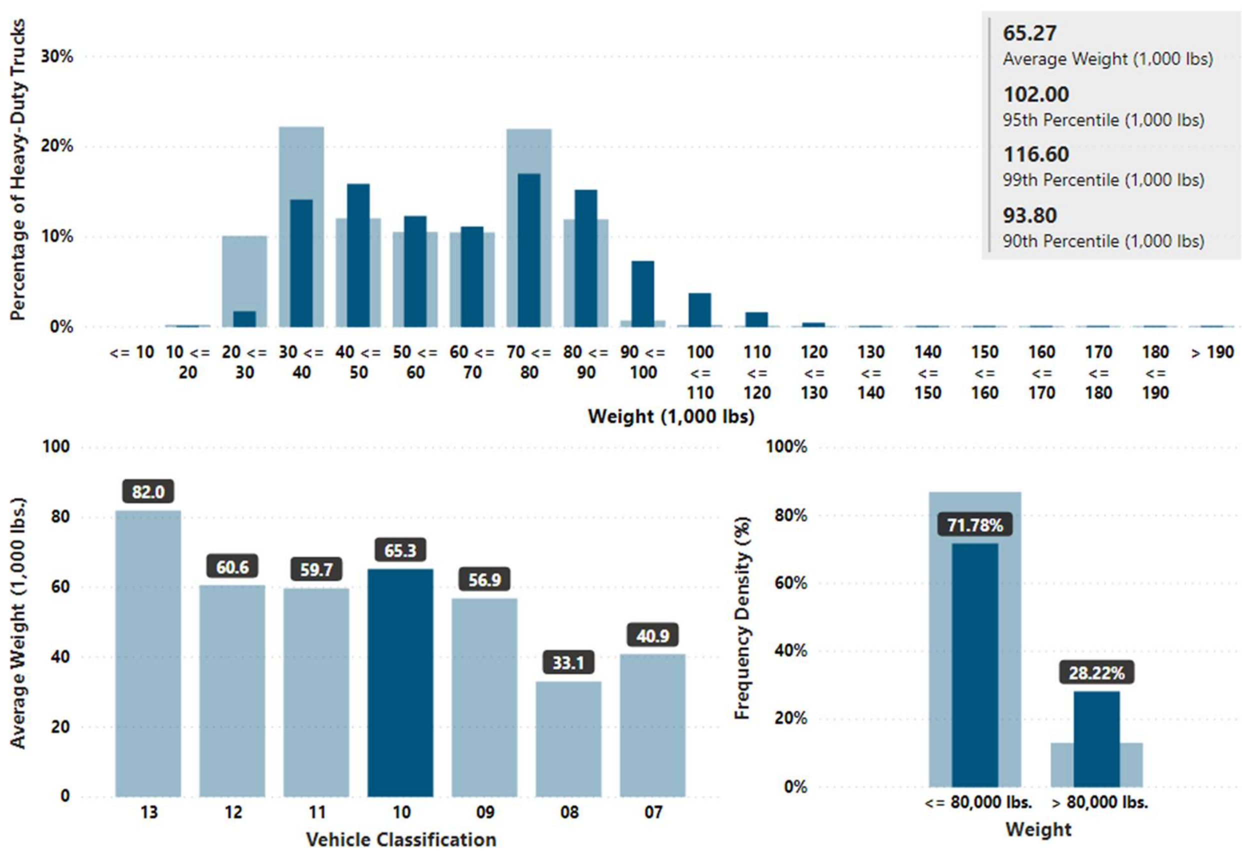

Figure C10. WIM Data for Class 10 Trucks

CLASS 9 TRUCKS

Class 9 trucks are single-trailer five-axle configurations, shown in Figure C11. This class of vehicle had by far the largest number of trucks in the overall fleet, with 9,114,107 trucks in this part of the WIM data, which is 87.2 percent of the total number of trucks in the entire data set.

Figure C11. Example Class 9 Truck

The average weight of the Class 9 trucks was 56,850 pounds, with 13.6 percent of the trucks being over 80,000 pounds. The distribution of the Class 9 truck was spread, with 22 percent being between 30,000 and 40,000 pounds and 24 percent being between 70,000 and 80,000 pounds. No other category had more than 13 percent. Figure C12 shows the data from the Class 9 trucks.

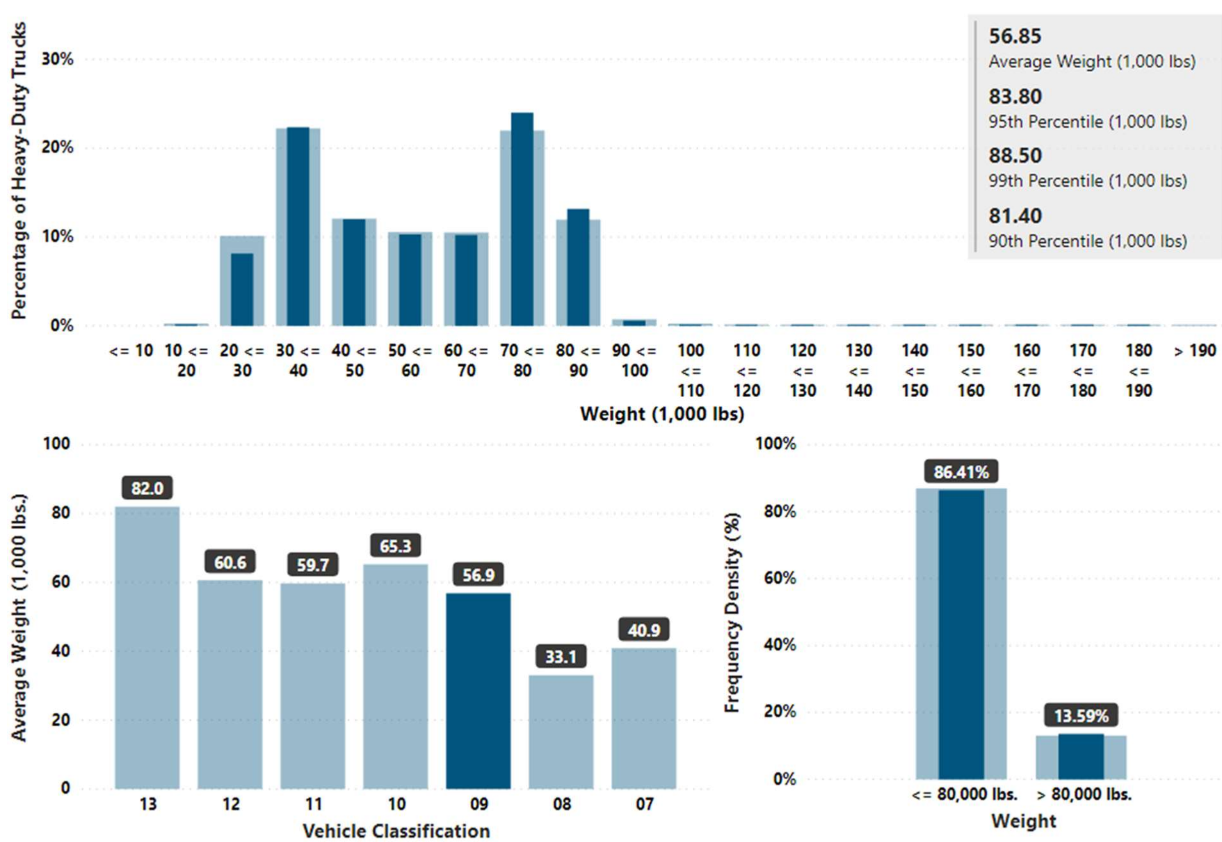

Figure C12. WIM Data for Class 9 Trucks

CLASS 8 TRUCKS

Class 8 trucks are single-trailer configurations with three or four total axles. Figure C13 shows three examples of Class 8 trucks. The WIM data had 633,672 Class 8 trucks.

Figure C13. Example Class 8 Trucks

The Class 8 trucks had the lowest average weight of any of the truck class at just 33,070 pounds. Most of the trucks, 47 percent, that were Class 8 were between 20,000 and 30,00 pounds. Only 0.2 percent of the trucks (1,384) were over the 80,000-pound limit. Of those that were OW, 60 percent were less than 90,000 total pounds. Figure C14 shows the data from the Class 8 trucks.

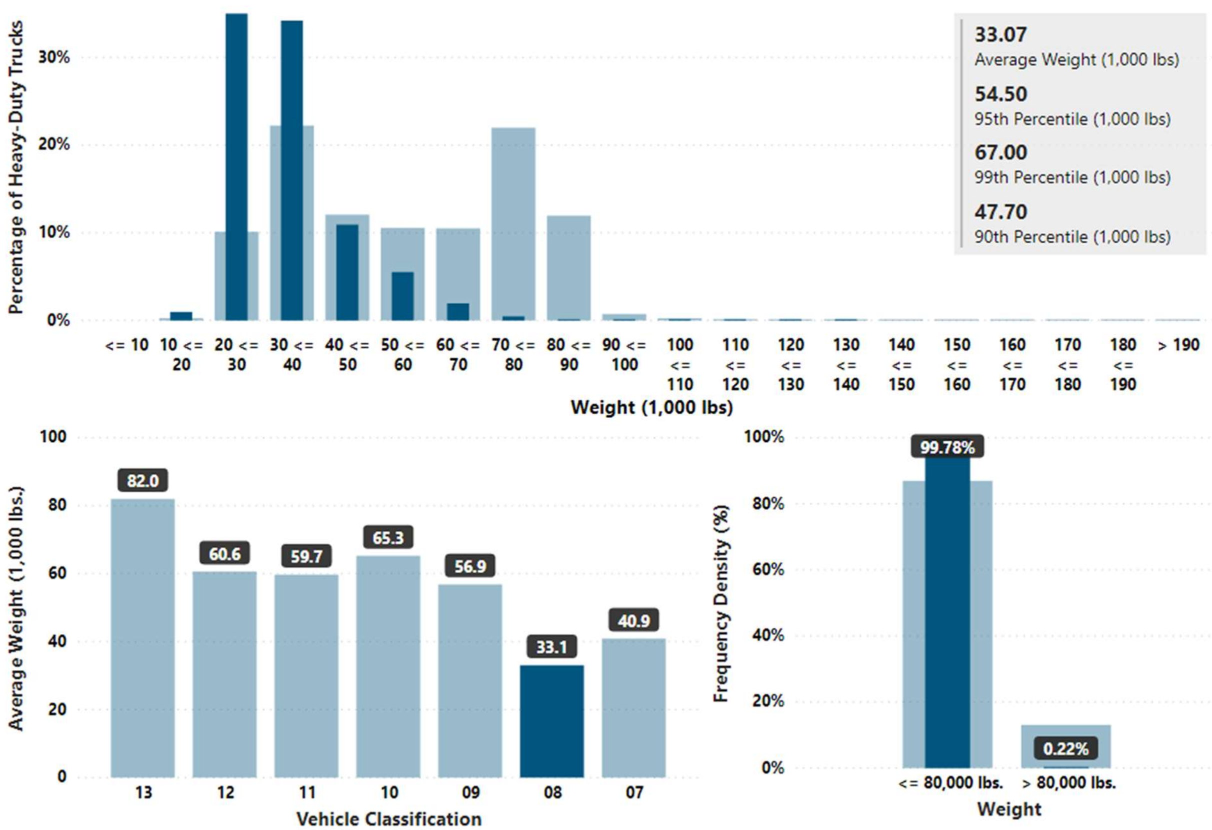

Figure C14. WIM Data for Class 8 Trucks

Class 7 Trucks

The last class of trucks is the Class 7 truck, which is a single unit with four or more axles. Figure C15 shows an example of a Class 7 truck.

Figure C15. Example Class 7 Truck

Class 7 vehicles had the fewest number of trucks in the data, at just 32,695 trucks included. The average weight was 40,900 pounds, with 1.5 percent being over 80,000 pounds. The Class 7 trucks had a similar distribution as the Class 8 trucks, with the highest number of trucks (28 percent) falling between 20,000 and 30,000 pounds. Figure C16 shows the data collected for the Class 7 trucks.

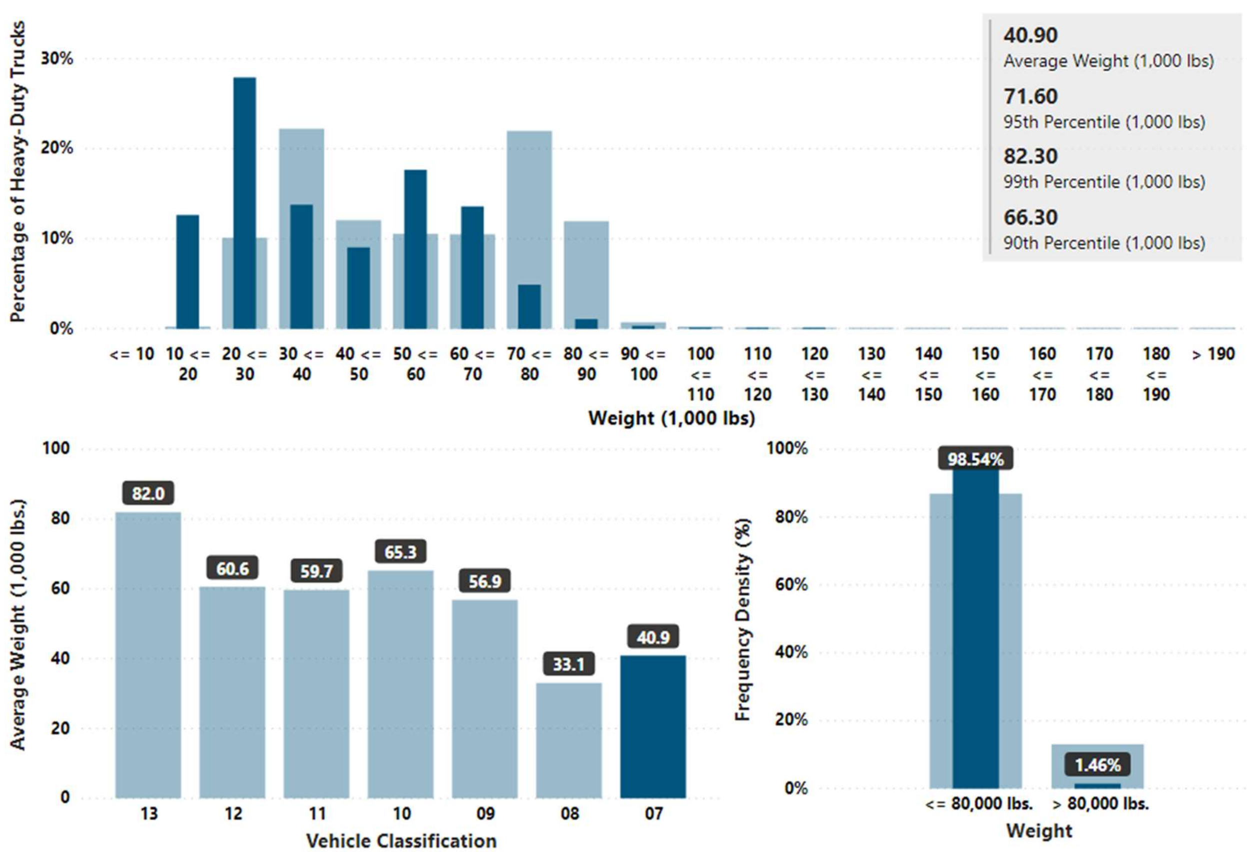

Figure C16. WIM Data for Class 7 Trucks

APPENDIX D: EMISSIONS IMPACTS OF OVERWEIGHT VEHICLES

Weight is an important factor influencing the power load on an engine. Vehicle mass is one of the main factors influencing a vehicle's fuel consumption under low-velocity driving conditions (30, 31, 32, 33). In general, the power demand can be expressed as a function of the weight of the vehicle, aerodynamic drag, speed of the vehicle, and road grade.

There is, however, only limited information on OS/OW vehicles and their emissions impacts. In general, OS/OW vehicles are expected to generate higher emissions due to two main factors:

- Excess weight, which causes higher power load on the engine, resulting in higher fuel consumption and higher emissions.
- Non-standard dimensions; odd-shaped, bulky, or large vehicles may have added drag or non-optimal aerodynamics that result in higher fuel consumption and emissions (30-33).

This appendix reviews existing literature and the state of the practice regarding vehicle emissions in the context of OS/OW operations. The main topics covered include the relationship between vehicular emissions and weight, the emissions impacts due to the varying geometry and size of the trucks, and the current weight/size considerations in the EPA MOVES model. This appendix also explores how to use this information to better understand the emissions from OS/OW vehicles. Given the context, the review

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30. Pagerit, S., P. Sharer, and A. Rousseau. Fuel Economy Sensitivity to Vehicle Mass for Advanced Vehicle Powertrains. *Proceedings of the SAE 2006 World Congress and Exhibition*, Vol. 2006, No. 724, 2006. https://doi.org/10.4271/2006-01-0665. Accessed August 6, 2018.
31. Bishop, J. D. K., N. P. D. Martin, and A. M. Boies. Cost-Effectiveness of Alternative Powertrains for Reduced Energy Use and CO2 emissions in Passenger Vehicles. *Applied Energy*, Vol. 124, No. 1, July 2014, pp. 44–61. https://doi.org/10.1016/j.apenergy.2014.02.019. Accessed August 6, 2018.
32. Natural Resources Canada. Vehicle Weight. http://www.nrcan.gc.ca/energy/efficiency/transportation/cars-light-trucks/buying/16755. Accessed August 6, 2018.
33. Wohlecker, R., M. Johannaber, and M. Espig. *Determination of Weight Elasticity of Fuel Economy for ICE, Hybrid and Fuel Cell Vehicles.* SAE Technical Paper 2007-01-0343, 2007. https://doi.org/10.4271/2007-01-0343. Accessed August 6, 2018.

primarily discusses heavy-duty diesel vehicles and focuses on emissions of criteria pollutants and greenhouse gases/fuel consumption.

FINDINGS FROM LITERATURE

While not explicitly in the context of OW vehicles, several examples of testing have been conducted to determine the effect of weight variations on heavy-duty vehicle emissions. Table D9 summarizes the findings from the studies.

Durbin et al. (34) tested light heavy-duty diesel vehicles over a combination of test weights and driving cycles to determine the effect of payload on emissions. The results for diesel vehicles showed increasing PM, CO_2, and NO_x emissions with increasing payload. The magnitude of the increase depended on the test cycle. The trends in hydrocarbon (HC) and carbon monoxide (CO) emissions were not consistent over the cycles.

34. Durbin, T. D., J. M. Norbeck, R. D. Wilson, and H. A. Galdamez. Effect of Payload on Exhaust Emissions from Light Heavy-Duty Diesel and Gasoline Trucks. *Environmental Science and Technology*, Vol. 34, No. 22, 2000, pp. 4708–4713. https://doi.org/10.1021/es001116y. Accessed August 6, 2018.

Table D9. Summary of Studies Relating to Vehicle Weight and Emissions

Study	Test Type or Drive Cycle	Pollutants Measured	Vehicle Type and Fuel	Study Findings
Durbin et al., 2000 (34**)**	Dynamometer/Federal Test Procedure	Total Hydrocarbons (THC), NO_x, CO_2, CO, and PM	Light heavy-duty vehicles—diesel (with variable sulfur content) and gasoline	Increases in PM, CO_2, and NO_x with increased weight.
McCormick et al., 1998 (36**)**	Dynamometer/Central Business District (CBD) and NY-composite	THC, NO_x, CO, and PM	Heavy-duty vehicles—diesel	Chassis test inertial weight had a significant effect on gram-per-mile emissions of all pollutants; however, on a gram-per-gallon basis, emissions were not a function of inertial weight except for PM, which was a weak function of inertial weight.
Gajendran and Clark, 2003 (37**)**	Dynamometer/ NY-composite, CBD, City Suburban Heavy Vehicle Route	THC, NO_x, CO, and PM	Transit bus and tractor truck—diesel	NO_x emissions have a nearly linear correlation with vehicle weight and did not vary much from vehicle to vehicle. CO and PM were found to be insensitive to the vehicle weight during nearly steady-state operation.
Sandhu et al., 2015 (38**)**	In use	THC, NO_x, CO_2, CO, and PM	Roll-off refuse trucks—diesel	The marginal effect of vehicle weight on fuel use and emissions is highest at low loads and decreases as load increases.

Study	Test Type or Drive Cycle	Pollutants Measured	Vehicle Type and Fuel	Study Findings
Franzese, 2011 (40**)**	In use	Fuel consumption (CO_2 can be inferred from results)	Class 8 freight trucks—diesel	The vehicle weight had only a marginal effect on fuel consumption—nonlinear and depended on road grade and speed.
Strimer et al., 2005 (41**)**	In use	CO_2 and NO_x	Tractor trailer—diesel	NO_x and CO_2 emissions of the heavy-duty diesel vehicle were affected substantially by the vehicle's overall weight in all types of use. For highway driving, the fuel economy decreased (though not in direct proportion) as the vehicle weight increased.
Brodrick et al., 2004 (42**)**	In use	THC, NO_x, CO_2, CO, and PM	Tractor trailer—diesel	At freeway speeds and during accelerations, an increase from 52,000 pounds to 80,000 pounds. GVW caused a greater than 40 percent increase in NO_x emissions (grams per mile).
Frey and Kim, 2006 (43**)**	In use	THC, NO_x, CO_2, CO, and PM	Dump trucks—diesel and bio-diesel	Fuel use and CO_2 emissions increase with vehicle size and weight. The emissions of other pollutants typically, but not always, increased by size and weight.

Study	Test Type or Drive Cycle	Pollutants Measured	Vehicle Type and Fuel	Study Findings
EPA, 2008 (44**)**	MOBILE6.2 model simulation	PM	Tractor trailer—diesel	PM emission rates increased with increasing payload.
Northeast States Center for a Clean Air Future, 2009 (45**)**	GT-POWER software simulation	Fuel consumption	Tractor trailer—diesel	Fuel consumption increased by 9 percent for increase in payload from 65,000 pounds to 80,000 pounds.
U.S. Department of Transportation, 2015 (46**)**	GT-POWER software simulation	Fuel consumption, NO_x and CO_2	Tractor trailer—diesel	Varying payloads tested from dead weight to 200,000 pounds for seven different vehicle types. The emissions and fuel consumption increased with increasing payload.

Keller and Fulper (35) found similar results when they compared how payload affected emissions from light heavy-duty diesel vehicles on conventional and off-cycle dynamometer test schedules. Payload increases resulted in increased NOx and PM on the cycles. Only slight changes in HC and CO were observed as payload increased. The level of emissions varied considerably between vehicles. McCormick et al. (36) examined the effect of changes in payload on PM, NOx, and CO emissions from a plow or dump truck with a 1993 engine run on the heavy-duty transient truck cycle. NOx and PM increases were observed as payload increased. Gajendran and Clark (37) collected and analyzed data over a variety of driving cycles to determine the effect of vehicle weight on PM, NOx, HC, and CO emissions from heavy-duty trucks and buses. HC emissions were found to be insensitive to weight, while CO and PM emissions were found to be a function of weight during transient operation but insensitive at steady-state operations. NOx emissions were found to vary nearly linearly with weight but were insensitive to transient operation in the test schedule. Applying an empirical equation to theoretical truckloads indicated potential NOx emissions increases of 54 percent for a doubling of the test weight.

CO2, NOx, and PM rates of a 2005 diesel front-loader refuse truck increased by 15 percent, 19 percent, and 4 percent, respectively, when comparing the 30,000 pounds of refuse truck weight with 65,000 pounds during a refuse collection duty cycle (38). Side-loader refuse trucks' NOx emission rates for loaded versus empty were similar for uphill driving and short acceleration and higher by 12 to 17 percent, respectively, for street and highway driving (39). Another study by Oak Ridge National Laboratory used

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35. Keller, C., and A. Fulper. *A Study of In-Use Emissions on Light Heavy-Duty Diesel Vehicles at Different Payloads Using a Chassis Dynamometer.* 2000.
36. McCormick, R. L., L. B. A. Ryan, T. L. Daniels, J. Yanowitz, and M. S. Graboski. *Comparison of Chasis Dynamometer In-Use Emissions with Engine Dynamometer FTP Emissions for Three Heavy-Duty Diesel Vehicles.* 1998.
37. Gajendran, P., and N. N. Clark. Effect of Truck Operating Weight on Heavy-Duty Diesel Emissions. *Environmental Science and Technology*, Vol. 37, No. 18, 2003, pp. 4309–4317. https://doi.org/10.1021/es026299y. Accessed August 6, 2018.
38. Sandhu, G. S., H. Christopher Frey, S. Bartelt-Hunt, and E. Jones. In-Use Activity, Fuel Use, and Emissions of Heavy-Duty Diesel Roll-Off Refuse Trucks. *Journal of the Air and Waste Management Association*, Vol. 65, No. 3, 2015, pp. 306–323. https://doi.org/10.1080/10962247.2014.990587. Accessed August 6, 2018.
39. Lee, D.-W., J. Zietsman, M. Farzaneh, and J. Johnson. Characterization of On-Road Emissions of Compressed Natural Gas and Diesel Refuse Trucks. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2233, 2011, pp. 80–89. https://doi.org/10.3141/2233-10. Accessed August 6, 2018.

the real-world information collected in that project to analyze the effects that vehicle speed and vehicle weight have on the fuel efficiency of Class 8 trucks. The results indicated that at any given speed, fuel efficiency decreases as vehicle weight increases although the relationship between fuel efficiency and vehicle weight is not linear, especially for vehicle weights above 65,000 pounds (40). The researchers at the University of West Virginia found that when the total test weight of a 1996 heavy-duty tractor was increased from 34,640 pounds to 79,700 pounds, the not-to-exceed NOx emissions increased by 30 to 40 percent. The researchers also found that the marginal effect of weight on emissions decreases as the vehicle weight increases (41). Based on real-world on-road emissions testing on a tractor-trailer, for a 54 percent increase in vehicle weight, NOx emissions in grams per mile increased by at least 40 percent during strong acceleration and high-speed steady-state modes (42). Based on real-world measurements, loaded dump trucks had approximately 30 percent higher fuel consumption than when empty. The researchers also found that loaded concrete mixer trucks had a 60 percent higher fuel use rate and 50 percent higher NOx and PM emission rates than empty trucks (43).

EPA has worked on evaluating the reduction in emissions of heavy-duty trucks for different weight classes (44). Figure D17 summarizes the study results, which show the PM emission rate increases with the increasing weight class. The definitions of different GVW classes are:

- IIb: 8,501 to 10,000 pounds.
- III: 10,001 to 14,000 pounds.
- IV: 14,001 to 16,000 pounds.

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40. Franzese, O. *Effect of Weight and Roadway Grade on the Fuel Economy of Class 8 Freight Trucks*. 2011.
41. Strimer, C. M., N. N. Clark, D. Carder, M. Gautam, and G. Thompson. *Impact of Vehicle Weight on Truck Behavior and Emissions, Using On-Board Measurement*. SAE Technical Paper 2005-01-3788, 2005. https://doi.org/10.4271/2005-01-3788. Accessed August 6, 2018.
42. Brodrick, C.-J., E. Laca, A. Burke, M. Farshchi, L. Li, and M. Deaton. Effect of Vehicle Operation, Weight, and Accessory Use on Emissions from a Modern Heavy-Duty Diesel Truck. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1880, 2004, pp. 119–125. https://doi.org/10.3141/1880-14. Accessed August 6, 2018.
43. Frey, H., and K. Kim. Comparison of Real-World Fuel Use and Emissions for Dump Trucks Fueled with B20 Biodiesel Versus Petroleum Diesel. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1987, 2006, pp. 110–117. https://doi.org/10.3141/1987-12. Accessed August 6, 2018.
44. U.S. Environment Protection Agency. *Average In-Use Emissions from Heavy-Duty Trucks—Emission Facts*. EPA-420-F-08-027. 2008.

- V: 16,001 to 19,500 pounds.
- VI: 19,501 to 26,000 pounds.
- VII: 26,001 to 33,000 pounds.
- VIIIa: 33,001 to 60,000 pounds.
- VIIIb: more than 60,000 pounds.

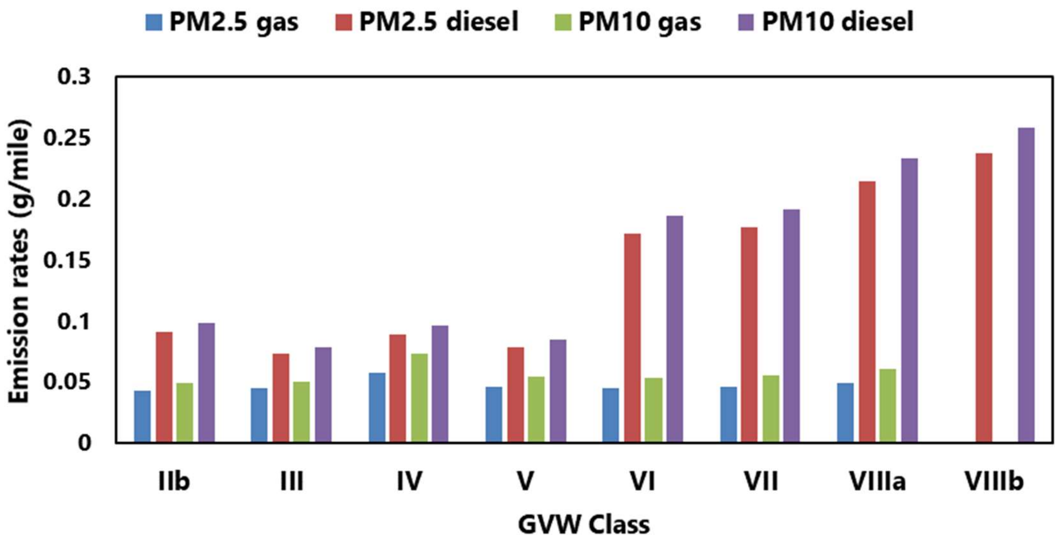

Figure D17. Average Heavy-Duty Truck Emission Rates by GVW Class (Grams per Mile)

Another study by the Northeast States Center for a Clean Air Future explores the fuel consumption and CO_2 emissions of heavy-duty long-haul combination trucks. Figure D18 summarizes the effect of vehicle weight on fuel economy and fuel savings. The graph shows that the fuel economy decreases from around 5.9 mile per gallon (mpg) at a weight of 65,000 pounds to 5.4 mpg at a weight of 80,000 pounds, a difference of approximately 9 percent fuel savings at the lower weight (45).

45. Northeast Center for a Clean Air Future. *Heavy-Duty Long Haul Combination Reducing Truck Fuel Consumption and CO2 Emissions.* 2009.

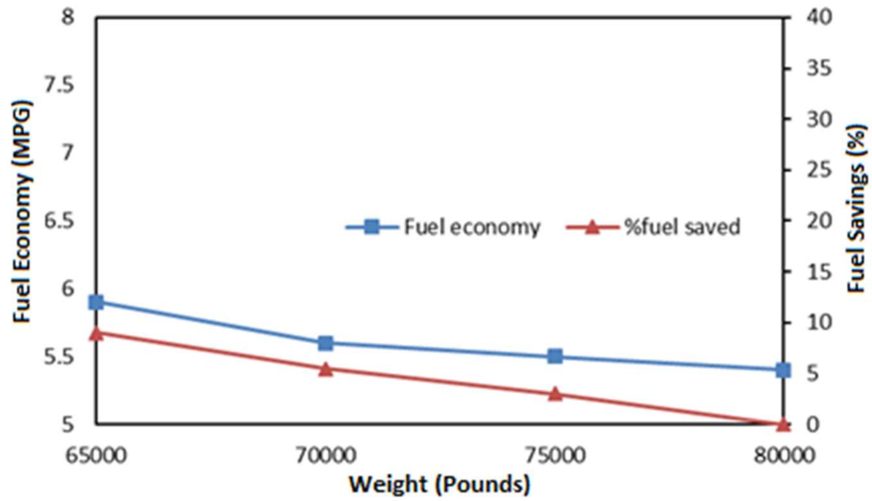

Figure D18. Effect of Vehicle Weight on Fuel Economy and Fuel Savings

The U.S. Department of Transportation conducted a comprehensive truck size and weight limits study in 2015, which also evaluated the effect of increasing payload on fuel consumption and emissions. In this study, a simulation method (termed GT-POWER) was used on a 2011 model Detroit DD15 engine. The simulations were designed to replicate varying payloads for different vehicle types as shown in Table D10. The payload scenarios varied up to a maximum permissible limit of 80,000 pounds and additional scenarios to evaluate OW loads up to 200,000 pounds (46).

Table D10. Definition of Different Scenarios Based on Vehicle Type and Payload

Vehicle	Gross Combination Weight (lb)							
	Allowed	01	1	2	3	4	5	6
A	80,000	34,622	50,000	65,000	80,000	200,000		
B	88,000	34,622	50,000	65,000	80,000	88,000	200,000	
C	91,000	36,255	51,633	66,633	81,633	91,000	200,000	
D	97,000	36,255	51,633	66,633	81,633	97,000	200,000	
E	80,000	31,376	46,754	61,754	76,754	80,000	200,000	
F	80,000	33,738	49,116	64,116	80,000	200,000		
G	105,500	41,454	56,832	71,832	86,832	105,500	200,000	
H	129,000	47,852	63,230	78,230	93,230	111,898	129,000	200,000

46. U.S. Department of Transportation. *Modal Shift Comparative Analysis—Comprehensive Truck Size and Weight Limits Study—Technical Report.* 2015.

A 5-axle vehicle (3-S2) (baseline).

B 5-axle vehicle (3-S2).

C 6-axle vehicle (3-S3).

D 6-axle vehicle (3-S3).

E Tractor plus two 28-ft trailers (2-S1-2) (baseline).

F Tractor plus two 33-foot trailers (2-S1-2).

G Tractor plus three 28-foot trailers (2-S1-2-2).

H Tractor plus three 28-foot trailers (3-S2-2-2).

Based on the results and graphs provided in the study, the following can be inferred regarding the relationship of payload with fuel consumption and emissions for OW trucks:

- Up to 1.3, 9.9, 14.9, and 17.6 percent increases in fuel consumption for increases of approximately 10,000, 20,000, 70,000, and 120,000 pounds, respectively, in excess weight over the 80,000-pound limit.
- Up to 12, 37, 78, and 166 percent increases in CO_2 emissions for increases of approximately 10,000, 20,000, 70,000, and 120,000 pounds, respectively, in excess weight over the 80,000-pound limit.
- Up to 4, 15, 29, and 63 percent increases in NO_X emissions for increases of approximately 10,000, 20,000, 70,000, and 120,000 pounds, respectively, in excess weight over the 80,000-pound limit.

Implications for Emissions of Permitted OW Vehicles

A review of the literature revealed that vehicle weight is an important parameter that influences emissions. Studies have demonstrated that an increase in payload mostly results in increased NO_x, PM, and CO_2 emissions/fuel consumption. While some studies report a linear relationship between weight and emissions, others indicate nonlinear increases with marginal increases in weight. However, a majority of the tests have studied vehicles that are below or very close to 80,000 pounds.

Furthermore, when the increase in vehicle weight was considered with respect to an overall reduction in truck VMT, savings in both fuel consumption and emissions were observed. EPA's SmartWay Program modeled different weight and size configurations of trucks to evaluate fuel consumption and emissions. The program found that longer combination vehicles, such as the Rocky Mountain double (with a weight range of 105,500 to 129,000 pounds) consumes 13 percent less fuel per ton-mile of freight than a typical combination truck (47). In addition, a National Cooperative Highway Research Program study estimated that fuel consumption is reduced by 6.2 to 13.8 percent and CO2 reduced by 3 to 8 percent with longer combination vehicles (with weight up to 108,000 pounds) because of the reductions in overall truck VMT (48). Also, a study by the American Transportation Research Institute found fuel savings of 14 to 21 percent and CO2 reductions of 6 to 11 percent by replacing 80,000-pound trucks with 100,000-pound trucks (49).

Emissions Impacts of OS Vehicles

Vehicle aerodynamic resistance is an important factor influencing fuel consumption, especially at high-speed driving conditions. Aerodynamic resistance is expressed as a function of the square of a vehicle's velocity and is proportional to the product of the aerodynamic drag coefficient, frontal area, and air density. The product of the aerodynamic drag coefficient and the frontal area is referred to as the *aerodynamic drag*. Changes to the size of the vehicle or its shape and aerodynamic design affect aerodynamic drag and influence fuel economy and CO2 emissions. However, no studies have explored the direct impact of the aerodynamics of OS vehicles on emissions (50).

Focusing on the improvement of vehicle aerodynamic losses during the design and manufacturing process in the past decades has resulted in the reduction of the vehicle drag coefficient (51). For heavy-duty trucks, a wide range of technology is currently available or under development that could provide significant drag reduction of tractor-trailers. Initiatives such as EPA's SmartWay Program have used several verified technologies that include aerodynamic devices applicable to tractor-trailers (52). At a

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47. U.S. Environmental Protection Agency. SmartWay Program. https://www.epa.gov/smartway. Accessed September 19, 2018.
48. National Cooperative Highway Research Program. *Directory of Significant Truck Size and Weight Research*. 2012.
49. American Transportation Research Institute. *Estimating Truck-Related Fuel Consumption and Emissions in Maine: A Comparative Analysis for a 6-Axle, 100,000-Pound Vehicle Configuration*. 2009.
50. Hucho, W.-H. *Aerodynamics of Road Vehicles: From Fluid Mechanics to Vehicle Engineering*. Butter, 2013.
51. Kobayashi, S., S. Plotkin, and S. K. Ribeiro. Energy Efficiency Technologies for Road Vehicles. *Energy Efficiency*, Vol. 2, No. 2, 2009, pp. 125–137. https://doi.org/10.1007/s12053-008-9037-3. Accessed August 6, 2018.
52. U.S. Environmental Protection Agency. SmartWay Program. https://www.epa.gov/smartway. Accessed September 19, 2018.

steady speed of 65 miles per hour on a flat road, aerodynamic drag and rolling resistance account for 21 percent and 13 percent, respectively, of the total fuel used by a Class 8 heavy-duty tractor (53).

While the literature has studied the benefits of improved vehicle aerodynamics, no existing research has studied the emission impacts of OS vehicles or those with peculiar dimensions. However, it can be inferred that their non-standard and bulky dimensions increase aerodynamic resistance and reduce fuel economy, though the extent of the impact is not clear. The literature discusses some examples that have assessed CO2 emissions or fuel consumption impacts of changes in aerodynamic resistance on heavy-duty vehicles, summarized in Table D11. While not directly assessing OS or non-aerodynamic vehicles, these studies do provide some insight into potential fuel consumption and CO2 emissions impacts by providing information on the impact of aerodynamics and vehicle weights on fuel consumption and CO2 emissions.

53. U.S. Department of Energy. *21st Century Truck Partnership—Pursuing Technologies That Lead to Sustainable Commercial Truck Transportation: ACEEE Workshop on Emerging Technologies for Heavy-Duty Vehicle Fuel Efficiency.* 2007.

Table D11. Studies of Aerodynamics and Fuel/Emissions Impacts for Diesel Tractor-Trailers

Source	Drive Cycles/ Methods	Parameters Measured	Drag Reduction Device Tested	Findings
Mccallen et al., 2004 **(**54**)**	Laboratory	Fuel consumption and CO_2	Base flap drag device	Using a base flap drag device with a low-boy trailer and side skirts results in a 22 to 25 percent reduction in drag coefficient. This translates to 11 to 12 percent savings in fuel consumption.
Chowdhury et al., 2013 **(**55**)**	Laboratory—wind tunnel	Drag coefficient	Front fairings, side skirts, and gap filling	Results indicated a 17 percent reduction in drag coefficient. Full skirting with front fairing, gap filling, and side skirting can reduce up to 26 percent aerodynamic drag.
Leuschen and Cooper, 2006 **(**56**)**	Laboratory—wind tunnel	Drag coefficient and fuel consumption	Fairings, side skirts, and vortex generators	Mirrors cause the highest aerodynamic loss of all other components. Maximum drag reduction was for fairings followed by skirts and vortex generators.

54. Mccallen, R. C., K. Salari, J. M. Ortega, and C. J. Roy. *DOE's Effort to Reduce Truck Aerodynamic Drag—Joint Experiments and Computations Lead to Smart Design.* 2004.
55. Chowdhury, H., H. Moria, A. Ali, I. Khan, F. Alam, and S. Watkins. A Study on Aerodynamic Drag of a Semi-Trailer Truck. *Procedia Engineering*, Vol. 56, 2013, pp. 201–205. https://doi.org/10.1016/j.proeng.2013.03.108. Accessed August 6, 2018.
56. Leuschen, J., and K. Cooper. *Full-Scale Wind Tunnel Tests of Production and Prototype, Second-Generation Aerodynamic Drag-Reducing Devices for Tractor-Trailers.* SAE Technical Paper 2006-01-3456, 2006, pp. 1–8. https://doi.org/10.4271/2006-01-3456. Accessed August 6, 2018.

Source	Drive Cycles/ Methods	Parameters Measured	Drag Reduction Device Tested	Findings
Schoon and Pan, 2007 **(**57**)**	Laboratory—wind tunnel	Drag coefficient and fuel consumption	Fairings, base curls, side skirts, and angles plates	The best drag reduction (23 percent) is achieved for a configuration with lengthened side extender and air fairing, straight skirt, and trailer wake angled plate.
Hirz, 2011 **(**58**)**	3D-CFD model simulation	Drag coefficient and fuel consumption	Geometry of driver cab and payload in different configurations using 3D-CFD model	The most efficient configuration of the driver cab and the payload was found using the 3D-CFD model. The final configuration achieved 11 percent fuel savings and 23 percent drag reduction.
Martini et al., 2011 **(**59**)**	3D-CFD model simulation	Drag coefficient and fuel consumption	Length and space between cab and payload evaluated using 3D-CFD mode	Generally, longer truck configurations improve efficiency. The increase in gap between cargo units has maximum increase on the drag coefficient.

57. Schoon, R., and F. P. Pan. *Practical Devices for Heavy Truck Aerodynamic Drag Reduction*. SAE Technical Paper 2007-01-1781, 2007. https://doi.org/10.4271/2007-01-1781. Accessed August 6, 2018.
58. Hirz, M. Environmental Impact of Aerodynamic Optimizations at Heavy Duty Commercial Vehicles. *EAEC European Automotive Congress*, June 2011.
59. Martini, H., B. Bergqvist, L. Hjelm, and L. Löfdahl. *Influence of Different Truck and Trailer Combinations on the Aerodynamic Drag*. SAE Technical Paper 2011-1-179, 2011. https://doi.org/10.4271/2011-01-0179. Accessed August 6, 2018.

Source	Drive Cycles/ Methods	Parameters Measured	Drag Reduction Device Tested	Findings
Schoon, 2007 **(**60**)**	Real world	Fuel consumption	Fairings, base curls, side skirts, and angles plates	Trailer forebody devices like fairings have resulted in significant fuel economy (11 to 15 percent) improvements.

REPRESENTING OS/OW VEHICLES IN EMISSIONS MODELING

Emissions modeling is used to estimate on-road mobile source emissions and to assess the emissions impacts of truck-related strategies. The emissions modeling process can be described as combining vehicle activity and vehicular emissions information to characterize vehicles' emissions. The methodologies used for regulatory emissions inventories such as the regional emissions analysis for transportation conformity are macroscopic in nature; that is, emissions are estimated at a regional scale.

EPA's MOVES model is the mandated model for all official mobile source emissions estimations in the United States, except for California. The MOVES model estimates vehicle emission factors based on second-by-second speed and acceleration of a vehicle combined with aggregated data for other key parameters such as vehicle weight, which is considered by vehicle type (known as *source type* in MOVES) (61).

The MOVES emissions model characterizes vehicle emissions on the basis of vehicle operating mode bins, for a range of source types and based on fuel type (61). The source types in MOVES that correspond to heavy-duty trucks include the refuse, single-unit short-haul, single-unit long-haul, combination short-haul, and combination long-haul trucks. MOVES generates emission factors for different sub-sources (known as *emission processes* in MOVES) including exhaust and crankcase (running, idling, and start), brake wear, and tire wear emissions (61).

EPA provides detailed documentation on the development of the heavy-duty emissions rates that go into the MOVES emissions model (62). The underlying data for this information come from a range of sources, primarily second-by-second in-use emissions testing, and chassis and engine dynamometer testing. MOVES uses a factor called

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60. Schoon, R. E. *On-Road Evaluation of Devices to Reduce Heavy Truck Aerodynamic Drag.* SAE Technical Paper 2007-01-4294, 2007. https://doi.org/10.4271/2007-01-4294. Accessed August 6, 2018.
61. U.S. Environmental Protection Agency. *MOVES2014a User Guide.* 2015.
62. U.S. Environmental Protection Agency. *Development of Emission Rates for Heavy-Duty Vehicles in the Motor Vehicle Emissions Simulator Final Report.* 2012.

vehicle specific power to link emissions to the power demand of a vehicle's engine. As shown in Equation D1, VSP is a combined measure of instantaneous speed, acceleration, road grade, and road load. For medium- and heavy-duty vehicles, VSP is converted to another factor called *scaled tractive power*, per Equation D2.

Equation D1: VSP Equation

$$VSP = \frac{A \times u + B \times u^2 + C \times u^3 + M \times u \times a}{M}$$

Equation D2: STP Equation

$$STP = VSP \times \frac{M}{f_m}$$

Where:

- u is the instantaneous speed of the vehicle (m/s).
- a is the instantaneous acceleration of the vehicle (m/s^2), including the impact of the grade ($a = a_{vehicle} + \sin(\operatorname{atan}(G/100))$ where G is the road grade in percent.
- A is a rolling resistance term.
- B is a rotational resistance term.
- C is a drag term.
- M is the vehicle's mass (metric ton).
- f_m is the fixed power scaling factor for medium- and heavy-duty vehicles.

MOVES's default values for these parameters are stored in the SourceUseTypePhysics table in the MOVES database. Users need to make changes to this table when including other vehicle weight values.

STP is calculated on a second-by-second basis for a medium- or heavy-duty vehicle operating over a specific speed trajectory (i.e., a drive cycle or drive schedule). Operating mode bins (opMode bins) are then defined according to the corresponding instantaneous speed and STP values. MOVES has a database of emissions rates for each opMode bin and vehicle type combination. The emissions associated with any given combination of drive cycle and vehicle type are estimated based on the distribution of time spent in opMode bins. Figure D19 graphically demonstrates this process. Table D12 provides the breakdown of STP and speeds used to classify the opMode bins.

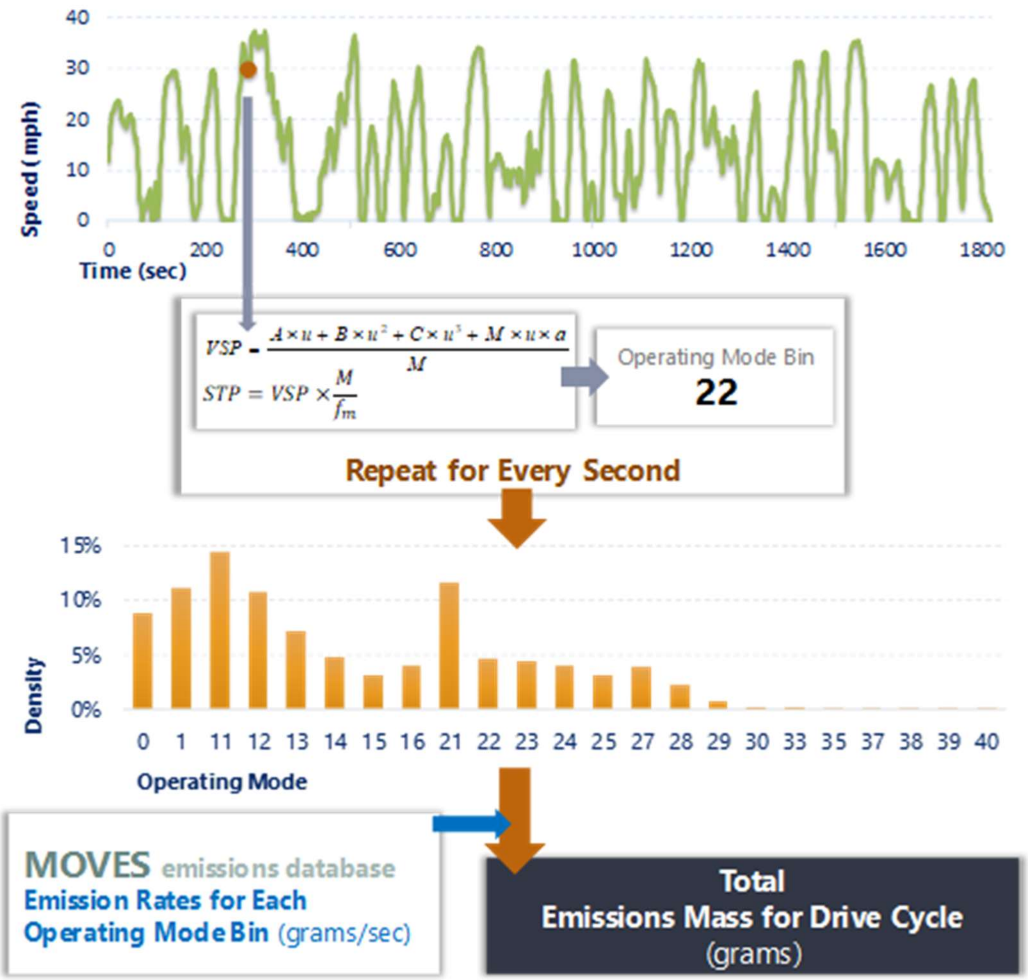

Figure D19. Emissions Estimation Process in MOVES

Table D12. opMode Definitions

OpMode Bin	Operating Mode Description	STP Value	Vehicle Speed (v, mph)
0	Deceleration/braking		
1	Idle		v < 1.0
11	Coast	STP < 0	1 ≤ v ≤ 25
12	Cruise/acceleration	0 ≤ STP < 3	1 ≤ v ≤ 25
13	Cruise/acceleration	3 ≤ STP < 6	1 ≤ v ≤ 25
14	Cruise/acceleration	6 ≤ STP < 9	1 ≤ v ≤ 25
15	Cruise/acceleration	9 ≤ STP < 12	1 ≤ v ≤ 25
16	Cruise/acceleration	12 ≤ STP	1 ≤ v ≤ 25
21	Coast	STP < 0	25 ≤ v ≤ 50
22	Cruise/acceleration	0 ≤ STP < 3	25 ≤ v ≤ 50
23	Cruise/acceleration	3 ≤ STP < 6	25 ≤ v ≤ 50
24	Cruise/acceleration	6 ≤ STP < 9	25 ≤ v ≤ 50
25	Cruise/acceleration	9 ≤ STP < 12	25 ≤ v ≤ 50
27	Cruise/acceleration	12 ≤ STP <18	25 ≤ v ≤ 50
28	Cruise/acceleration	18 ≤ STP < 24	25 ≤ v ≤ 50
29	Cruise/acceleration	24 ≤ STP < 30	25 ≤ v ≤ 50
30	Cruise/acceleration	30 ≤ STP	25 ≤ v ≤ 50
33	Cruise/acceleration	STP < 6	50 ≤ v
35	Cruise/acceleration	6 ≤ STP < 12	50 ≤ v
37	Cruise/acceleration	12 ≤ STP < 18	50 ≤ v
38	Cruise/acceleration	18 ≤ STP < 24	50 ≤ v
39	Cruise/acceleration	24 ≤ STP < 30	50 ≤ v
40	Cruise/acceleration	30 ≤ STP	50 ≤ v

The combination trucks (i.e., tractor-trailers) are usually the main focus of OS/OW studies. Table D13 shows MOVES's values for vehicle physics parameters, including the average vehicle weight. As shown in this table, MOVES's default values for vehicle weight are considerably lower than the 80,000-pound weight limit. Given that the weight ranges for OW vehicles are greater than 80,000 pounds, it is unclear whether the underlying emissions data in the MOVES's emission rates database for operating mode bins would be representative of vehicles that are OS/OW.

Table D13. Default Vehicle Physics Coefficients for Combination Truck (MOVES2014 and MOVES2014a)

Vehicle Type	Model Years	M Average Mass (Metric Tons)	A Rolling Resistance	B Rotational Resistance	C Aerodynamic Drag	f_{scale} Mass Factor (Metric Tons)
Short-haul combination truck (Source Type 61)	1960–2013	22.98 (50,650 pounds)	1.5382	0	0.0040	17.1
	2014–2050	22.83 (50,329 pounds)	1.4305	0	0.0038	17.1
Long-haul combination truck (Source Type 62)	1960–2013	24.60 (54,236 pounds)	1.6304	0	0.0042	17. 1
	2014–2050	24.42 (53,836 pounds)	1.4739	0	0.0037	17.1

In the past few years, state departments of transportation and enforcement agencies have widely adopted WIM technology as the main tool to enforce roadway weight limits. WIM data are seen as a new source of information to enhance the local weight inputs for emissions modeling. A recent study by researchers at the University of California, Riverside developed a method of incorporating weight data from WIM stations to adjust vehicle weight parameter in MOVES. While this study used MOVES's existing emissions rates, it demonstrated that including the actual vehicle weight data (versus assuming an average weight value per vehicle class) for assigning operational mode bins in MOVES resulted in 78 percent higher NOx emissions and 30 percent higher PM emissions (63).

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63. Boriboonsomsin, K., G. Wu, P. Hao, and M. Barth. Fusion of Vehicle Weight and Activity Data for Improved Vehicle Emission Modeling. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2503, January, 2015, pp. 153–162. https://doi.org/10.3141/2503-17. Accessed August 6, 2018.

APPENDIX E: STUDY DESIGN PLAN

This appendix describes the study design plan created to help fill in the gaps in data identified in the initial tasks associated with the project. The four areas with gaps in the data identified are:

- OS/OW vehicle characteristics.
- OS/OW vehicle activity.
- OS/OW vehicle emission rates.
- Unauthorized OS/OW vehicle operations.

The remainder of this appendix describes the data needs and how they were addressed with data collection and analysis.

VEHICLE CHARACTERISTICS

The first piece of information needed for emissions analysis of OS/OW operations is the vehicle characteristics. The parameter of interest for this study is the age distribution of OS/OW trucks.

Vehicle Age

The vehicle age distribution has two applications in this study:

- It is a key input parameter for estimating emissions from vehicles. Researchers incorporated this information in the resulting emission estimation methodology for the NCTCOG NA area.
- Researchers used the age distribution to select representative trucks for emissions testing, which was conducted on a select set of vehicles as part of the study.

The study team identified and used the following data sources for OS/OW vehicle age information.

Texas Permitting and Routing Optimization System

TxPROS is an online system maintained by TxDMV, allowing fleets to apply and obtain OS/OW (and other) permits. The research team obtained the TxPROS permit dataset for the period covering September 2015 to August 2018. The dataset includes information on vehicles that have received a permit, including their model year.

Vehicle Registration Data

Vehicle registration data maintained by TxDMV contain information on every vehicle registered in Texas, including the vehicles' model year and rated horsepower. The collection and use of vehicle model year (age) information from the vehicle registration dataset for emissions estimation applications have been established and fully documented by the Texas A&M Transportation Institute (64). As part of this study the most recent vehicle age distribution information for the NCTCOG region was used. The provided information contained the age distribution of each vehicle type by county, which was used for quality control and to evaluate the age distributions from the TxPROS dataset.

Engine Size and Horsepower

The study team also examined the potential use of the engine size distribution or horsepower of OS/OW trucks as a secondary information source to better inform the selection of OS/OW trucks for emissions testing. Because the engine size or horsepower information is recorded in the vehicle registration database, the study team needed to identify each truck (i.e., through the license plate number or vehicle identification number). An examination of the available information in the TxPROS dataset obtained by the study team showed that individual OS/OW trucks could not be identified from the data, and therefore the extraction of engine information would be impossible from the available data sources. The study team therefore did not include the engine size information in this study.

VEHICLE ACTIVITY

The second type of information needed for the emissions impact analysis of OS/OW vehicles was the activity data of these vehicles. The two key vehicle activity parameters needed to accurately conduct a regional emissions impact analysis are VMT and average speed, which, at a minimum, were needed by road type. When possible, a more refined characterization by time of day (i.e., morning, midday, afternoon, or nighttime) and day of the week (i.e., weekend or weekday) helped to improve the accuracy of the emissions estimation. The study team identified the following data sources for these parameters.

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64. Perkinson, D. G. *VMT Mix Estimation Method Refinement for MOBILE6.* Texas Commission on Environmental Quality, Umbrella Contract 60200-03-06: Task 2. Texas Transportation Institute, August 2003.

TxPROS OS/OW Permit Data

As with the vehicle characteristic data, the TxPROS data were used to characterize the OS/OW truck activities. TxPROS includes routing data for single-permit OS/OW loads, which make up almost 80 percent of the issued permits. The study team processed this route information in a geographic information systems application to extract the VMT by road type for these single-permit trips. The extracted data were analyzed to build representative VMT by road type values for each county in the NCTCOG NA area.

Vehicle Data Logger

In addition to using the TxPROS dataset, the study team used onboard diagnostic (OBD) data loggers to collect detailed route and speed data from a sample of permitted OS/OW trucks operating in the NCTCOG area. Figure E20 shows the data logger that researchers used to collect these activity data. The data logger connects to the SAE J1939 data port of heavy-duty vehicles and logs the information about the operations of the vehicle at a 1-Hz frequency (i.e., second by second). The data include the vehicle speed, engine speed, engine load, and many other parameters. The data loggers also include a GPS recorder that records the location of the vehicle while operating.

Figure E20. HEMData Data Logger

The OBD data loggers are meant to be installed on vehicles and left for an extended period of time. The loggers have a cellular data connection that allows them to send data files back to a central server after each vehicle trip. This allows the study team to follow and analyze the data in near real time. The data collection plan called for a sample of at least three permitted OS/OW trucks—operated by companies that often carry OS/OW loads—to be equipped with a data logger. The data loggers were installed for approximately three months on each vehicle.

Emissions Characteristics of OS/OW Trucks

In addition to the vehicle characteristics and activity, the other piece of information needed for the analysis is the emissions rates for OS/OW vehicles. This section describes the data collection equipment, vehicle sample selection, testing process, and test routes that were used to collect emissions data on OS/OW trucks.

To establish emissions rates for OS/OW vehicles, a sample of three trucks were tested using a PEMS. The PEMS used for all tests was comprised of two separate devices. The ECOSTAR unit manufactured by Sensors, Inc., (Figure E21Figure E21) measures gaseous emissions including CO, CO_2, NO_x, and THC. In addition to the gaseous measurement, the ECOSTAR also measures the exhaust flow at the tailpipe, which allows for the calculation of the mass of each pollutant, as well as GPS, ambient temperature, relative humidity, and OBD data.

In addition to the ECOSTAR, a PM measurement device developed by AVL was used to collect PM data. The PM PEMS includes both a filter measuring module and a micro-soot sensor module that performs second-by-second measurement. The concentration readings, when used in conjunction with the exhaust flow observations from the ECOSTAR unit, provide the total PM emissions for the vehicle being tested. Figure E22 shows the PM PEMS unit.

Figure E21. ECOSTAR PEMS Unit

Figure E22. AVL PM PEMS Unit

UNAUTHORIZED OS/OW OPERATIONS

In order to collect information on unauthorized OS/OW operations the research team worked with commercial vehicle enforcement officers in the DFW area during enforcement activities. This is discussed in further detail in Appendix F.

APPENDIX F: PEMS DATA PROCESSING

This appendix describes the steps that were used to process the emissions data collected using PEMS during the emissions collection task. After emissions testing, the data were processed to calculate second-by-second emissions rates (grams per second) from the raw data collected by the PEMS devices. The devices (i.e., two PEMS units and the PAMS unit) have software that converts the binary data collected by the units into a comma-separated values format. These software packages were used as part of the data-processing step.

The process used to calculate the second-by-second emissions rates is as follows.

The first step after extracting the binary data from the data collection units is to time-align the data from the gaseous PEMS. The gaseous PEMS measures both the concentrations of pollutants, in parts per million (ppm), as well as the exhaust flow from the tailpipe, in standard cubic feet per minute (SCFM). These two measurements (pollutant concentrations and exhaust flow) must be aligned separately for each of the pollutants.

Once the data were downloaded via the Sensor Tech post-processor (Figure F23) from Sensors, Inc., each of the pollutants was time-aligned to the exhaust flow using the Pearson correlation coefficient (PCC), which calculates the relationship between two continuous variables. The data were aligned by shifting the pollutant concentration data forward and backward, using one-second intervals, for a total of 20 seconds in each direction. After each shift, a new PCC was calculated. The time shift that resulted in the best correlation (i.e., highest PCC) was used as the time shift for that pollutant. Those time shifts were then entered into the Sensor Tech post-processor software (Figure F24) as exhaust transport delays, and the data were then reprocessed. This process results in time-aligned gaseous emissions data that are used for the remainder of the data-processing task.

Once the gaseous data were processed and time-aligned, the same process was conducted for the PAMS data collected during the emissions testing. A PCC-based time alignment process between the exhaust flow data and the engine data (specifically the engine revolutions per minute [rpm]) was conducted. This time alignment was then used to merge the gaseous emissions data with the PAMS data. The combined gaseous and PAMS data were then merged with the PM data using the Concerto software from AVL (Figure F25). The Concerto software used the raw data from both the gaseous and PM data, and calculated the emissions rates, in grams per second, for each pollutant. The output from Concerto includes the emission rates and PAMS data.

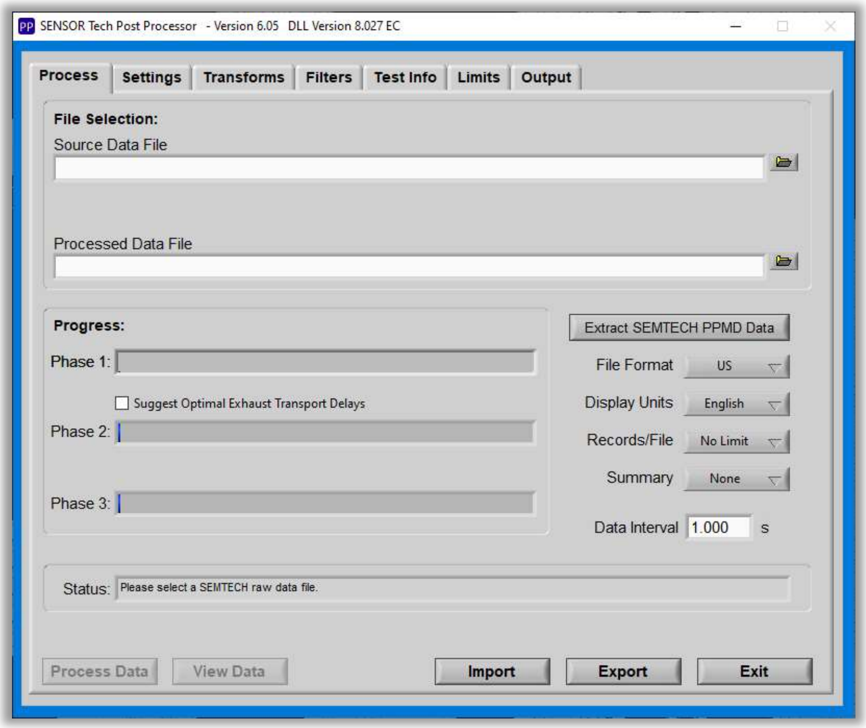


Figure F23. Sensors, Inc., Post-Processing Software

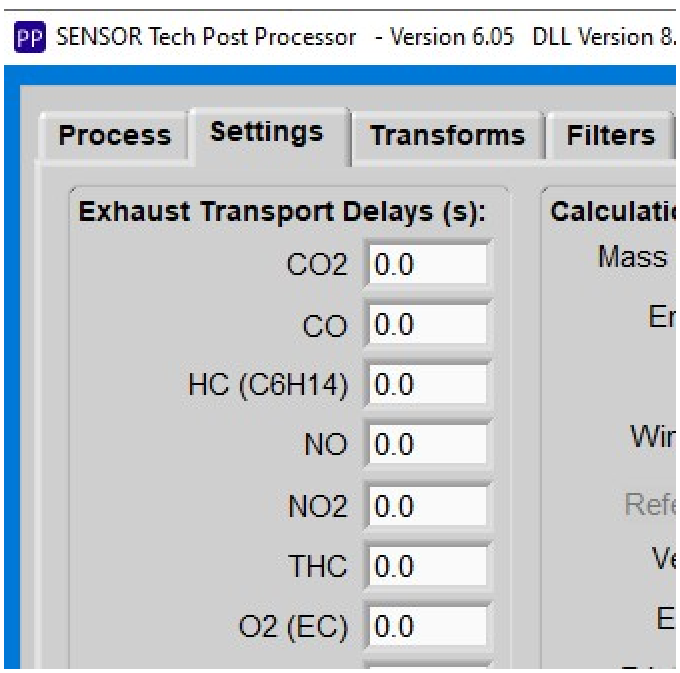


Figure F24. Sensors, Inc., Post-Processing Time Alignment

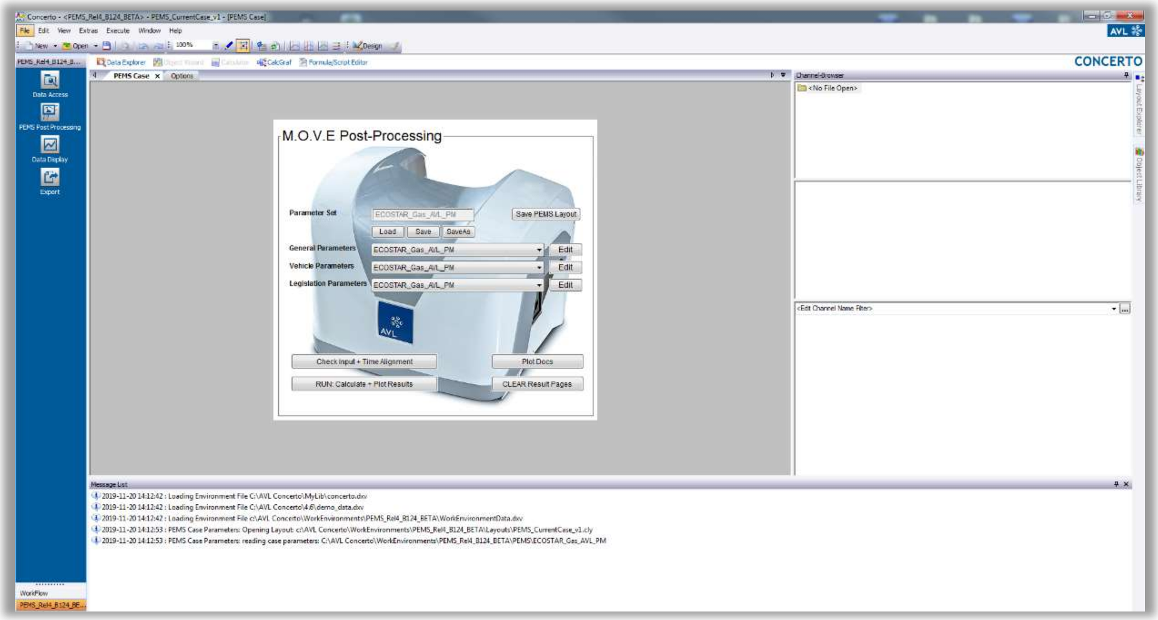


Figure F25. AVL Concerto Software

The combined data file was split into four data tables in the Power BI file to facilitate the data modeling and analysis process. Table F14 summarizes the four main PEMS data tables and the different parameters within them.

Table F14. Summary of Data Tables from PEMS Testing

PEMS Data Table	Parameters
PEMS Emissions	• Time Sequence (s) • Scenario ID • Pollutant • Emission Mass (g/s) • Emission Concentration (ppm)
PEMS Exhaust and Fuel	• Time Sequence (s) • Scenario ID • Exhaust Mass Flow Rate (kg/s) • Exhaust Temperature (C) • Exhaust Volumetric Flow Rate (SCFM) • Fuel Rate (gal/s) • Instantaneous Fuel Flow (g/s)
GPS-Speed-Weather	• Time Sequence (s) • Scenario ID • Latitude • Longitude • GPS Ground Speed (mph) • Altitude (m) • Weather Probe Humidity (%) • Weather Probe Temperature (C)
VI Data	• Time Sequence (s) • Scenario ID • Actual Engine Percent Torque (%) • Engine Percent Load at Current Speed (%) • Engine Speed (rpm) • SCR Intake NO_x (ppm) • SCR Intake Temperature (C) • SCR Intermediate NH_3 (ppm) • SCR Intermediate Temperature (C) • SCR Outlet NO_x (ppm) • SCR Outlet Temperature (C) • Speed (km/h)

APPENDIX G: UNAUTHORIZED OVERSIZE/OVERWEIGHT VEHICLE OPERATIONS

To understand the prevalence of OS/OW violations in the NCTCOG area, researchers worked with commercial-vehicle enforcement officers to collect weight and violation data in the DFW area. Researchers developed a survey template (Figure G26) to collect information on vehicle characteristics, permit type, vehicle and axle weights, vehicle type, trip information, type of operation (i.e., short versus long haul), and fleet size. Researchers participated in two types of enforcement:

- Fixed-field enforcement.
- Ride-along enforcement.

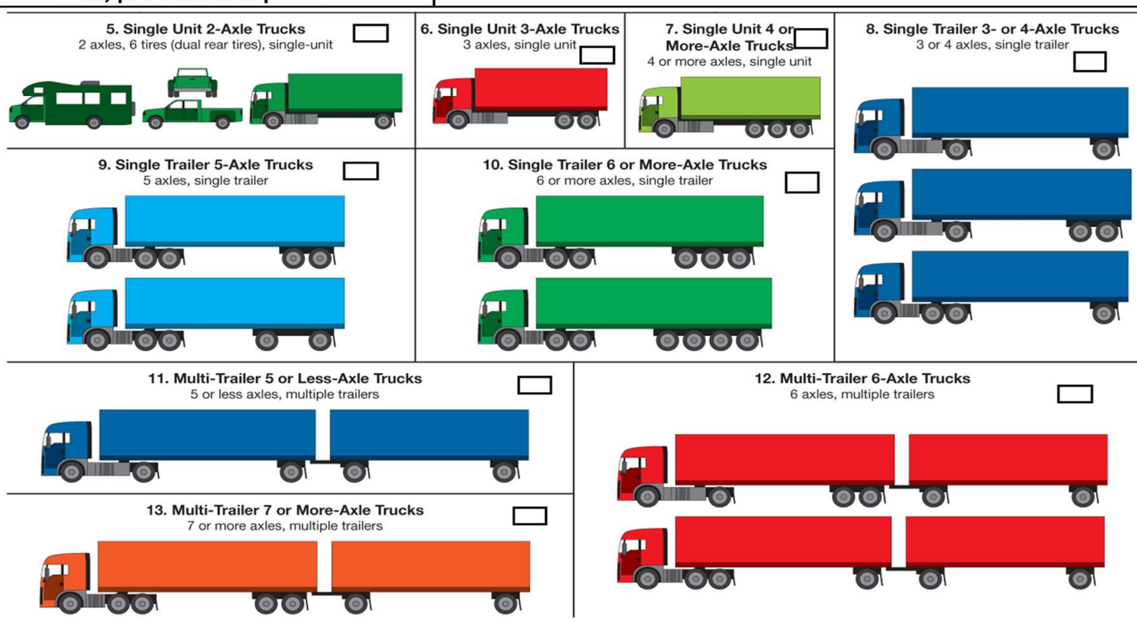
FIXED-FIELD ENFORCEMENT

Researchers worked with the Lewisville Police Department, Carrollton Police Department, Denton County Sheriff's Office, City of Little Elm, and TxDPS to observe four joint enforcement programs conducted in the DFW area. The dates and locations where the enforcement programs were conducted are as follows:

- March 27, 2019—1600 S Stemmons Freeway in Lewisville.
- April16, 2019—121 Tollway and Marchant in Carrollton.
- May 15, 2019—weigh station on IH 45 North Service Road at Fulghum Road in Hutchins.
- May 16, 2019—IH 35 on Westgate Drive in Denton.

The fixed-field enforcement program involved multiple enforcement department officials setting up a weight scale at a predetermined location and officials escorting vehicles from the road to the location. Figure G27 shows the scale used for one of the fixed-location enforcements observed by researchers. At the scale location, the officers conducted safety and OS/OW inspections.

Address of inspection event	**121 Tollway and Marchant, Carrollton, Texas**
Closest main highway	**One block North of the Tollway on Marchant**
Model year	
Make and Model	
VIN	
Is Vehicle Oversize (Y/N)	
Type of OS Permit (none if illegal load)	
Is Vehicle Overweight (Y/N)	
Vehicle Weight by Axle	**1)** **2)** **3)** **4)** **5)** **6)**
Total Axle weights	
Total Axle weights sufficient	
Type of OW permit (none if illegal load)	
Engine emissions control label	☐
Does emissions control label match truck?	☐
If no, provide description:	



Trip Information	
Origin (city or zipcode)	**Destination (city or zipcode)**
Typical operation area	
Short haul ☐	**Long haul** ☐
Operating Time in the DFW Region (%)	
Size of fleet	
<10	**31-40** ☐
11-20	**41-50** ☐
21-30	**>50** ☐

Figure G26. Ride-Along Survey Form.

Figure G27. Scale Used for Fixed-Location Enforcement

The overall process involves the following:

1. Officers scan vehicles from the shoulders of the freeways for any potential violators. Officers target vehicles based on certain visual clues (e.g., vehicle condition and how deflated the tires look).
2. After flagging a potential violator, officers escort the flagged vehicle to the designated area for the inspections. Two kinds of inspections are performed: safety (tires, brakes, lights, etc.) and OS/OW.
3. The vehicle is driven over the weight scale. In some cases, vehicles are not driven over the scale because the officers are confident that the vehicles are not OW (e.g., an empty vehicle) but have potential safety issues. Vehicles that do not pass the safety inspection are removed from service.
4. At the weight scale, officers read the weight of each axle and determine the overall weight of the vehicle. Figure G28 shows a paper copy of the weight report. If the OS truck has eight axles, officers use additional scales to determine the weight.

Figure G28. Paper Copy of Weight Report Generated by Scale Computer

5. Officers give citations to vehicles that exceed the authorized weight or size limits. Vehicles that exceed the weight by 1,000 pounds or less are given a waiver. This is to account for fluctuating readings of the scales, given the movement of vehicles, especially trucks that carry liquids. Officers cite some vehicles for axle weight violations or overall weight (GVW) violations.

Ride-Along Enforcement

The research team participated in two ride-along enforcement programs. Researchers observed how local police departments' commercial-vehicle enforcement officers patrol roads in the DFW area and inspect potential violators for weight-related violations. Researchers accompanied officers from the following law enforcement departments:

- Garland Police Department on April 14, 2019.
- Dallas County Sherriff's Office on May 13 to May 15, 2019.

The overall process involves the following:

1. The officers identify potential violators through visual clues such as bulging tires, trucks that are sitting low, or the size of the load.
2. Officers flag down potential violators and escort them to a safe area with enough space for conducting inspections (e.g., a church parking or empty parking lot).
3. In these inspections, the officers only check the weight and bridge formula weights of the trucks. The officers use portable WIM weight scales (each weighing about 30 to 40 pounds). The portable weight scales are positioned in front of the stopped vehicles, and drivers are asked to slowly drive on top of the scales.
4. Officers record the axle weight and determine the total weight of the vehicle.

It takes an average of 20 minutes to inspect a truck.

Findings

A total of 128 vehicles were escorted and weighed in all the enforcement activities that researchers observed. About 70 percent of the vehicles inspected were pulled over in the fixed-field enforcement program. More than 95 percent of all vehicles weighed (122 vehicles) were conducting mainly short-haul operations, making multiple trips per day. Of the 98 vehicles inspected at the fixed location, 19 (26.8 percent) were cited for weight.

Of the 30 vehicles inspected during the ride-along program, 8 vehicles (26.7 percent) were cited for weight. The Garland officers stated that on average half of the trucks that they inspect per day are cited for weight. Each officer typically inspects 5 to 6 trucks each day.

In the case of the fixed-field programs, the enforcement site was located such that most of the inspected vehicles were suspected of being overloaded on their trip to a landfill located in Lewisville. Most of the inspected trucks in this location were either dump trucks (five-axle single trailers) or waste collection trucks (three-axle single trailers65).

In the ride-along with the Garland Police Department officer, the officer focused on roads serving a rock yard in the morning, which resulted in all the trucks inspected being dump trucks filled with building material destined for the rock yard. In the afternoon, the officer targeted major highways, which resulted in more tractor-trailer trucks (i.e., five-axle single trailers) being inspected. In all cases, officers identified potential violators by visually observing their loads (e.g., trucks moving sheet rock, grass pallets, waste, concrete or cement, or building debris) and other visual clues. The researchers acknowledge that the sample from these observations is biased toward the certain loads that were the focus of the inspections and may not be a true representation of the population of OS/OW violations in the DFW region.

65. In a few cases, the trucks had an additional drop-down axle to accommodate additional weight if necessary.

APPENDIX H. FINAL EMISSION RATES

MY2005 Normal Load Rates

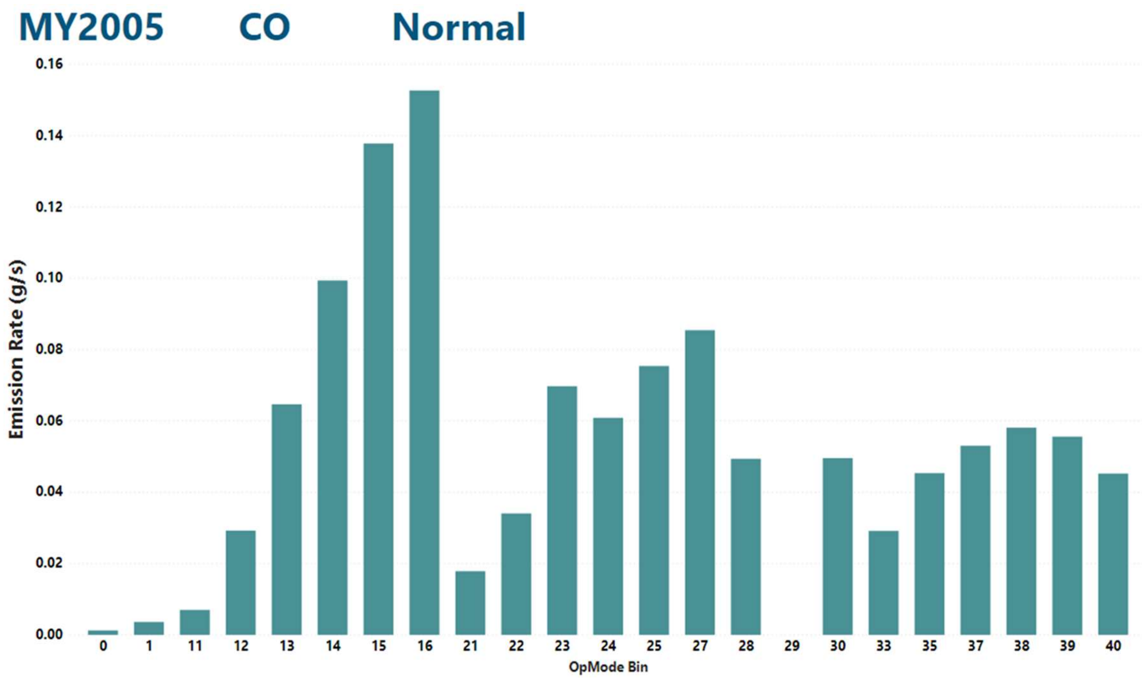


Figure H29. MY2005 Normal Load CO Emission Rates

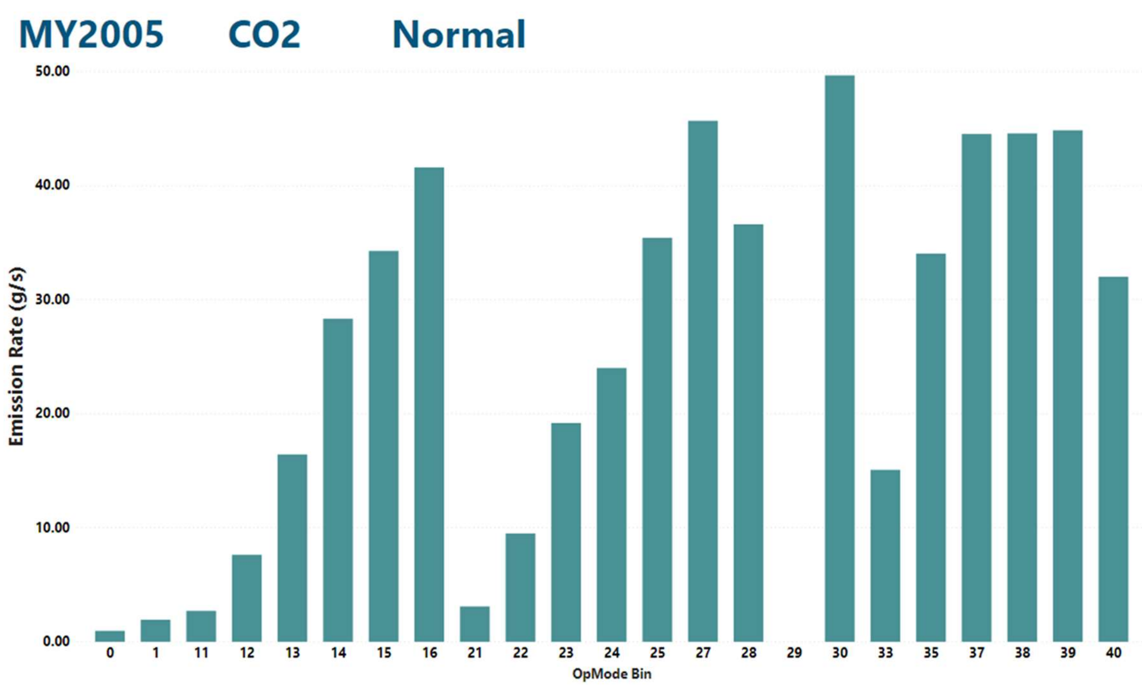


Figure H30. MY2005 Normal Load CO_2 Emission Rates

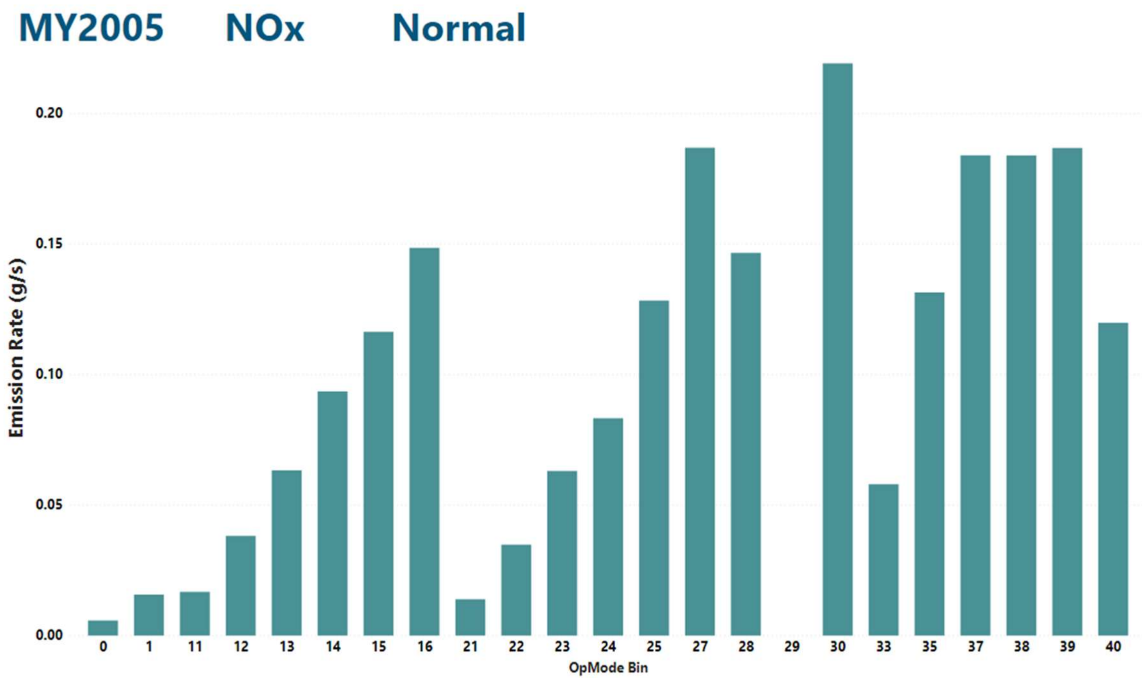


Figure H31. MY2005 Normal Load NO_x Emission Rates

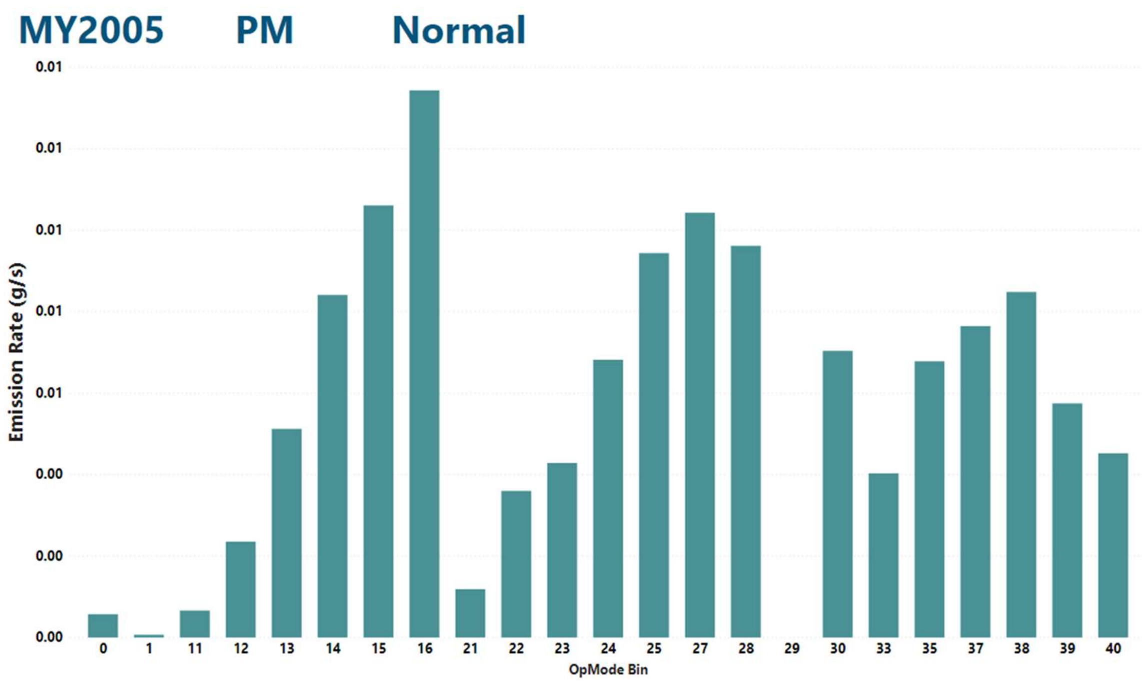


Figure H32. MY2005 Normal Load PM Emission Rates

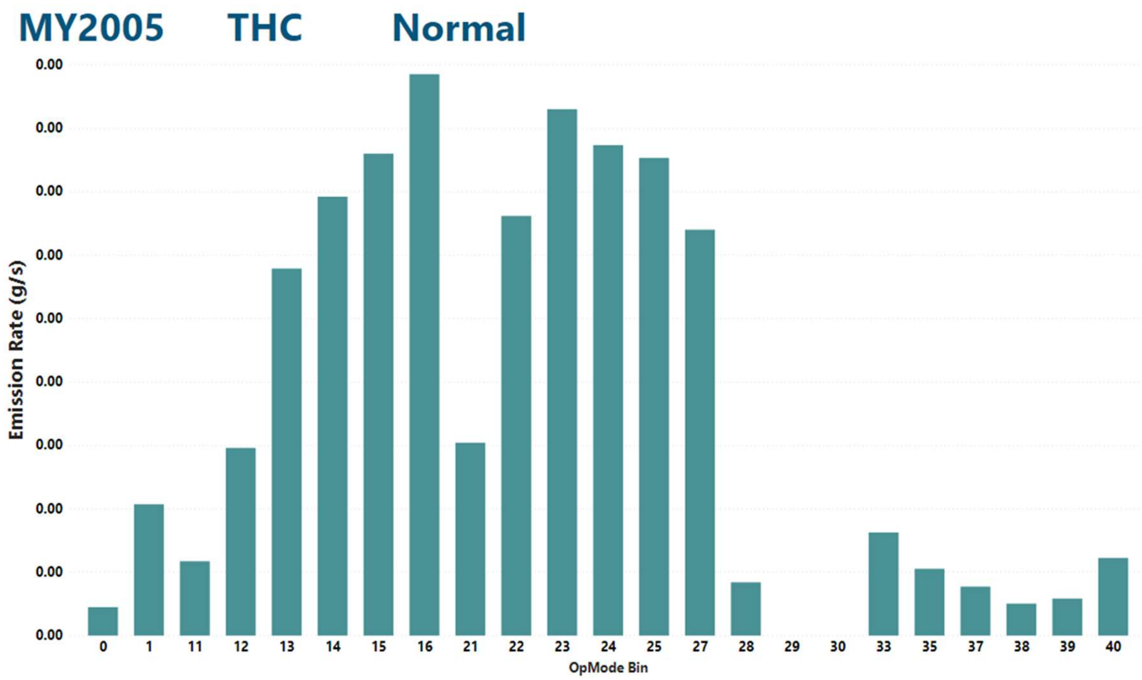


Figure H33. MY2005 Normal Load THC Emission Rates

MY2009 Normal Load Rates

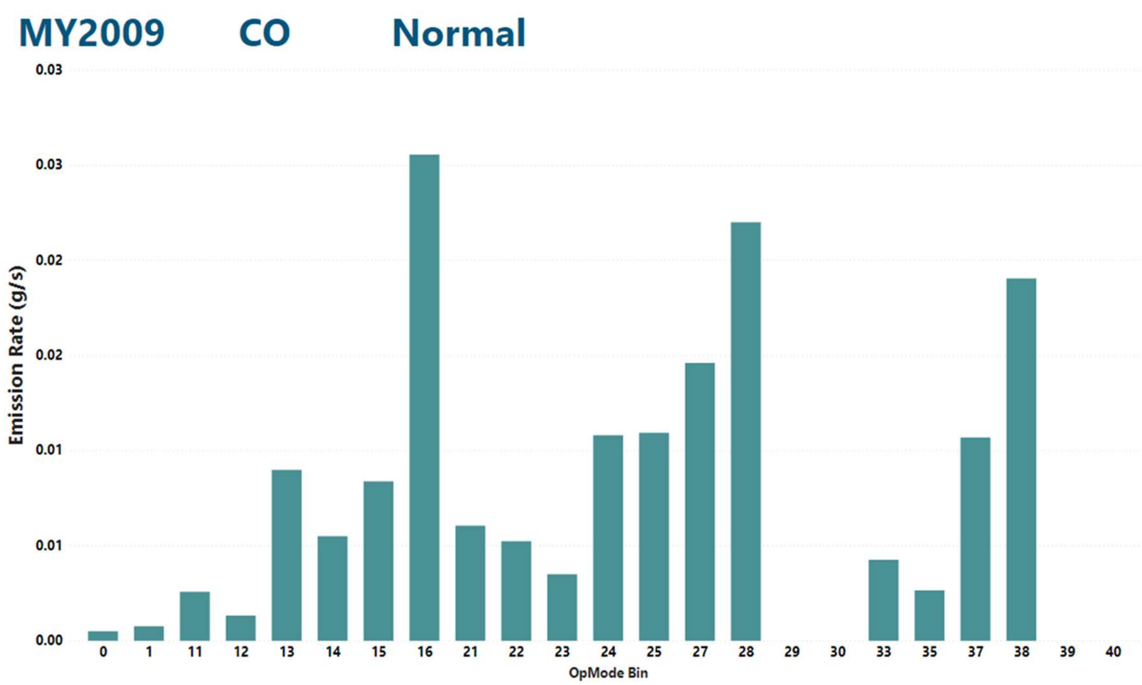


Figure H34. MY2009 Normal Load CO Emission Rates

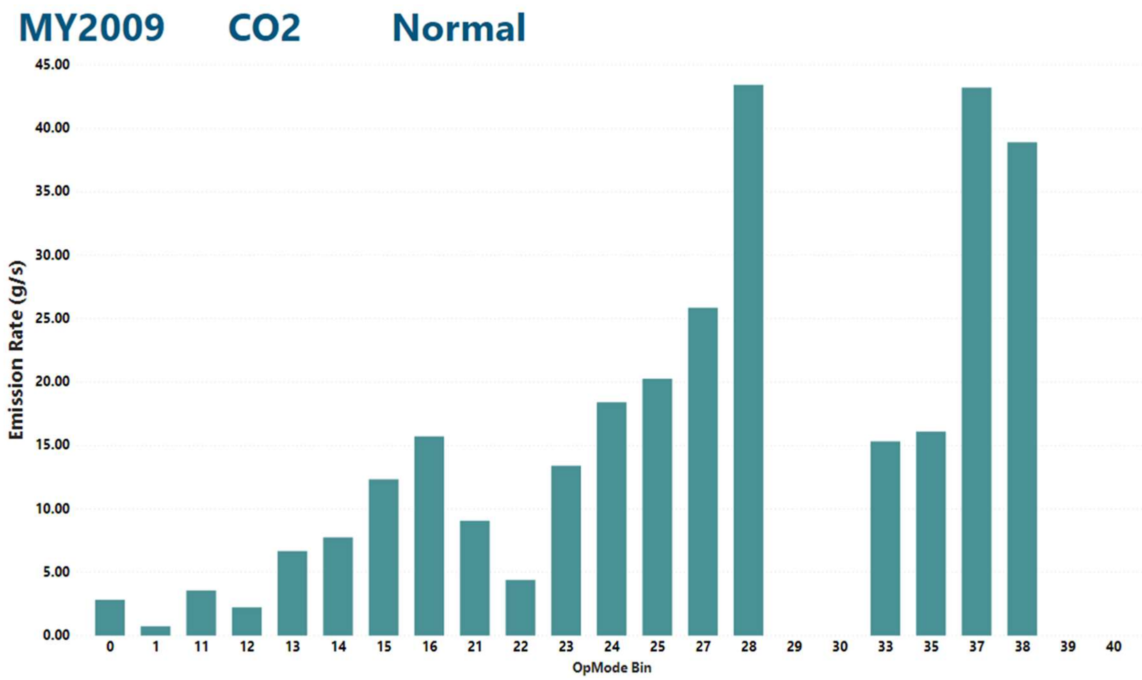


Figure H35. MY2009 Normal Load CO_2 Emission Rates

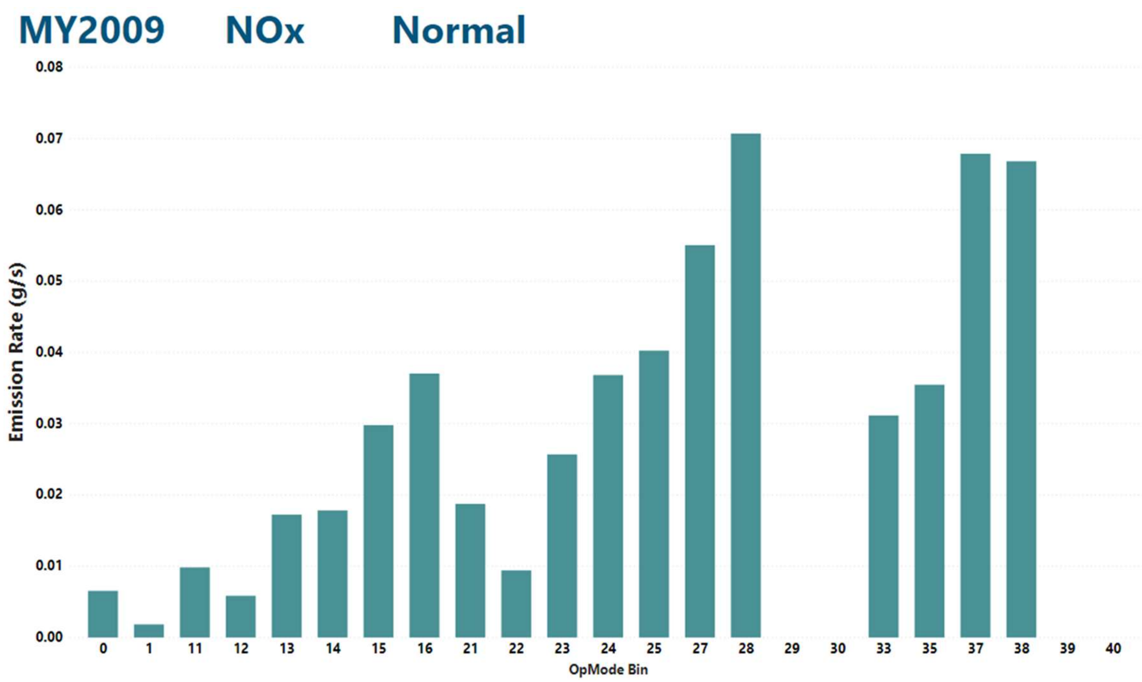


Figure H36. MY2009 Normal Load NO_x Rates

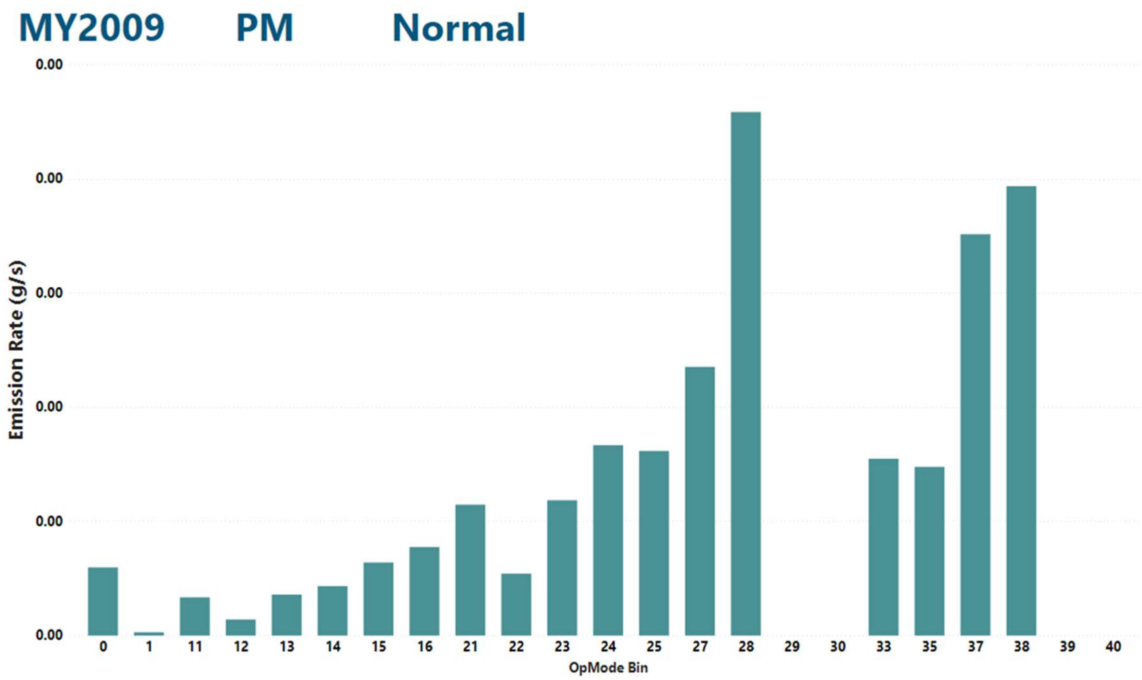


Figure H37. MY2009 Normal Load PM Emission Rates

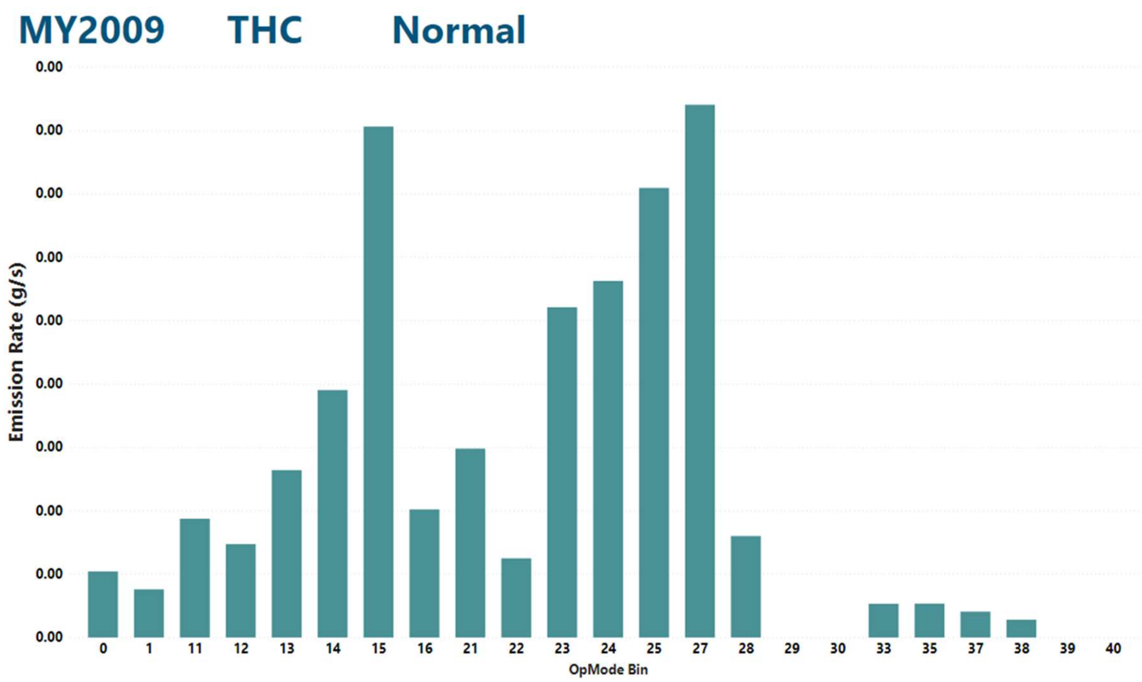


Figure H38. MY2009 Normal Load THC Emission Rates

MY2014 Normal Load Rates

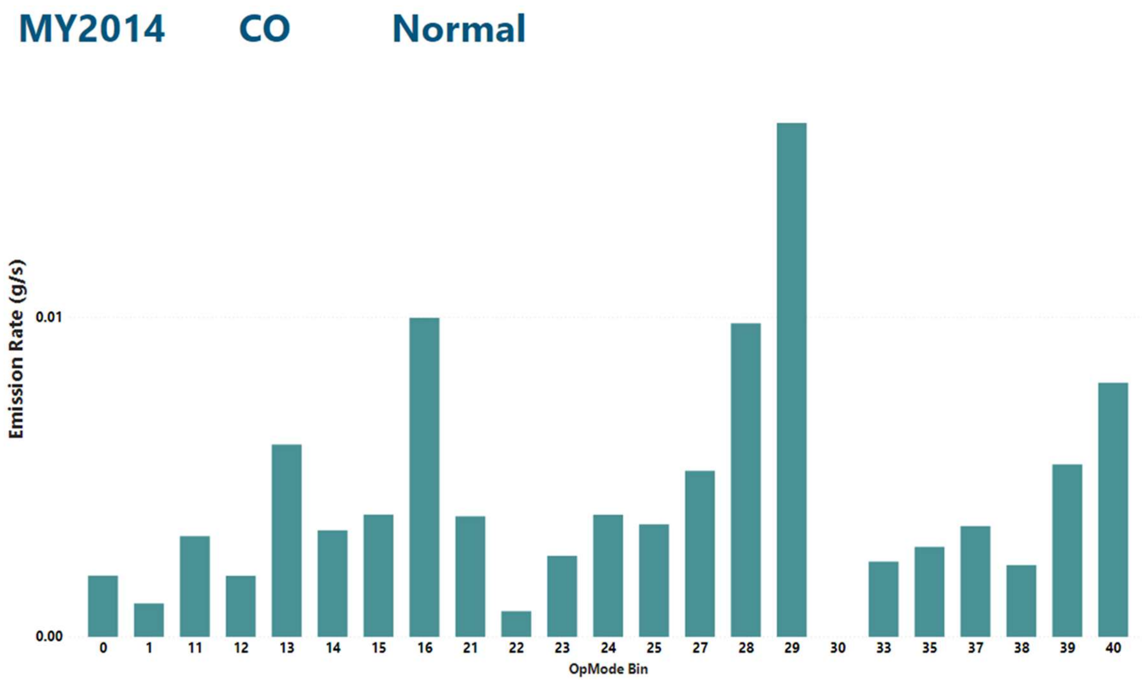


Figure H39. MY2014 Normal Load CO Emission Rates

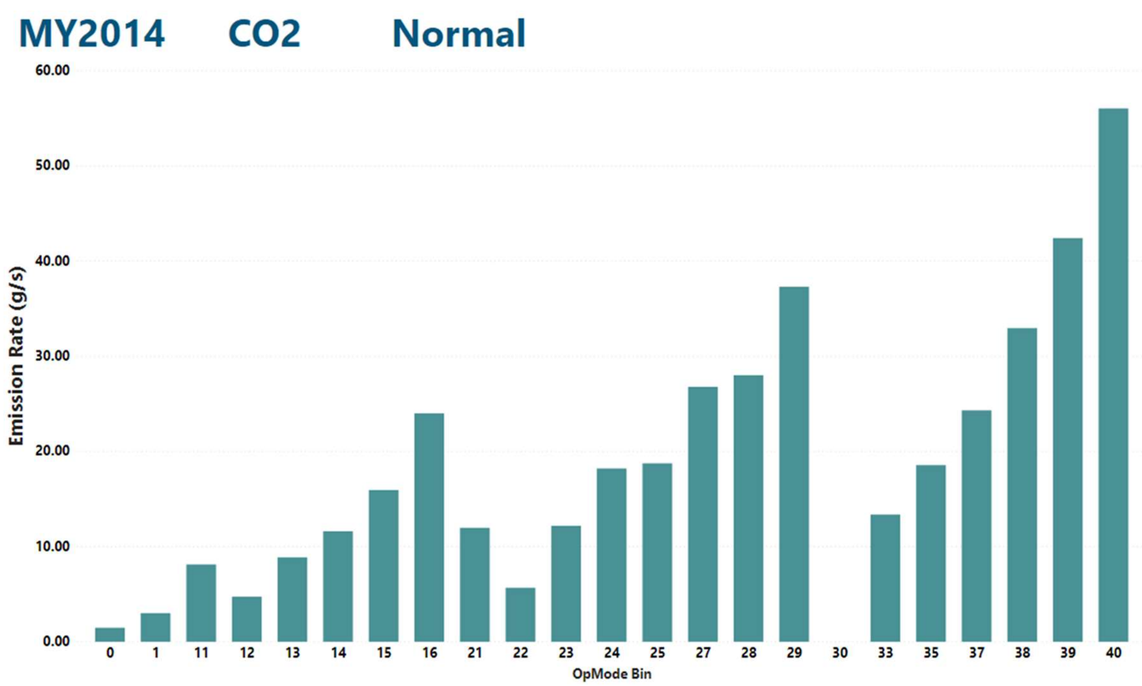


Figure H40. MY2014 Normal Load CO_2 Emission Rates

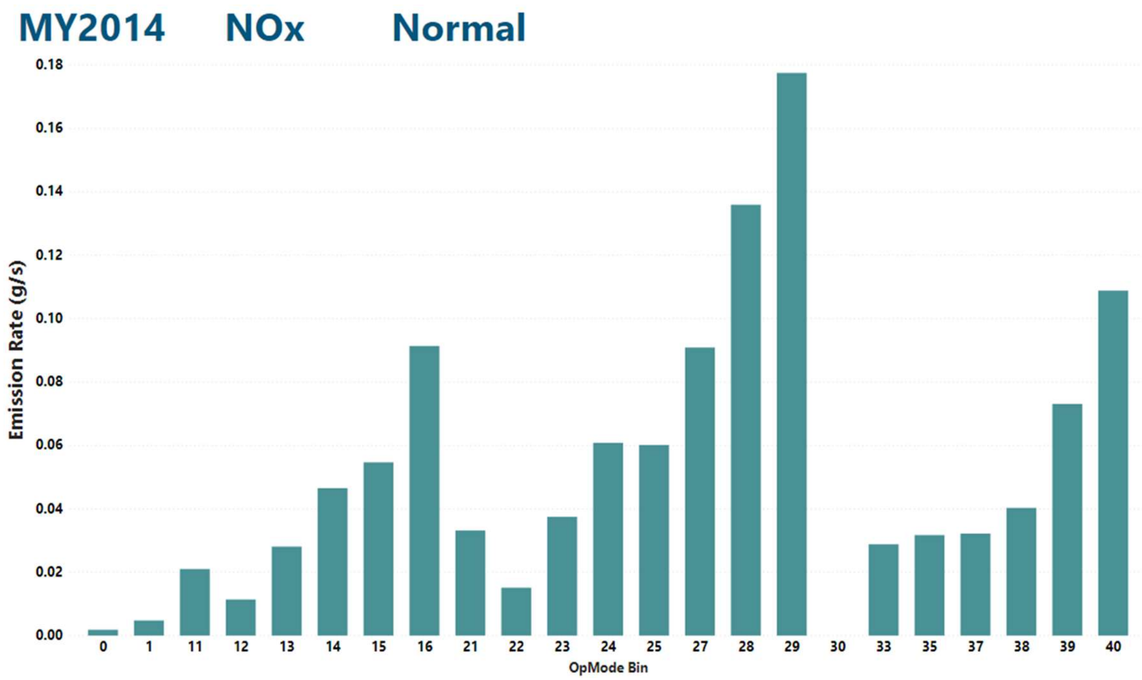


Figure H41. MY2014 Normal Load NO_x Adjusted Emission Rates

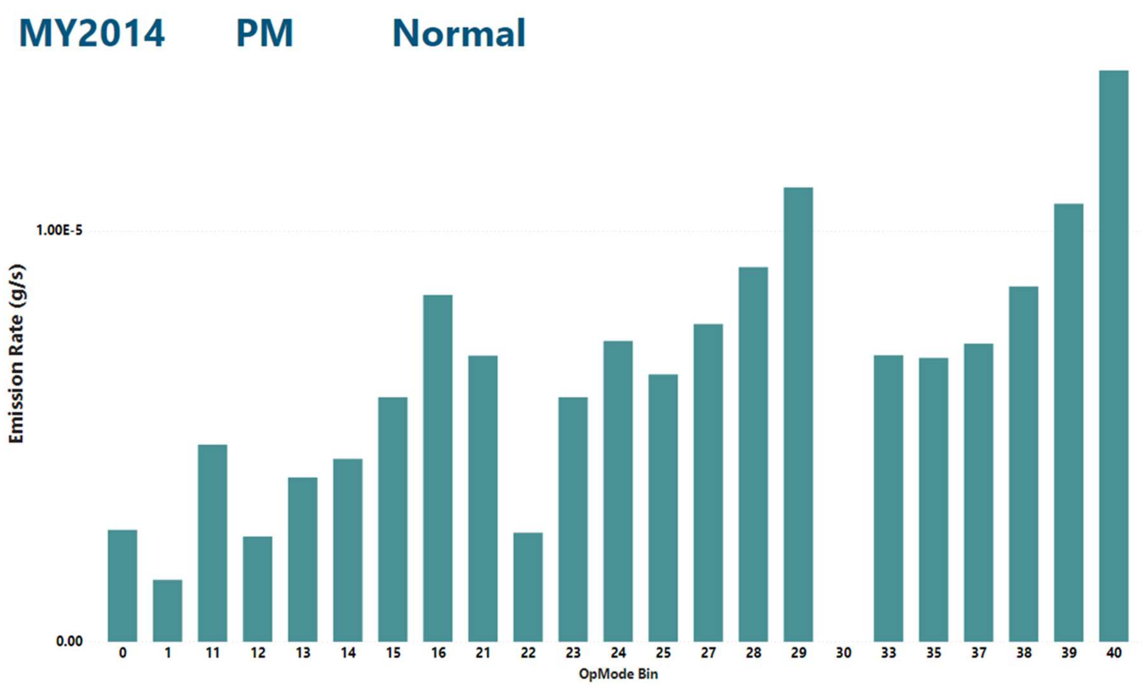


Figure H42. MY2014 Normal Load PM Emission Rates

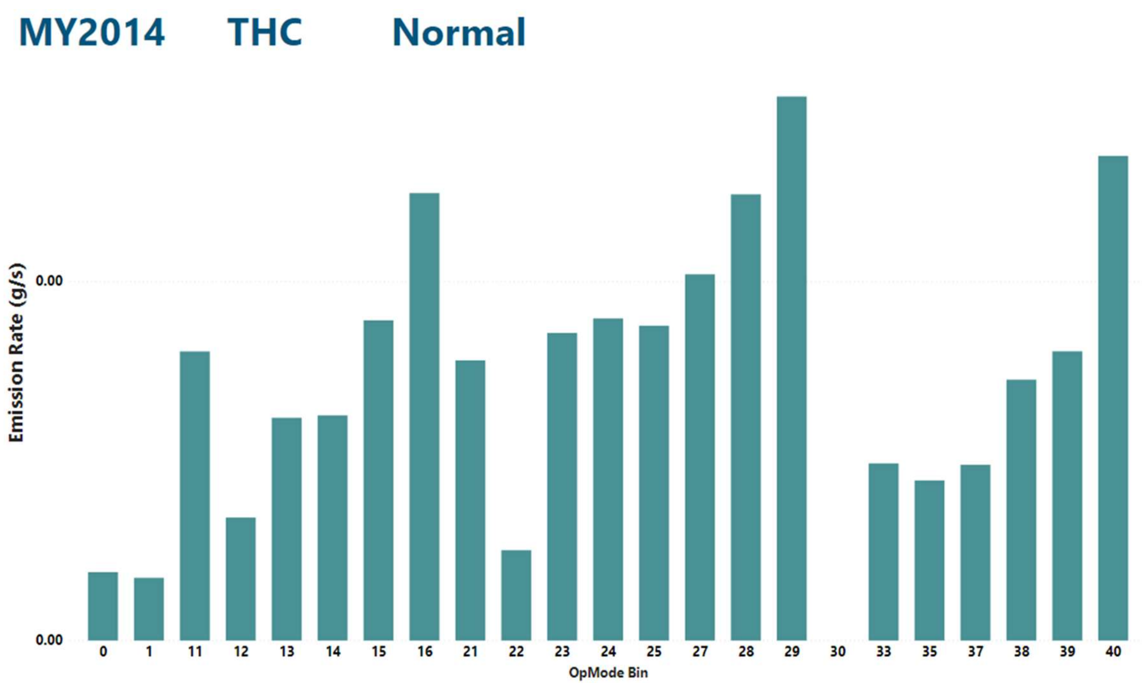


Figure H43. MY2014 Normal Load THC Emission Rates

MY2005 Legal Limit Load Rates

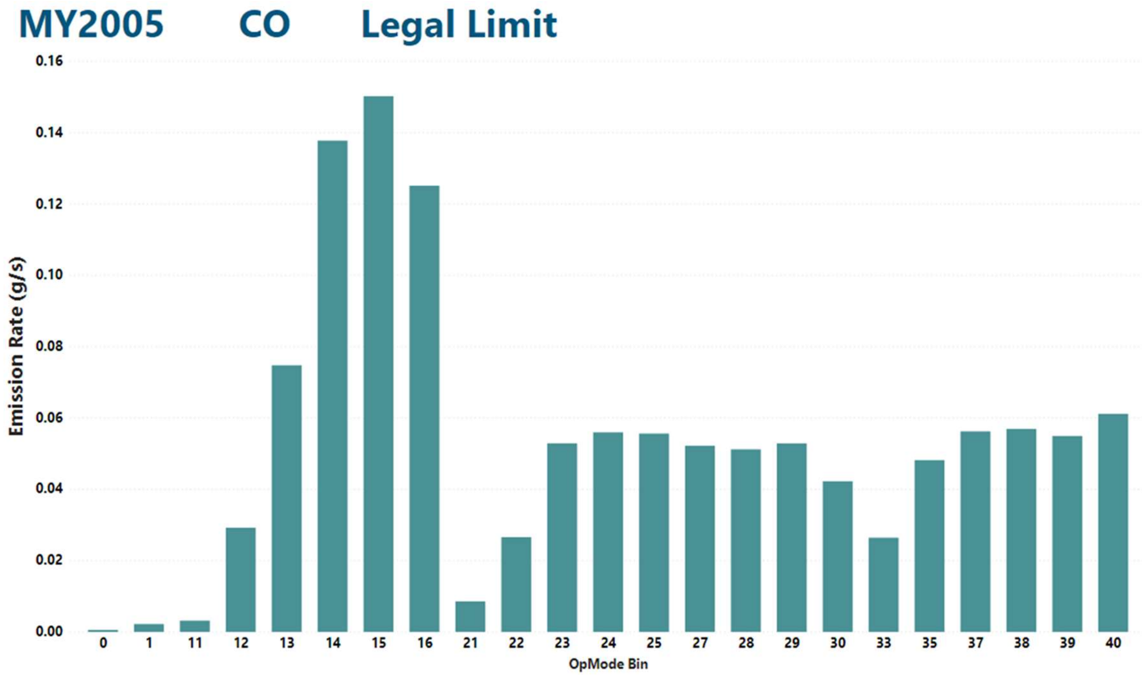


Figure H44. Legal Limit Load MY2005 CO Emission Rates

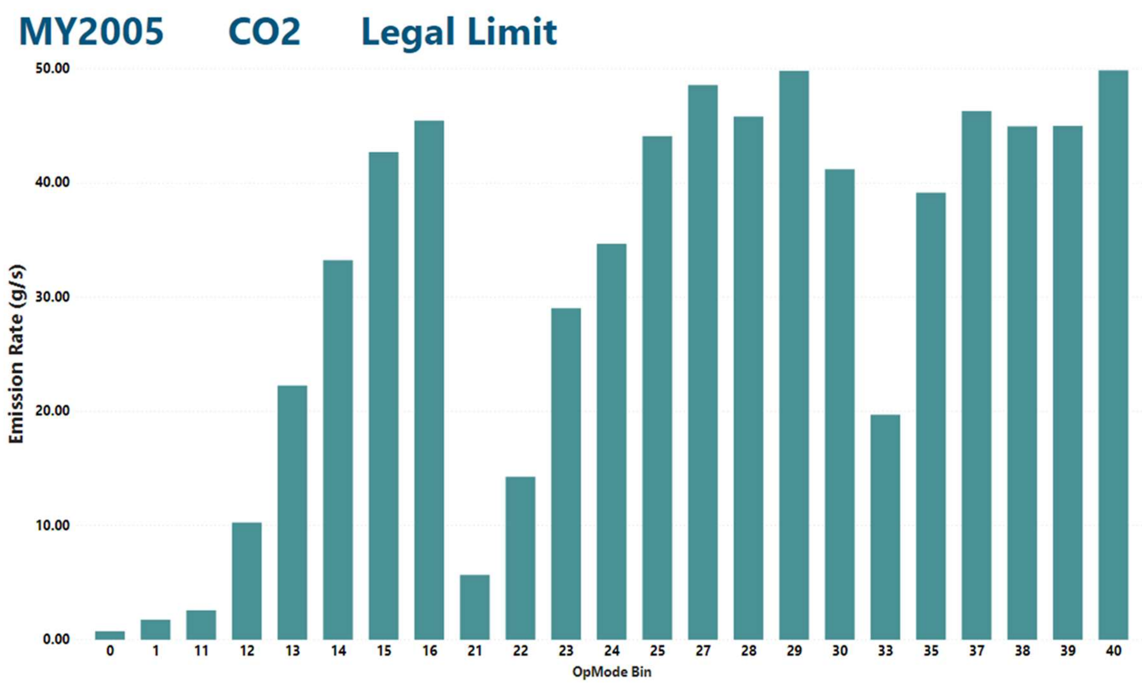


Figure H45. MY2005 Legal Limit Load CO_2 Emission Rates

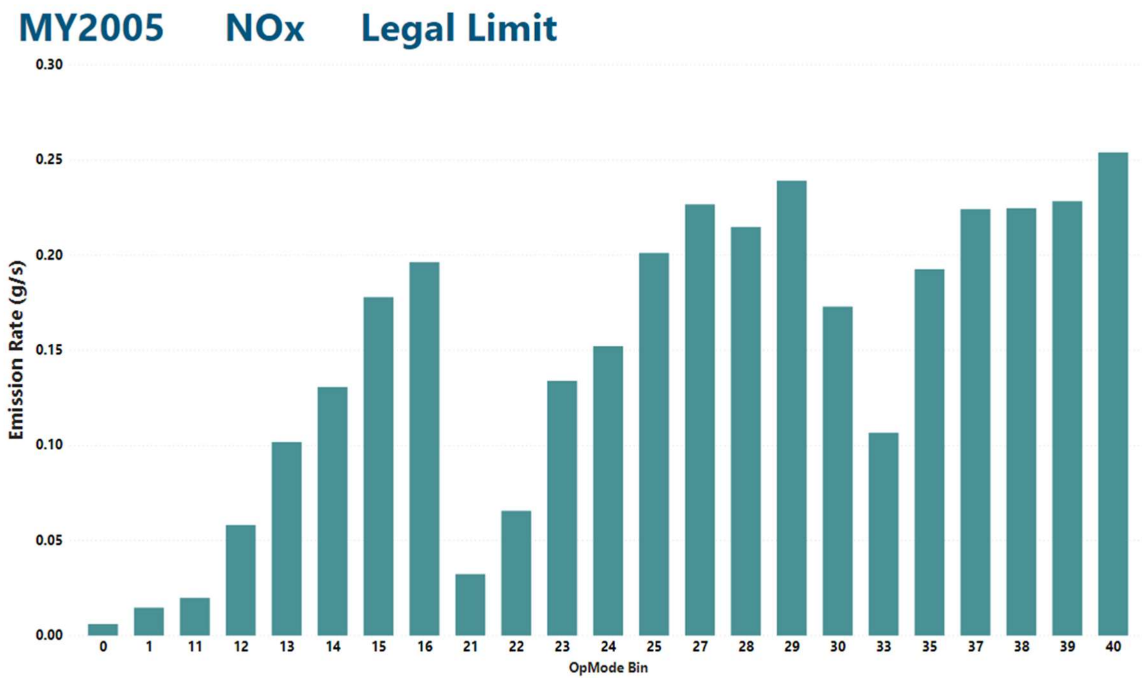


Figure H46. MY2005 Legal Limit Load NO_x Adjusted Emission Rates

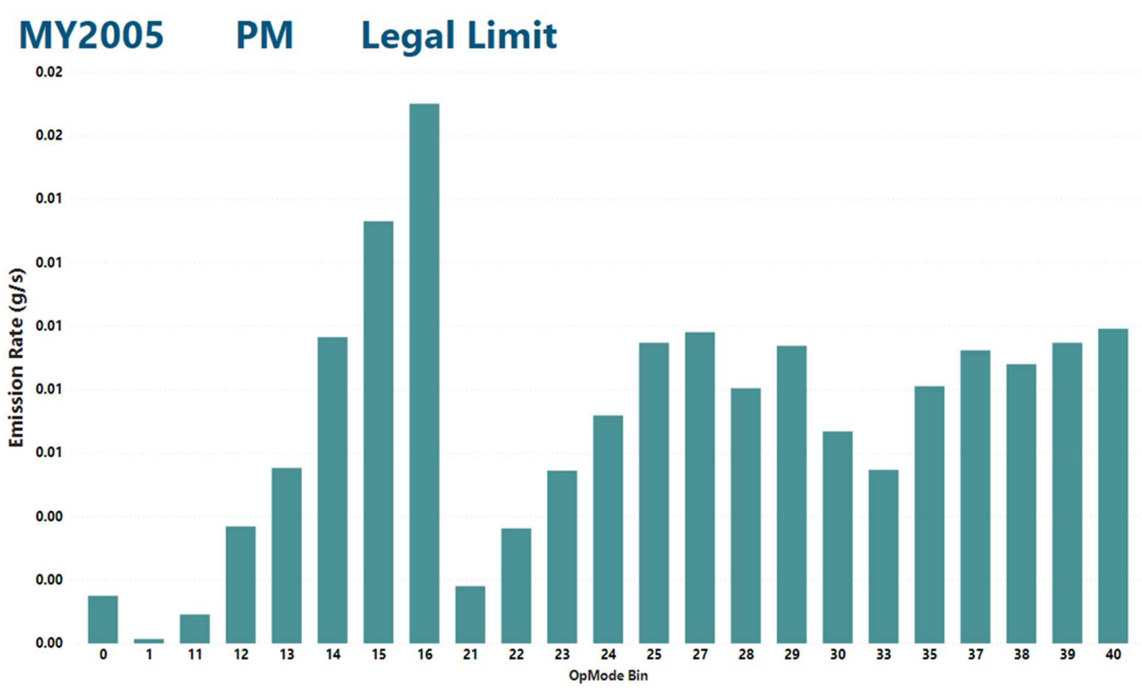


Figure H47. MY2005 Legal Limit Load PM Emission Rates

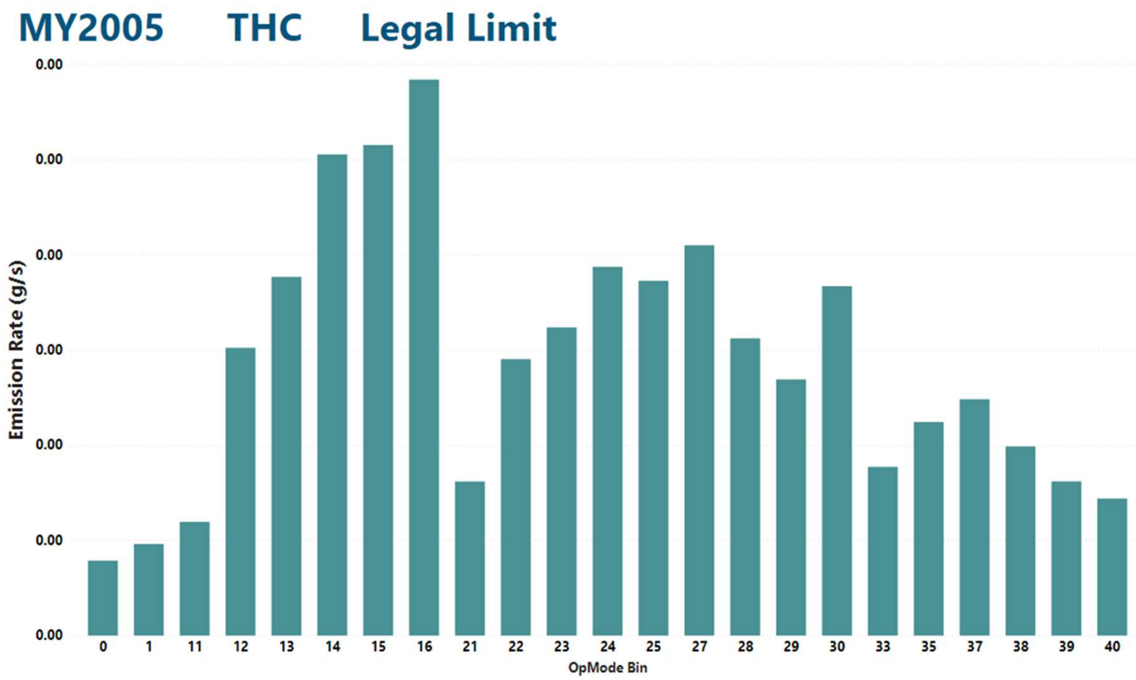


Figure H48. MY2005 Legal Limit Load THC Emission Rates

MY2009 Legal Limit Load Rates

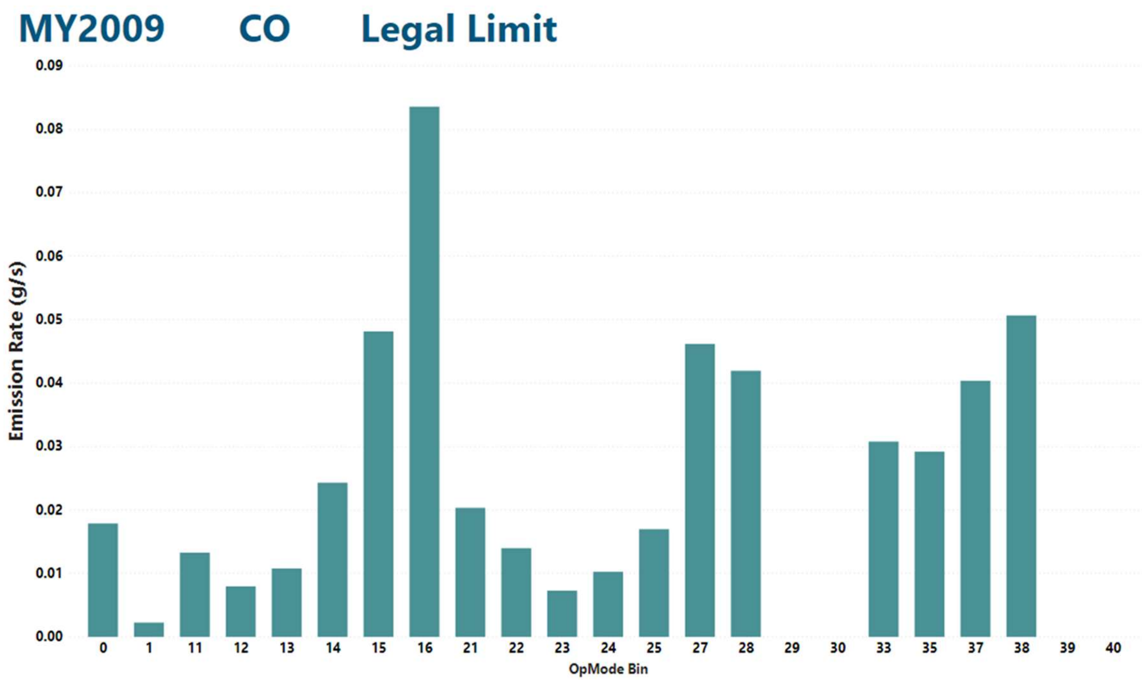


Figure H49. MY2009 Legal Limit Load CO Emission Rates

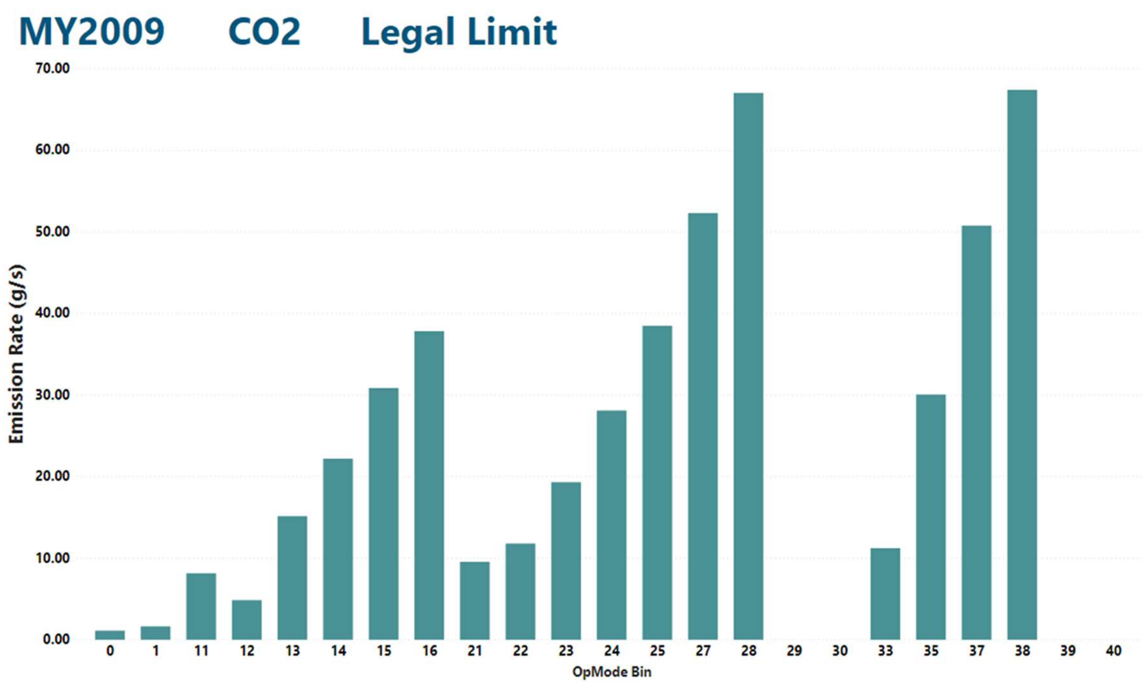


Figure H50. MY2009 Legal Limit Load CO_2 Emission Rates

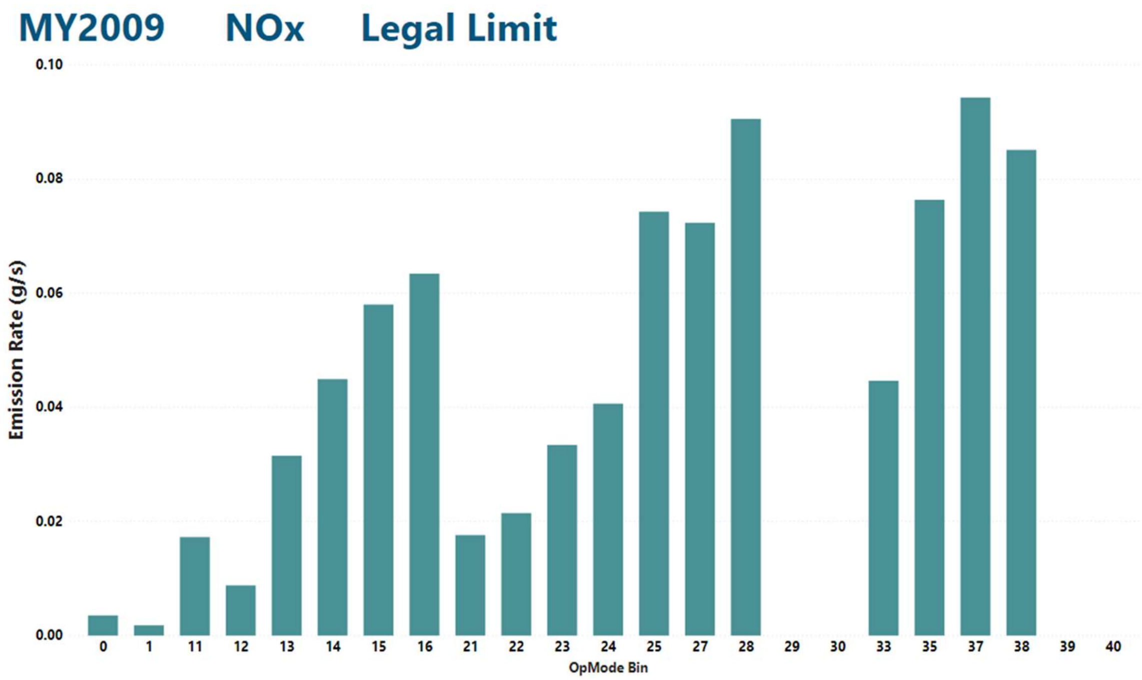


Figure H51. MY2009 Legal Limit Load NOx Adjusted Emission Rates

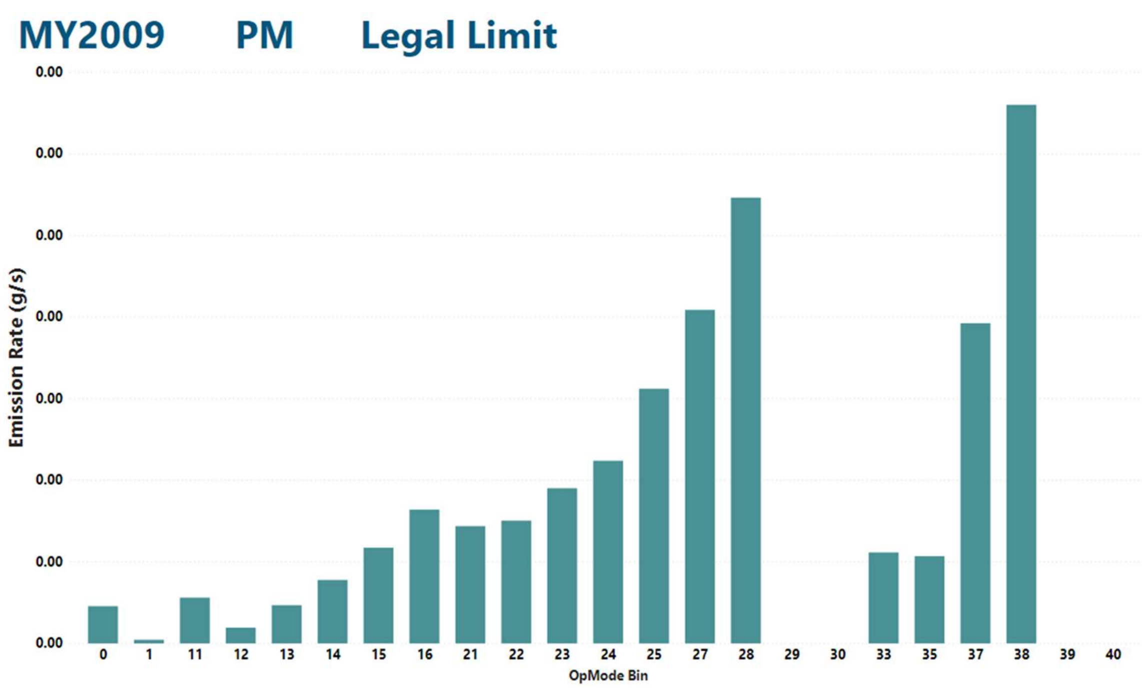


Figure H52. MY2009 Legal Limit Load PM Emission Rates

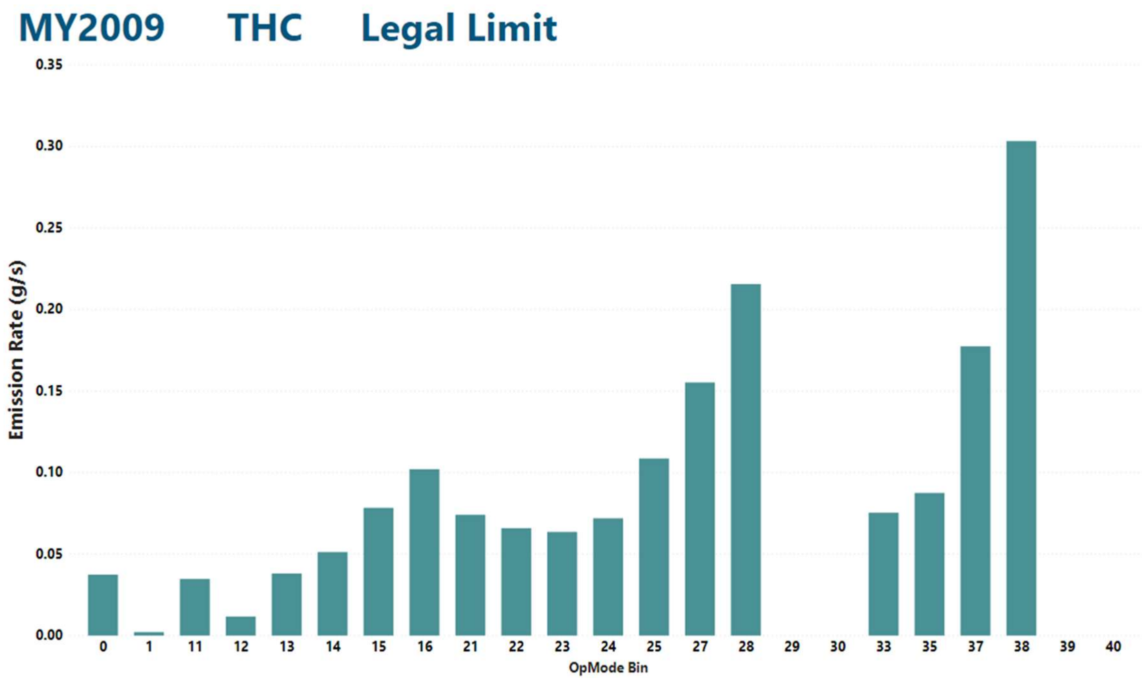


Figure H53. MY2009 Legal Limit Load THC Emission Rates

MY2014 Legal Limit Load Rates

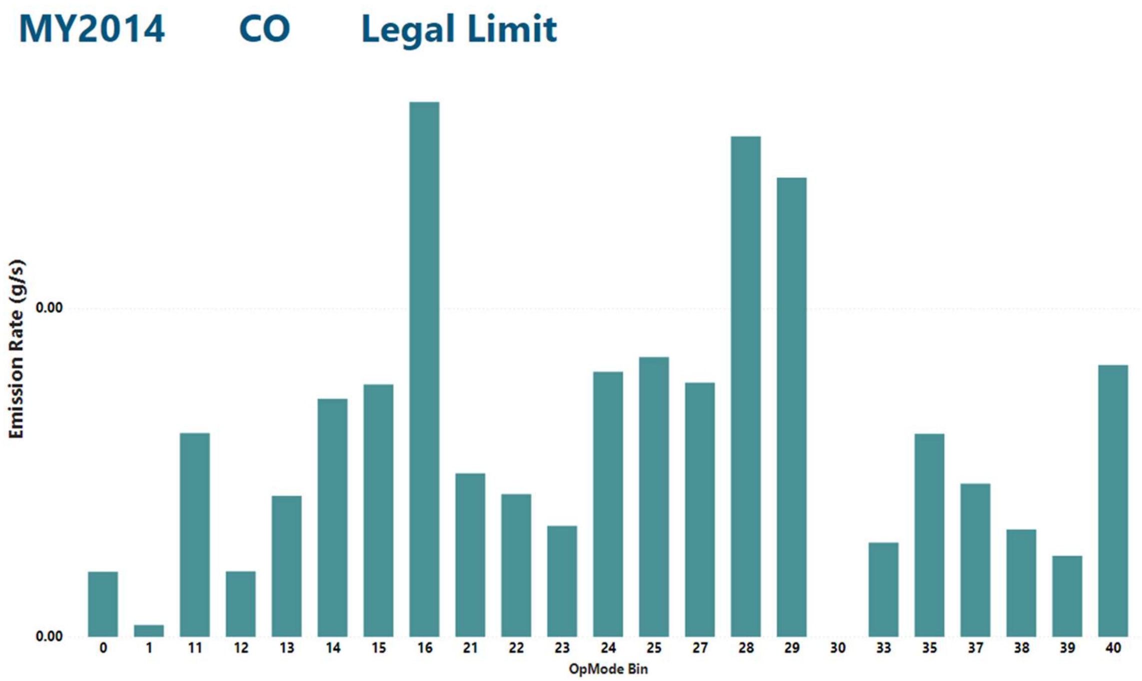


Figure H54. MY2014 Legal Limit Load CO Emission Rates

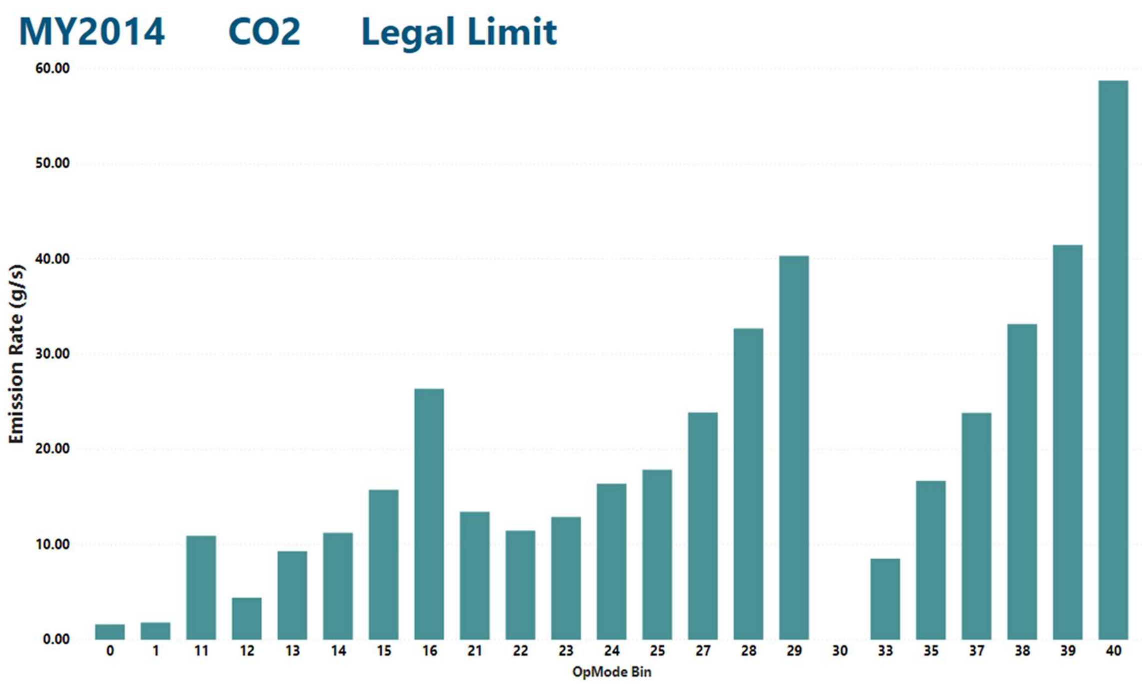


Figure H55. MY2014 Legal Limit Load CO_2 Emission Rates

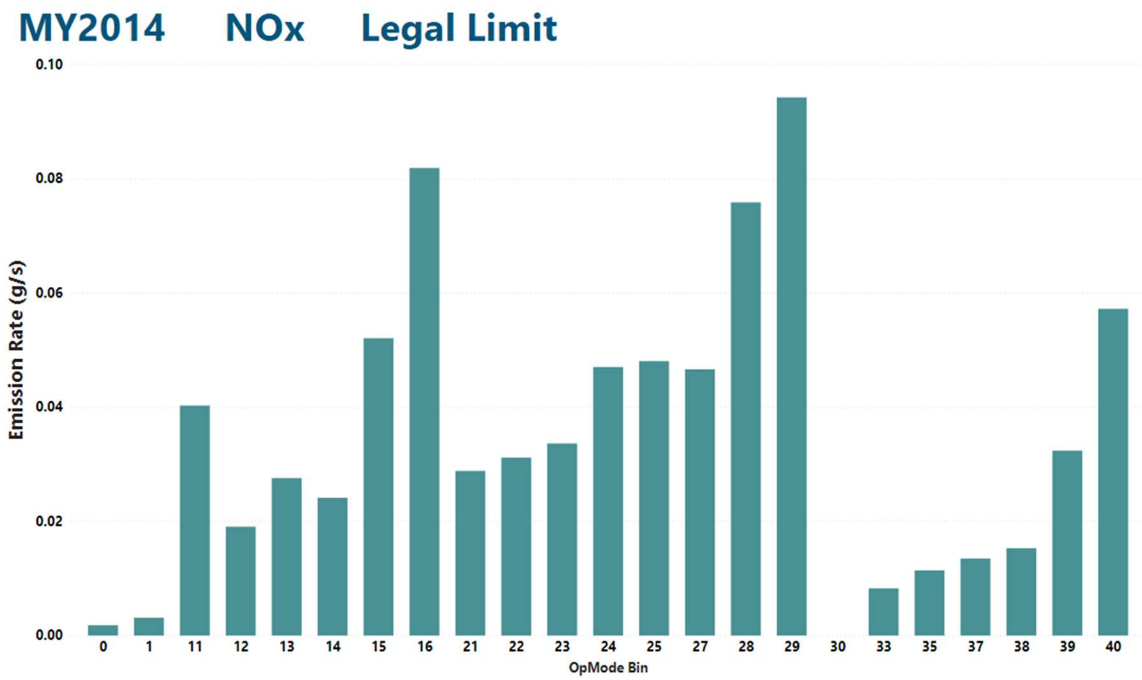


Figure H56. MY2014 Legal Limit Load NO_x Adjusted Emission Rates

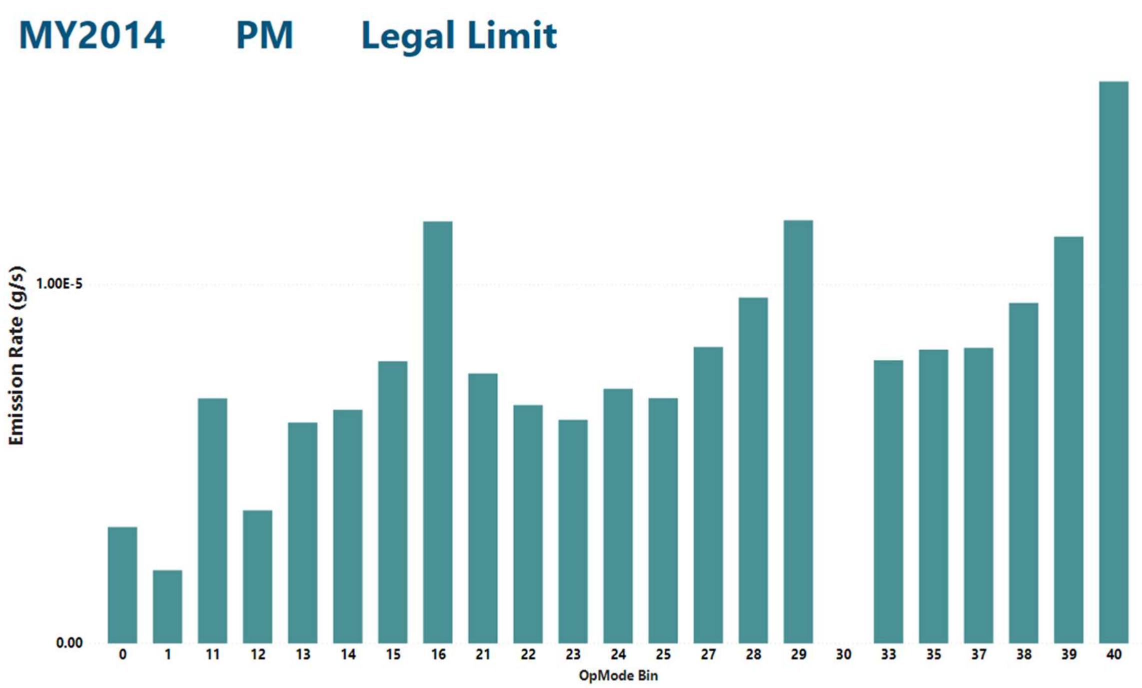


Figure H57. MY2014 Legal Limit Load PM Emission Rates

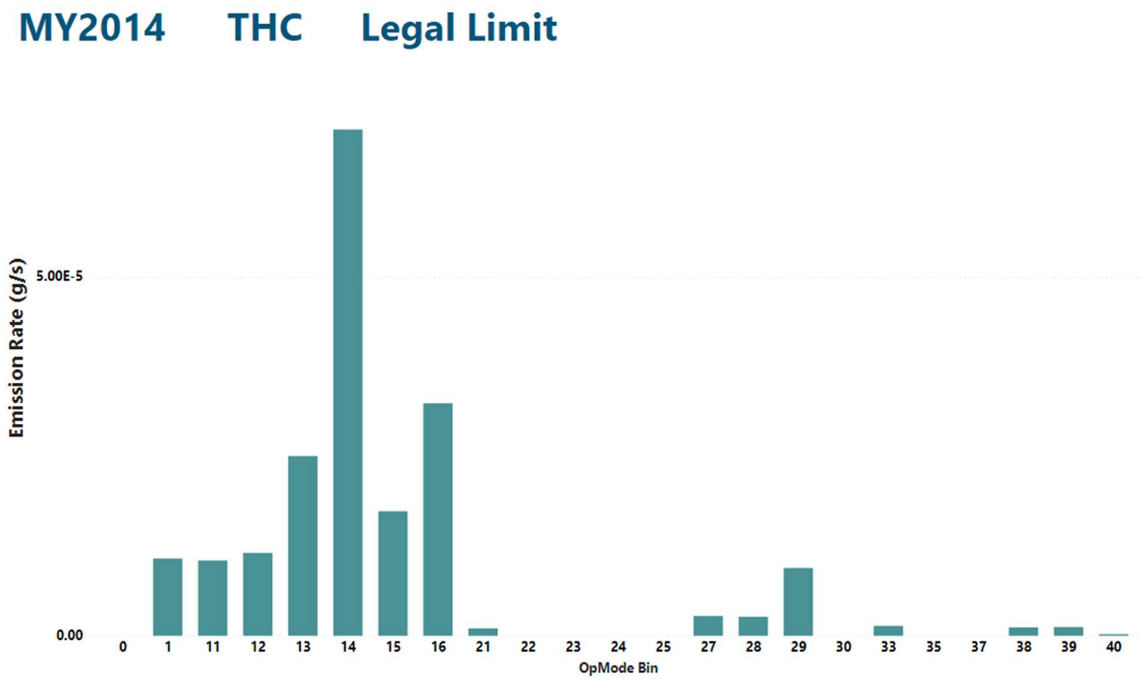


Figure H58. MY2014 Legal Limit Load THC Emission Rates

MY2005 Overweight Load Rates

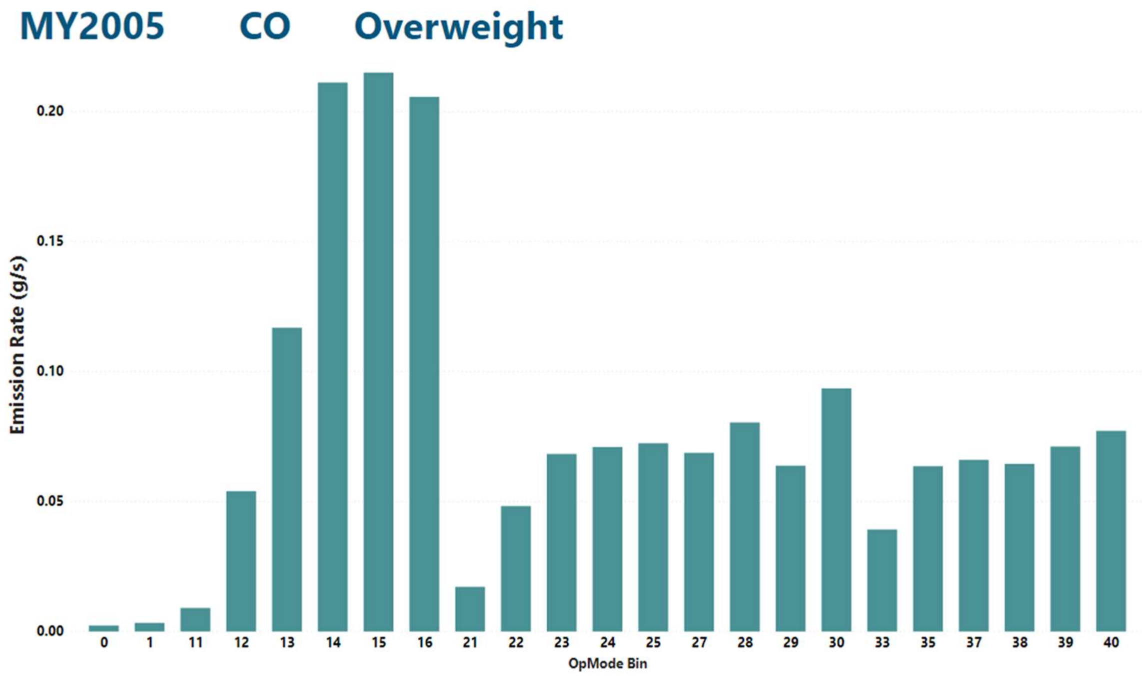


Figure H59. MY2005 Overweight Load CO Emission Rates

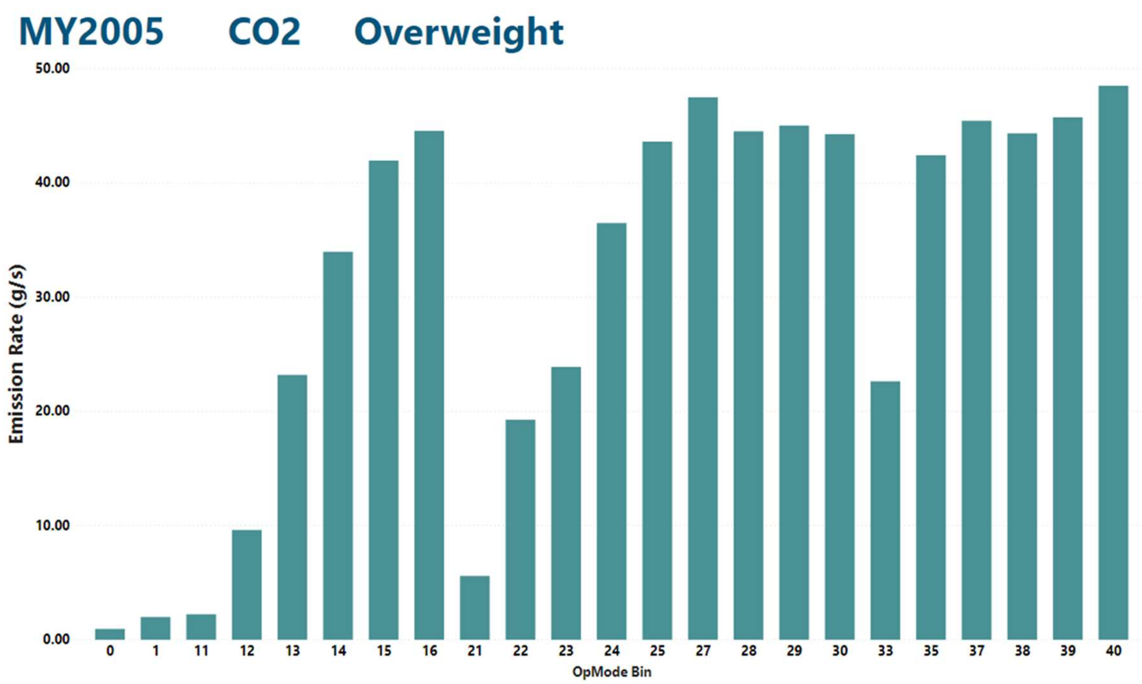


Figure H60. MY2005 Overweight Load CO_2 Emission Rates

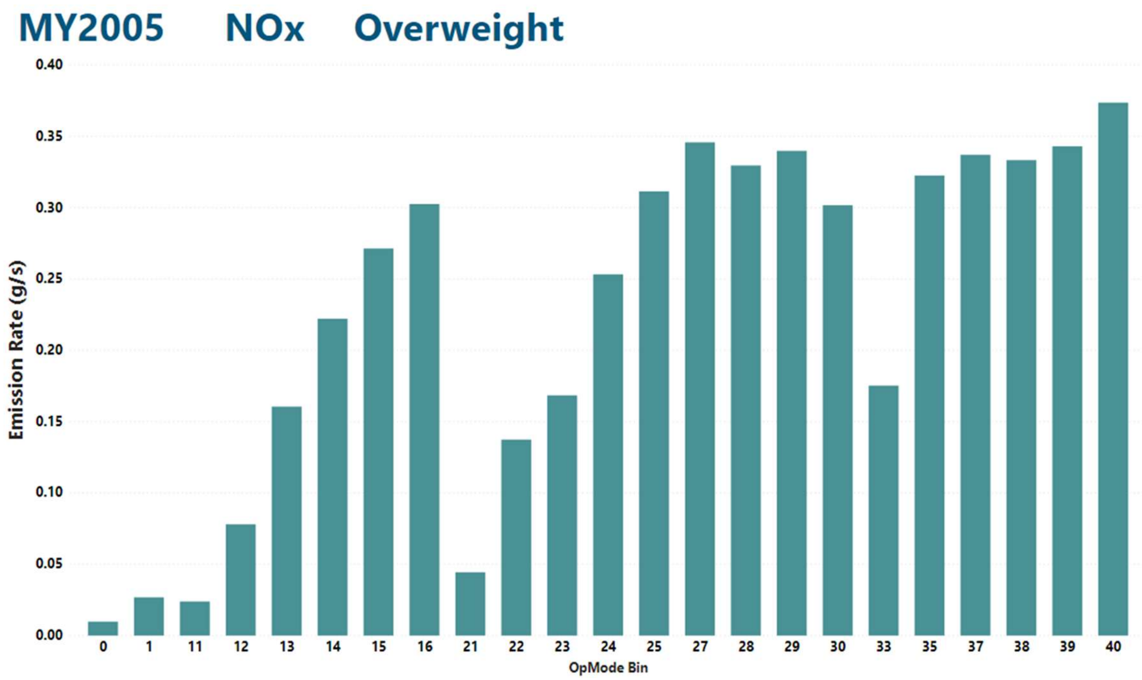


Figure H61. MY2005 Overweight Load NO_x Adjusted Emission Rates

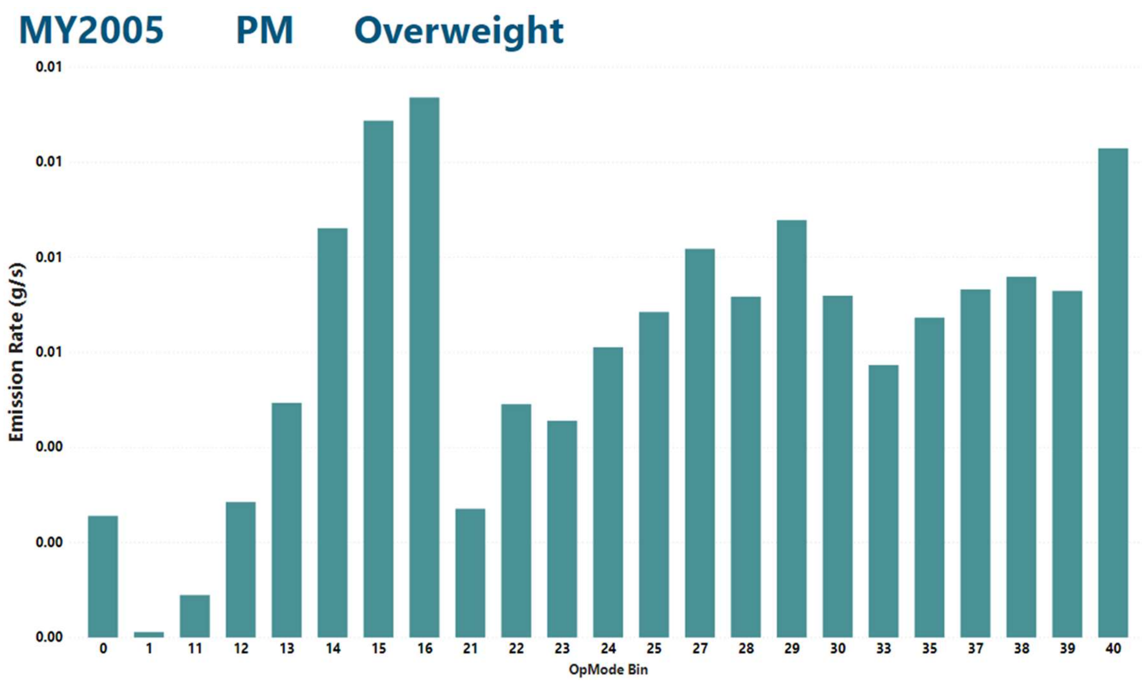


Figure H62. MY2005 Overweight Load PM Emission Rates

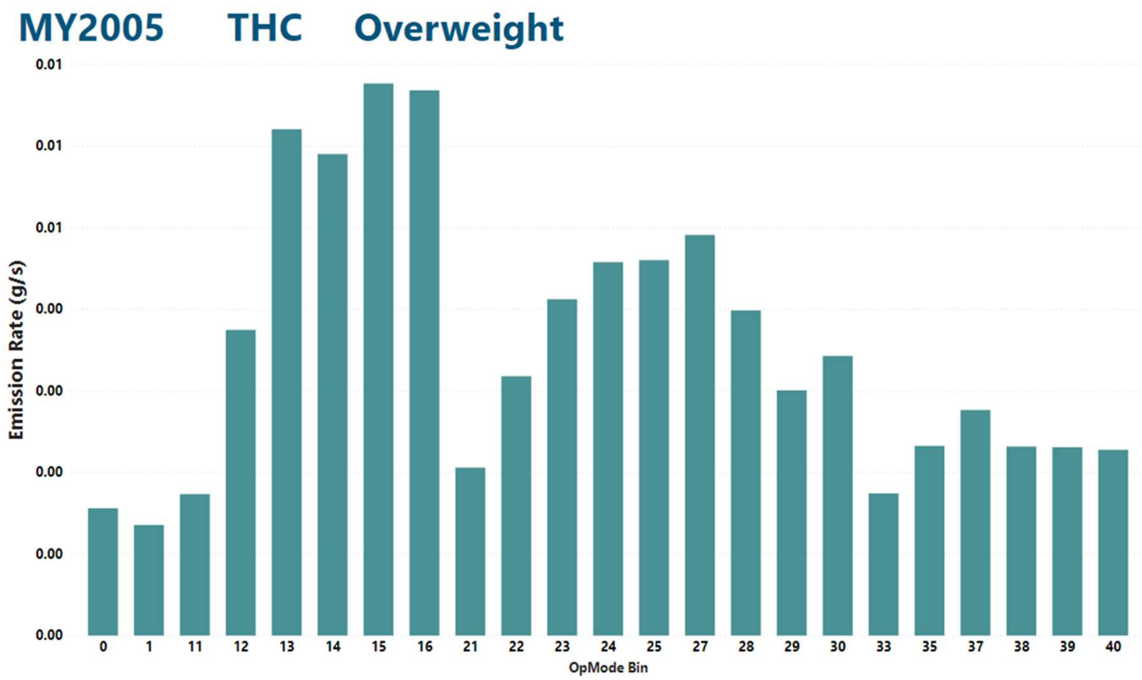


Figure H63. MY2005 Overweight Load THC Emission Rates

MY2009 Overweight Load Rates

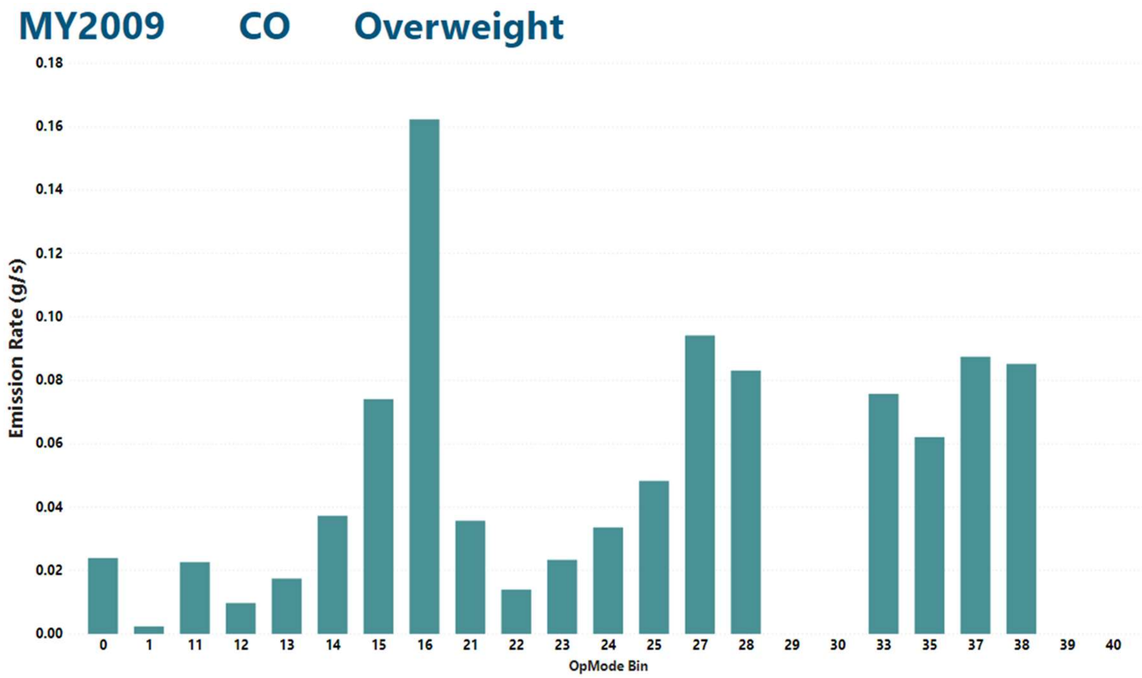


Figure H64. MY2009 Overweight Load CO Emission Rates

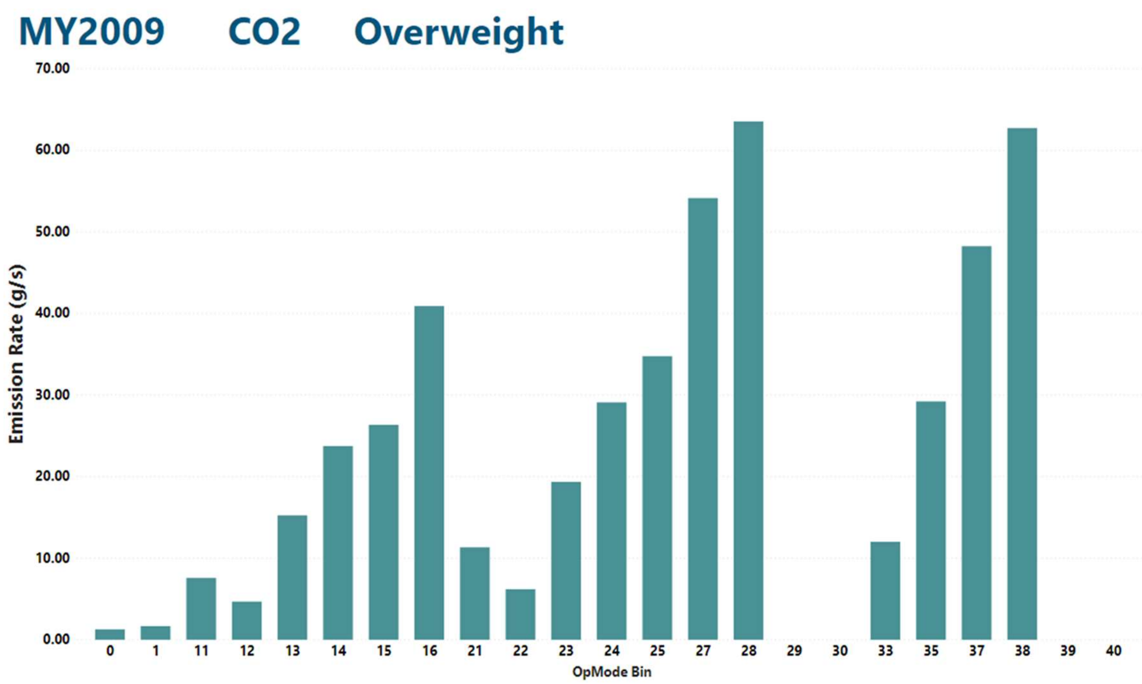


Figure H65. MY2009 Overweight Load CO_2 Emission Rates

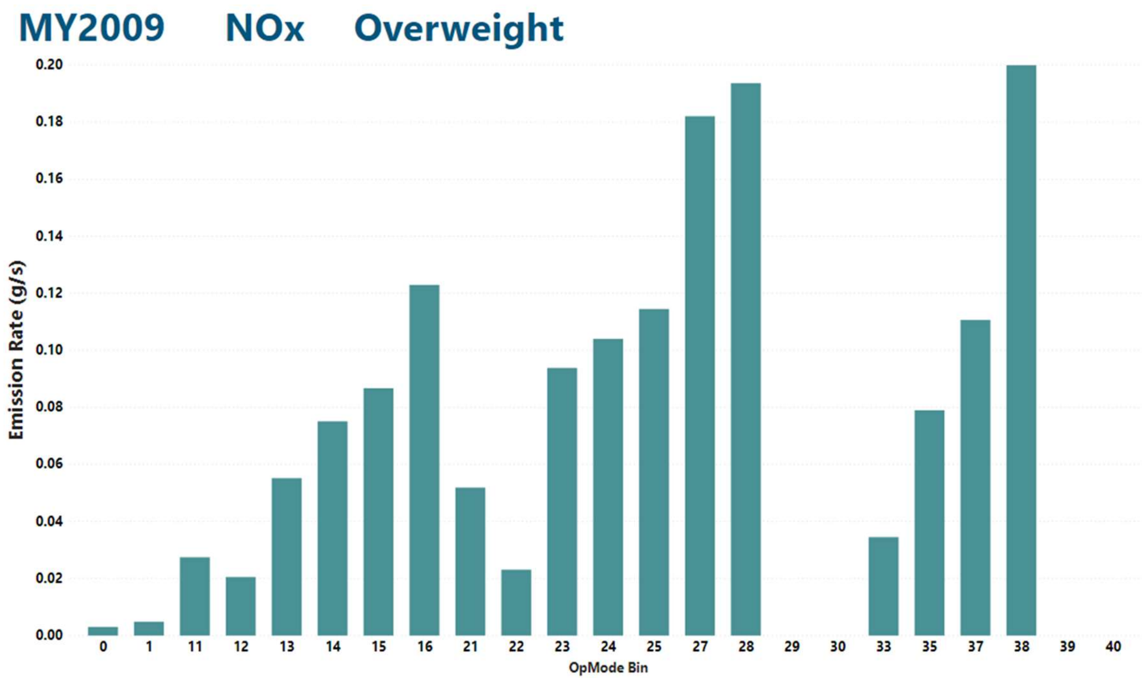


Figure H66. MY2009 Overweight Load NO_x Adjusted Emission Rates

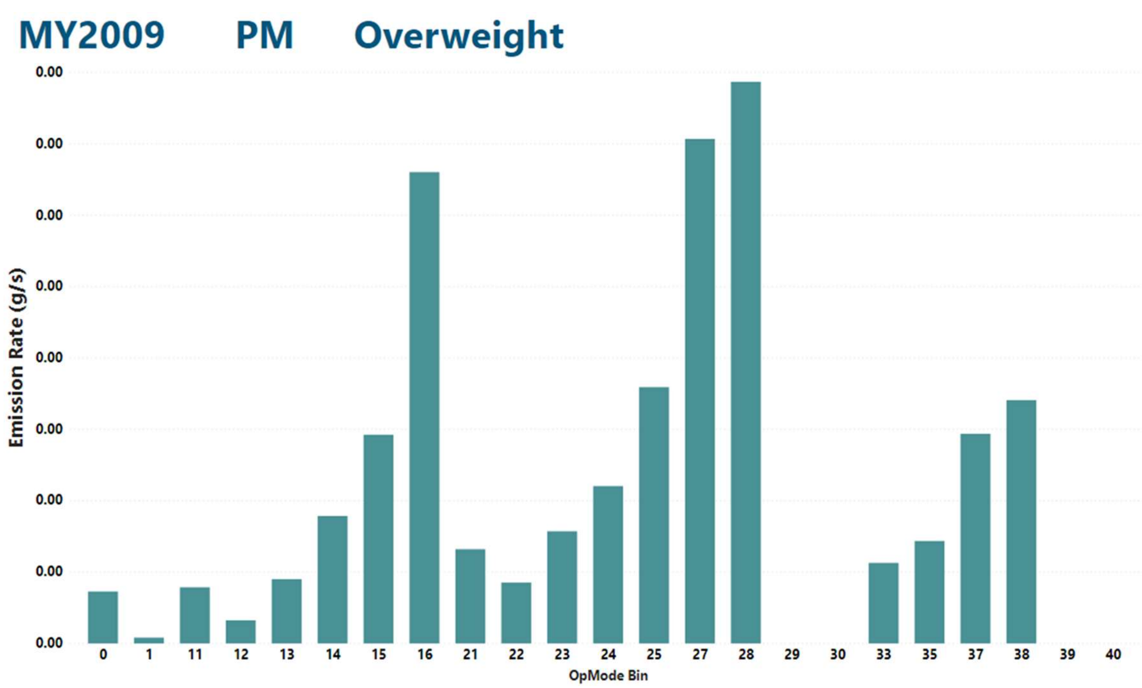


Figure H67. MY2009 Overweight Load PM Emission Rates

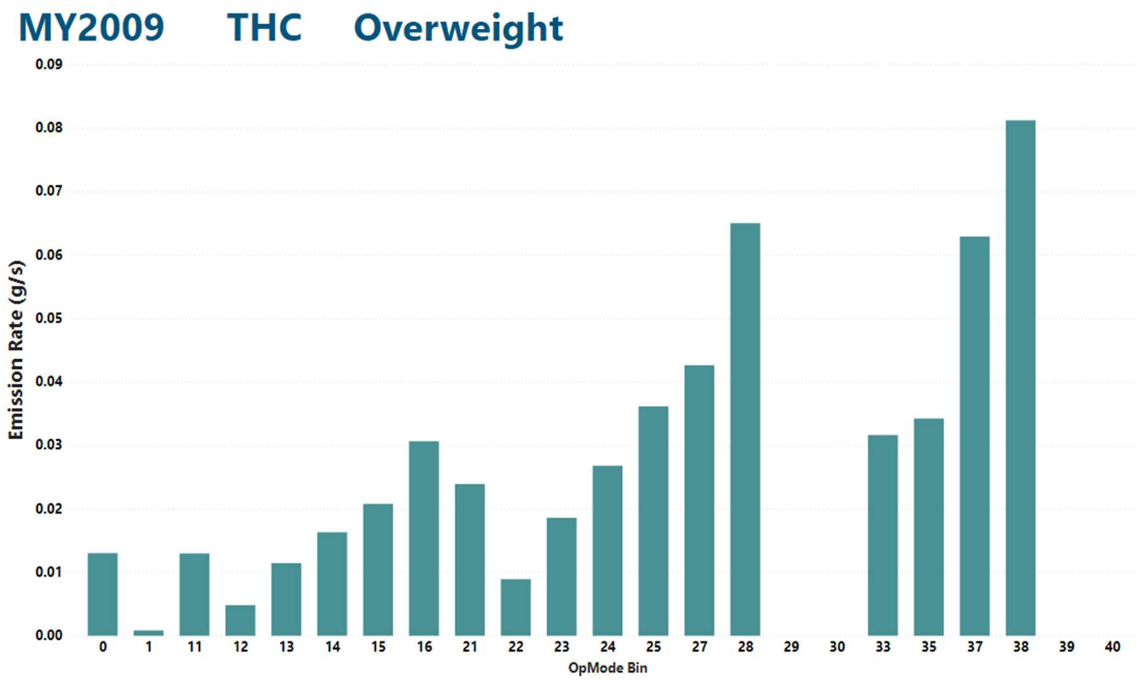


Figure H68. MY2009 Overweight Load THC Emission Rates

MY2014 Overweight Load Rates

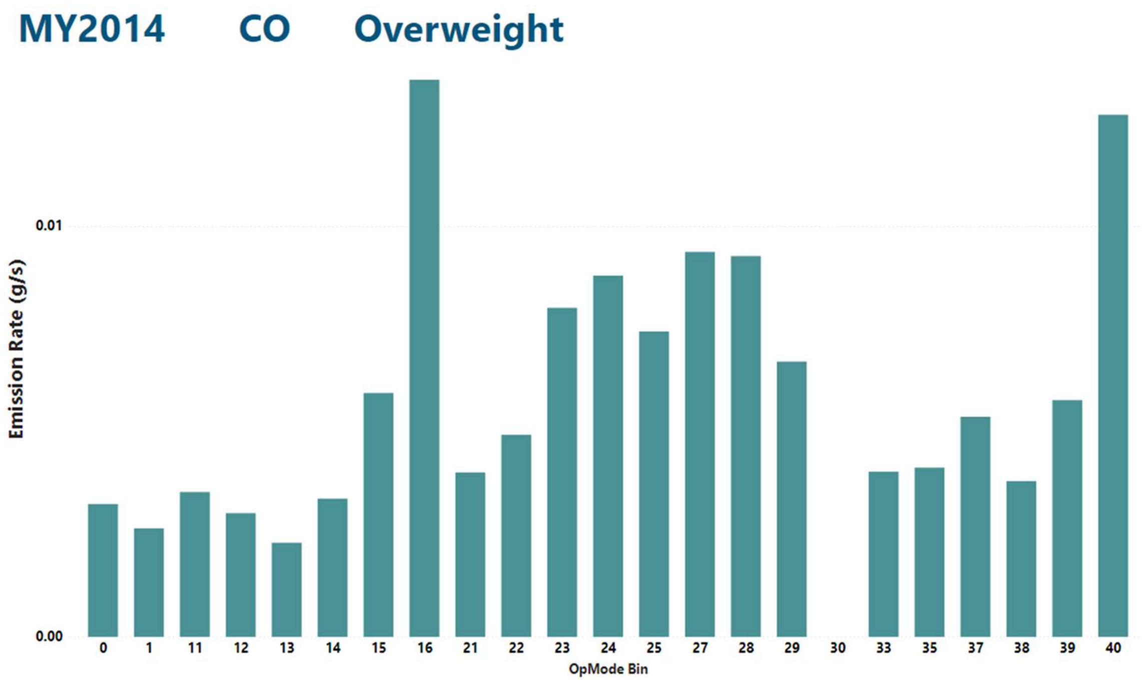


Figure H69. MY2014 Overweight Load CO Emission Rates

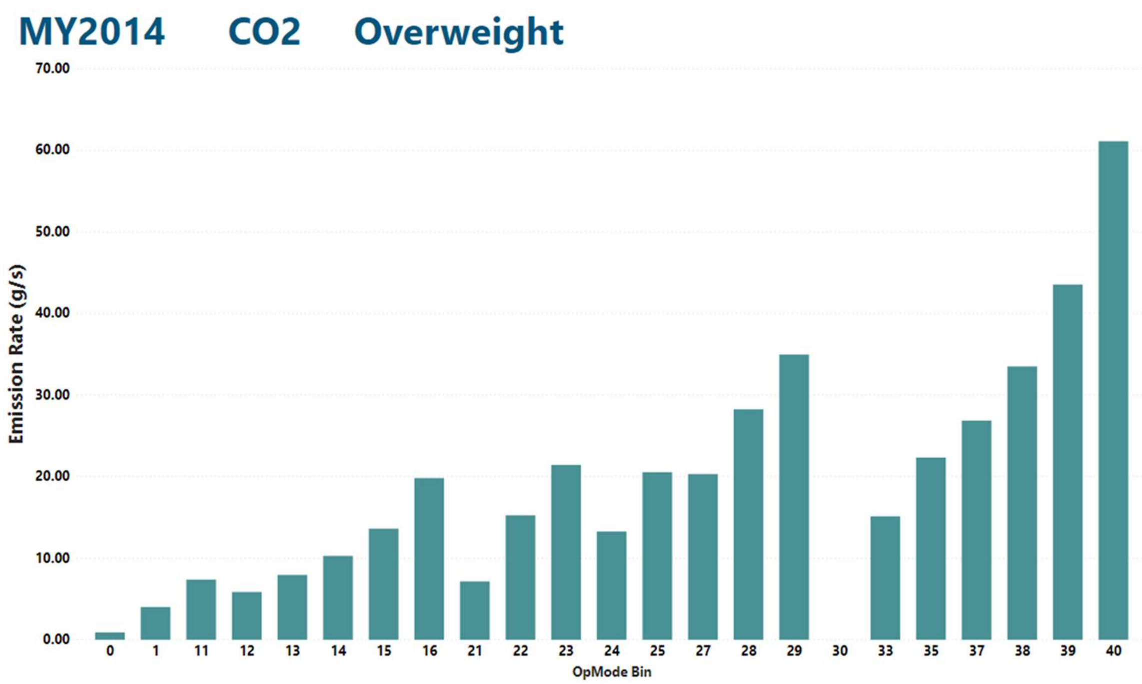


Figure H70. MY2014 Overweight Load CO_2 Emission Rates

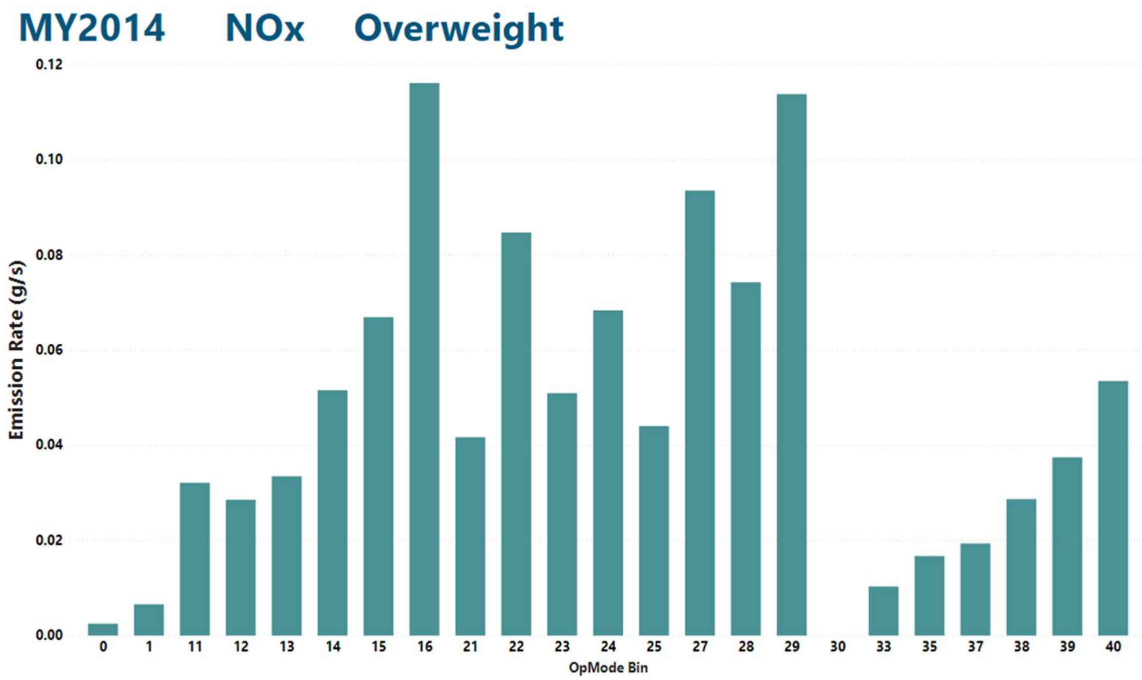


Figure H71. MY2014 Overweight Load NOx Adjusted Emission Rates

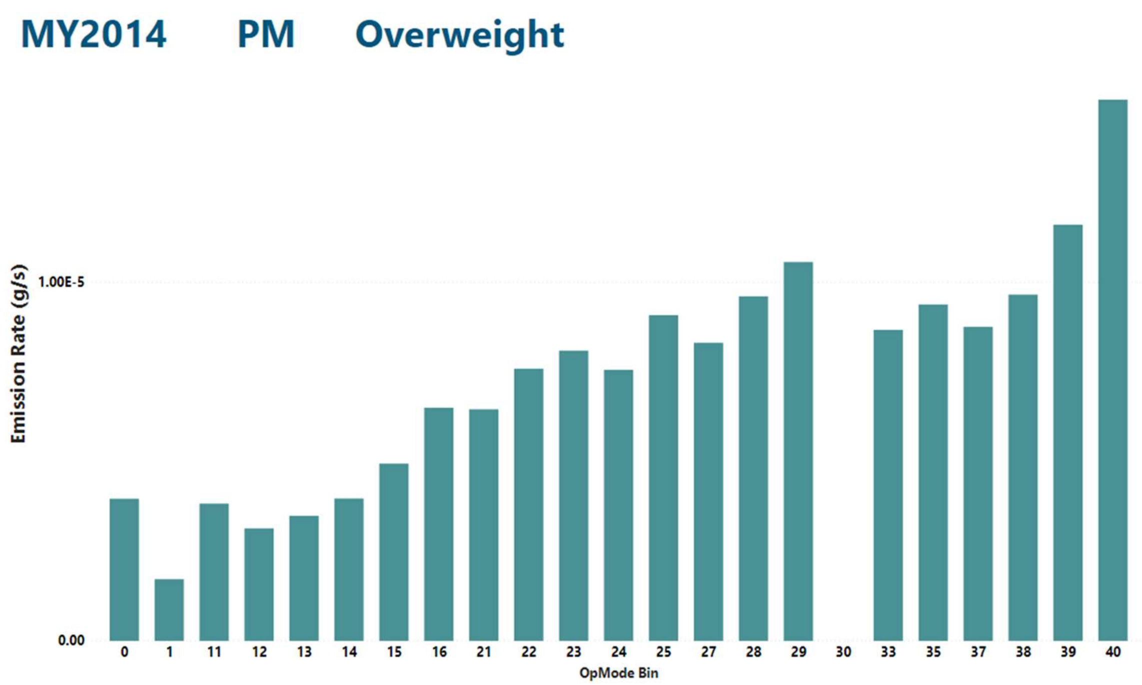


Figure H72. MY2014 Overweight Load PM Emission Rates

MY2014 THC Overweight

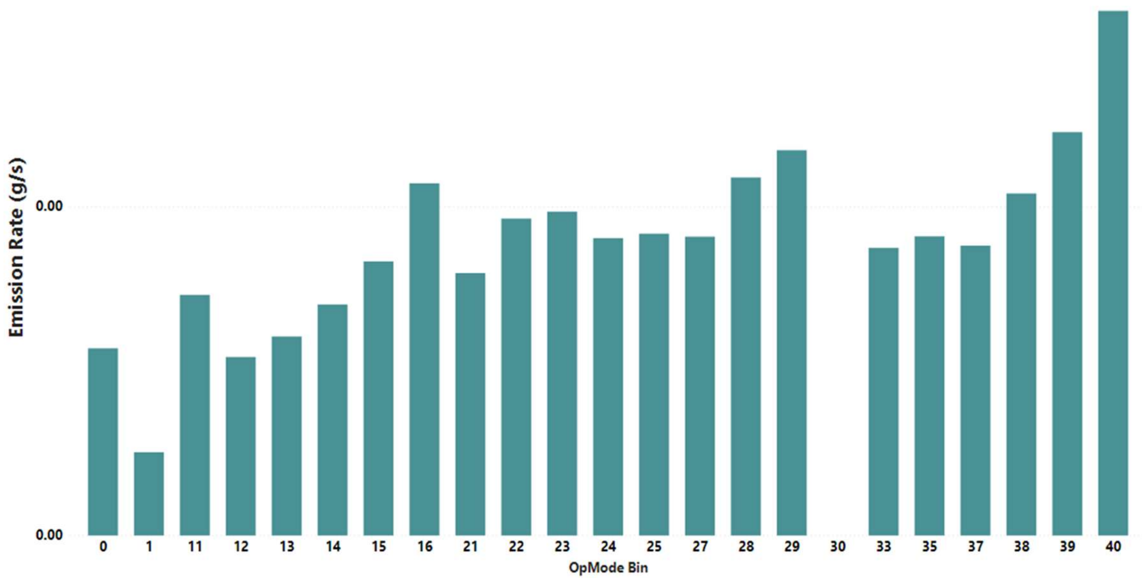


Figure H73. MY2014 Overweight Load THC Emission Rates

MY2005 Oversize Load Rates

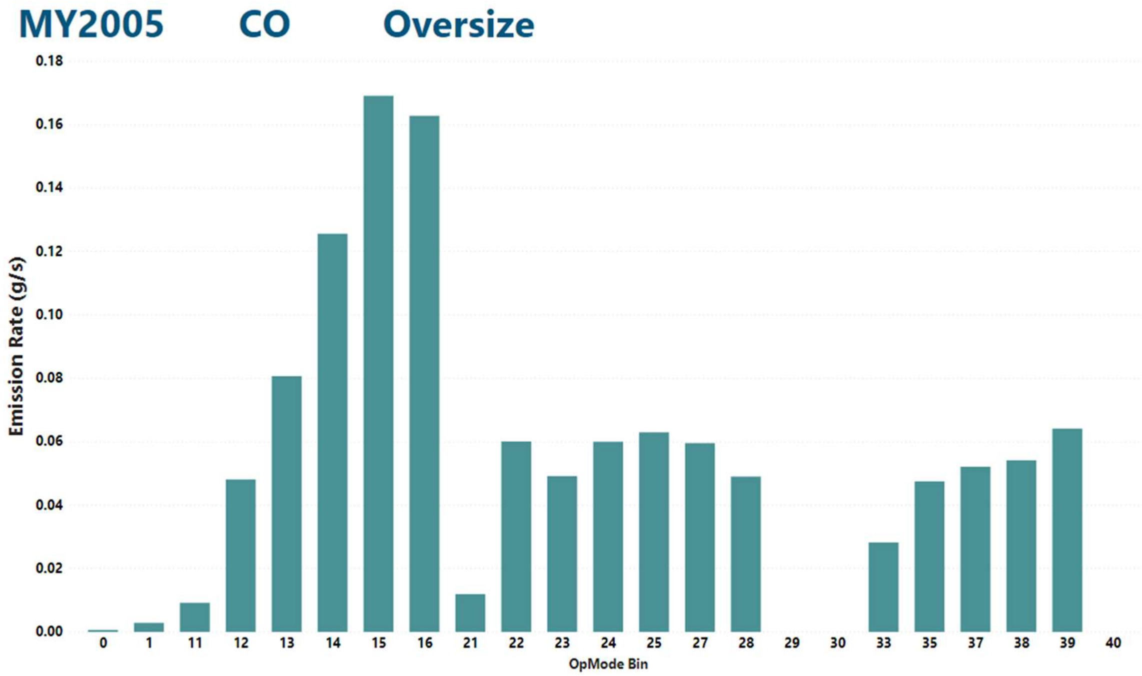


Figure H74. MY2005 Oversize Load CO Emission Rates

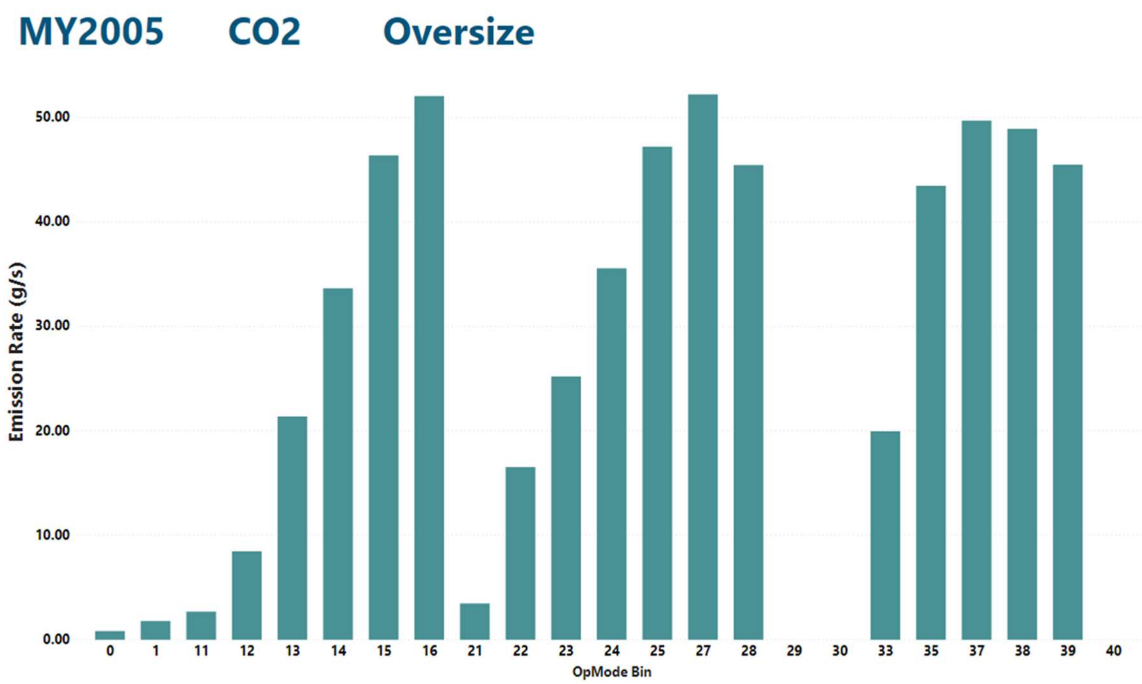


Figure H75. MY2005 Oversize Load CO_2 Emission Rates

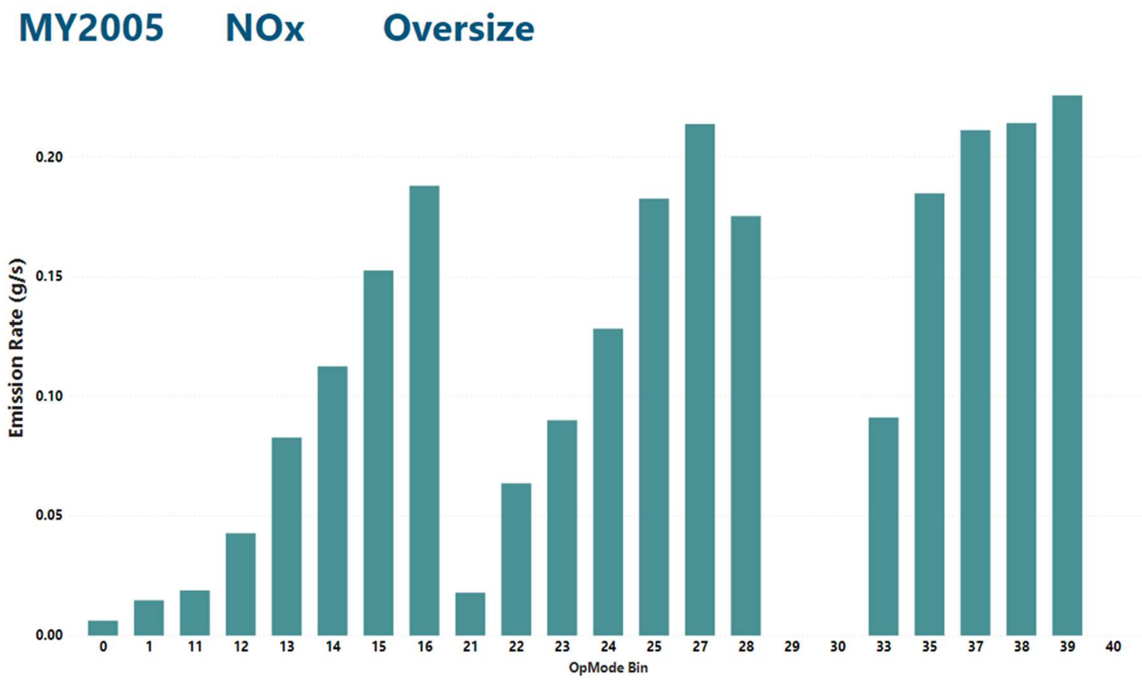


Figure H76. MY2005 Oversize Load NO_x Adjusted Emission Rates

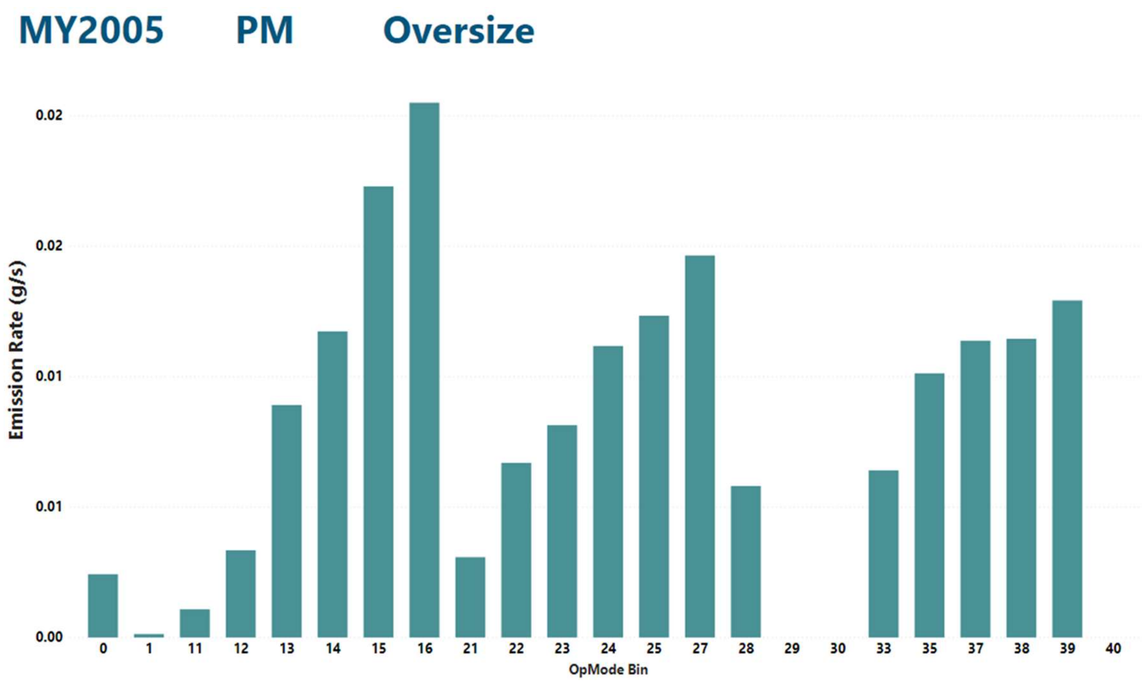


Figure H77. MY2005 Oversize Load PM Emission Rates

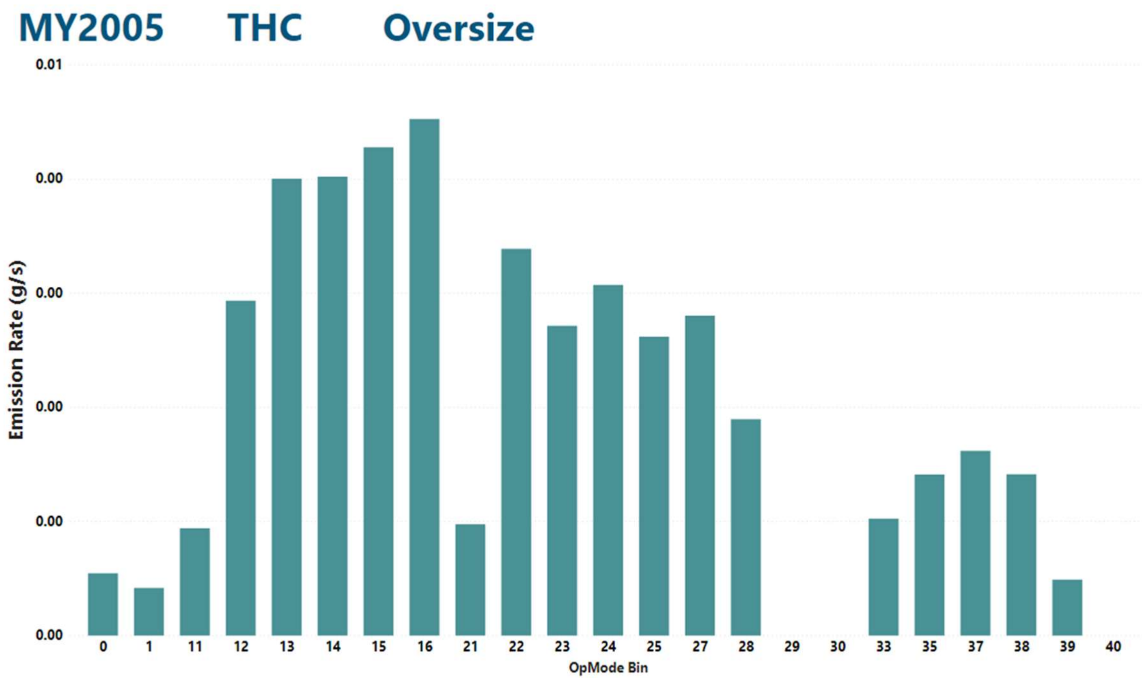


Figure H78. MY2005 Oversize Load THC Emission Rates

MY2014 Oversize Load Rates

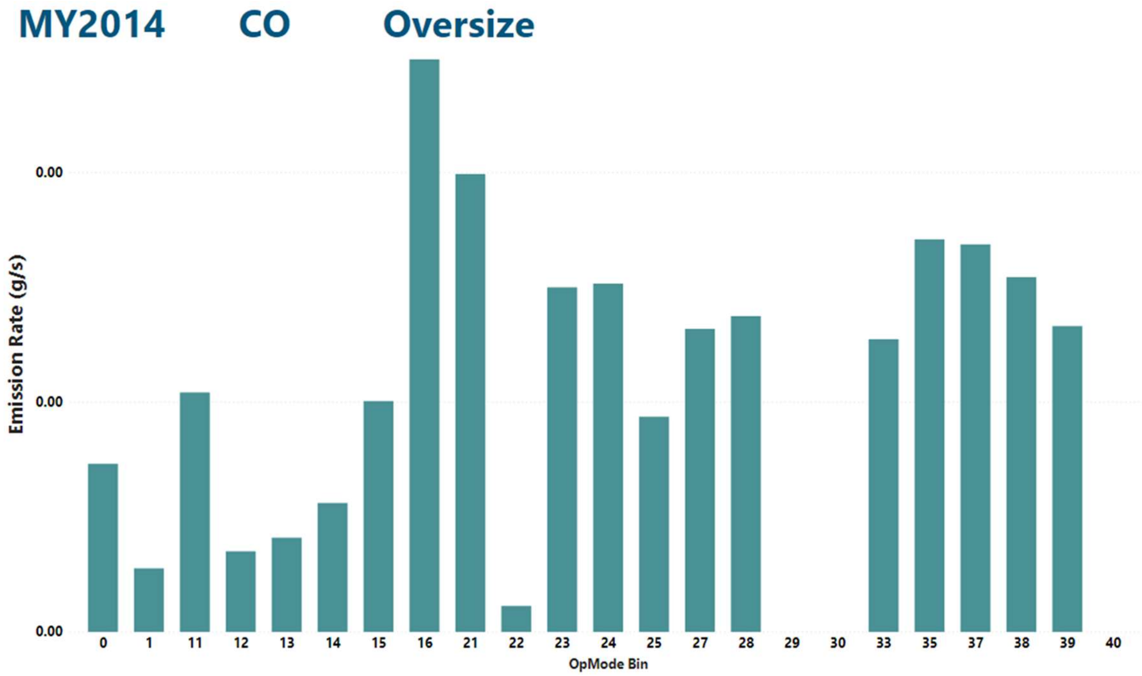


Figure H79. MY2014 Oversize Load CO Emission Rates

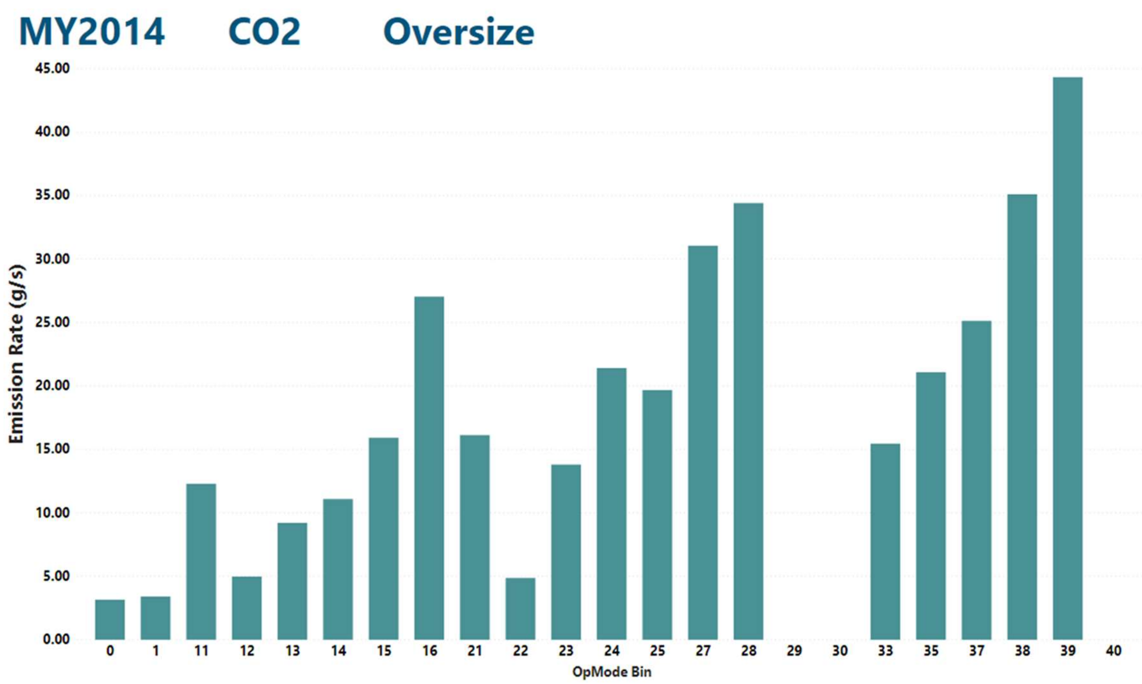


Figure H80. MY2014 Oversize Load CO_2 Emission Rates

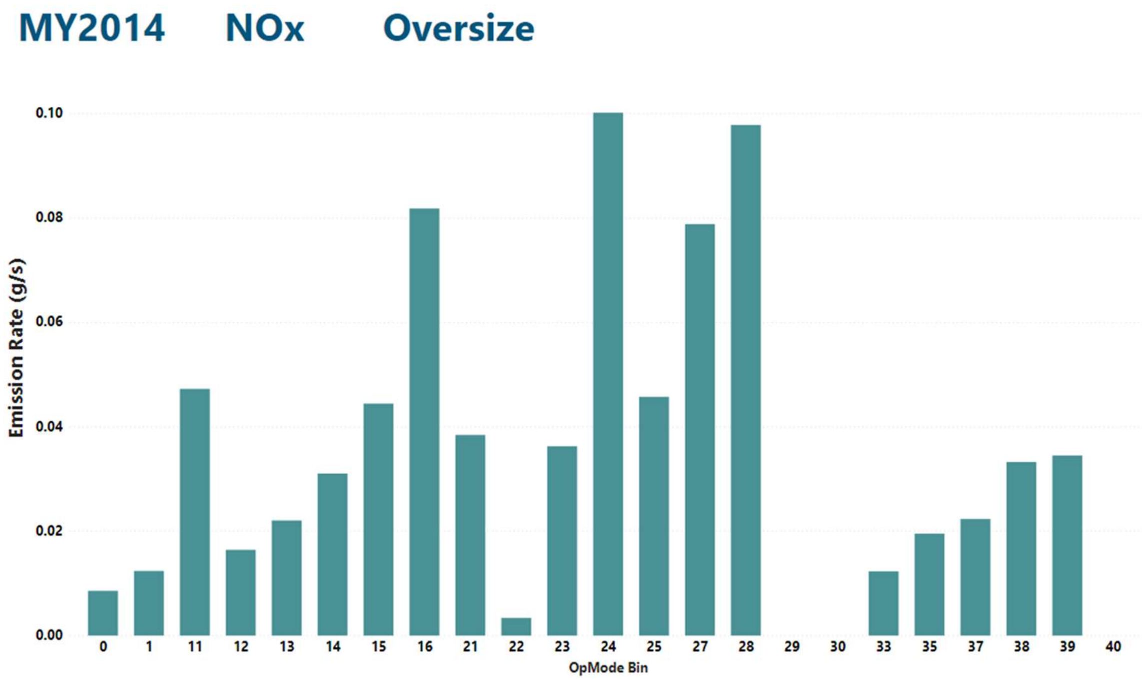


Figure H81. MY2014 Oversize Load NO_x Adjusted Emission Rates

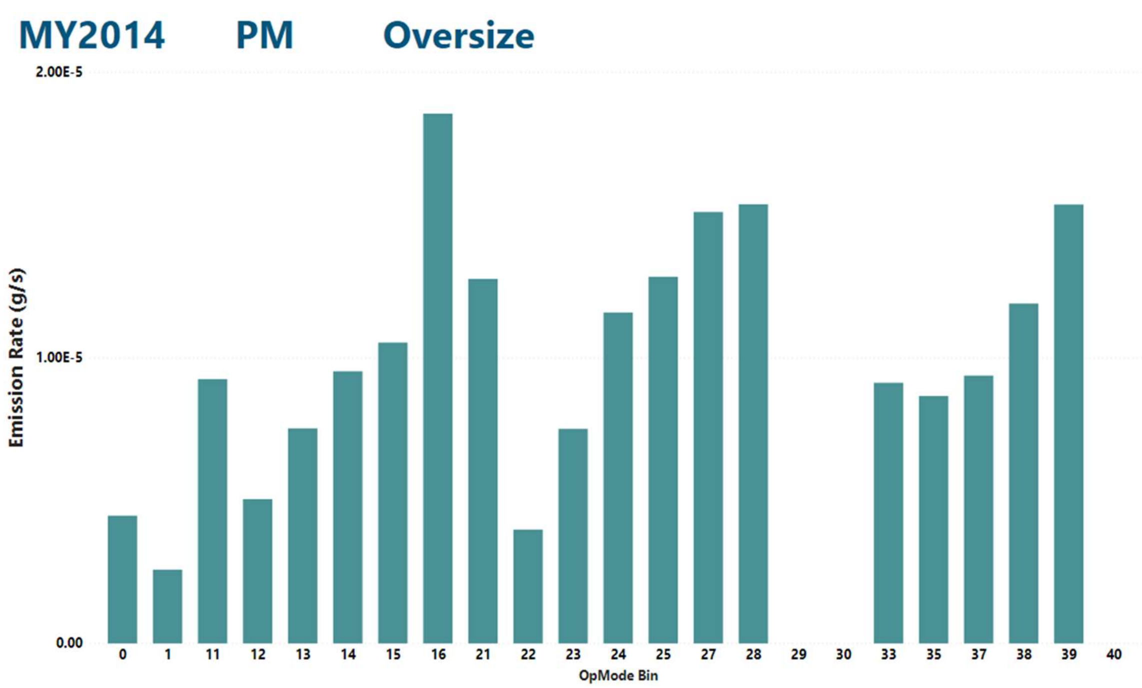


Figure H82. MY2014 Oversize Load PM Emission Rates

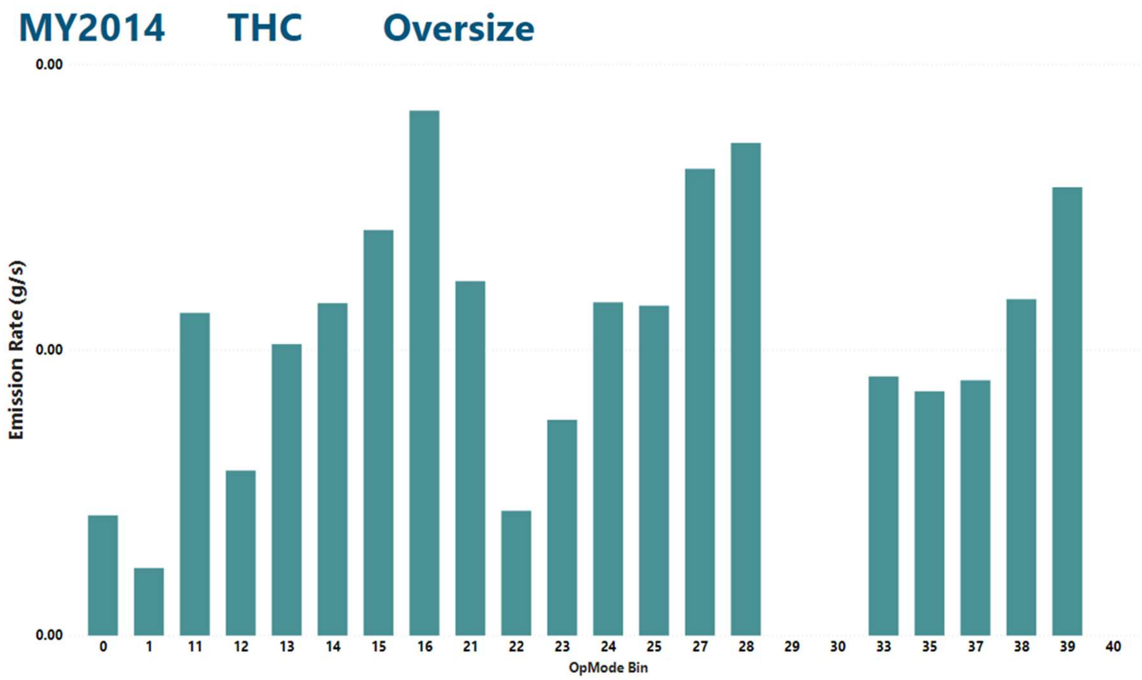


Figure H83. MY2014 Oversize Load THC Emission Rates